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Spatial Pattern of Crop Vulnerability to Drought in Jaffna District

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Abstract

Drought is a disastrous natural phenomenon which is generally viewed as a sustained and regionally extensive occurrence of below average natural water availability either in the form of rainfall, river runoff, or groundwater. Droughts are defined based on different factors and the efficient management of droughts depends mainly on the correct assessment. This study assessed the vulnerability of crop production to drought using multi-scale, multi-indicator methods and some of the data were analyzed during the collection of data through a questionnaire survey. Yield data, rainfall data, and socio – economic data were used to analyze the sensitivity, exposure, and adaptive capacity. Thes was done by identifying differences across and within fourteen DS divisions in Jaffna to reflect the three components of vulnerability: exposure, sensitivity, and adaptive capacity. In addition, overall mean vulnerability of a particular region was estimated. Jaffna's agricultural crop drought vulnerability, presented in a map form, was classified in the following categories: very low, low, moderate, high, and very high. The results of the study show that the vulnerability of crop production to drought in Jaffna district has discernible geographical and socioeconomic patterns with high vulnerability to drought. Three factors such as very high sensitivity indices, very high exposure indices and low adaptive capacity indices are contributies to this regions' vulnerability. The crop vulnerability to drought can be a step towards mitigation-oriented drought management and aid in reducing the impacts associated with drought.

Keywords: Adaptive capacity, crop drought, exposure, sensitivity, vulnerability

1. Introduction

Drought ranks first among natural disasters worldwide, with the World Health Organization (WHO) reporting that an estimated 55 million people are affected by droughts each year, making it the most serious hazard to livestock and crops in nearly every part of the world. Drought impacts can spread over a vast geographical area and affect all kinds of economic, environmental, physical and social lives.

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Drought is a temporary meteorological event, which starts from a deficiency of precipitation over an extended period of time compared to some long-term average conditions. Drought always starts with a shortage of precipitation, but may affect streams, soil moisture, groundwater, cultivation etc. The magnitude of drought impacts is determined by the level of development, population density and structure, demands on water and other natural resources, government policies and institutional capacity, technology, and the political system.

Droughts significantly impact both developed and developing countries, with the latter suffering more severely. Regions like Africa (especially Ethiopia), the Mediterranean, Mexico, India, Australia, and the Middle East are frequently affected (World Bank 2021; WMO/UNCCD 2023). Increasing water scarcity and climate change are expected to worsen the frequency and severity of droughts, prompting global concern.

Droughts are classified into meteorological, hydrological, and agricultural types, with agricultural drought causing the most severe impacts. It directly affects crop production by linking precipitation deficits, soil moisture shortages, and water resource decline greatly influencing farmers and national economies.

Agriculture is crucial to Sri Lanka's economy and rural livelihoods, with 31.8% of the population involved in the sector. The country mainly produces rice, tea, vegetables, and fruits. Its tropical climate, with average temperatures of 28–30°C, and rainfall ranging from 900 mm to 5,500 mm annually, supports crop growth. Monsoon winds create four seasonal rainfall patterns, with key crops like paddy, red onion, and chilies depending heavily on rain from October to February. However, climate change has disrupted these patterns, causing reduced yields and severe crop losses in districts like Jaffna, Kurunegala, and Hambantota (H. M. L. Herath1 and Krishnal Thirumarpan1*,201) Farmers face challenges such as droughts, high temperatures, poor irrigation, and limited awareness of crop insurance.

Jaffna district is situated in the dry zone. Therefore, Jaffna receives inadequate rainfall than other districts. According to the rainfall data of recent times, major cultivating period receives insufficient rainfall. Paddy cultivation depends not on major irrigation supply but on rainfall of the months from October to February. When compared with the previous data, during the paddy cultivating period, farmers receive insufficient rainfall in Jaffna. During the period from October to February, Jaffna recorded an average rainfall of 324.44 mm in 2021/2022 the highest value observed throughout the study period (2001/2002–2024/2025). Then the rainfall frequently decreased for some cultivating periods.

In addition, some parts of the division suffer from water shortages during periods of low rainfall. For example: *Kayts, Velanai, Karainagar*, and *Delft*. In addition, these regions are more vulnerable than other regions. Normally the people of these regions are struggling to get water for their basic needs.

Most paddy lands are abandoned due to ongoing drought conditions, especially in areas like the *Islands, Vadamaradchy, Thenmaradchy,* and *Kopay*. In 2012/2013, the target extent was 11,178 ha, with 11,095 ha sown and 3,390 ha damaged by drought. In 2013/2014, the target was 11,900 ha, but only 10,736.5 ha were sown, with 5,777 ha affected by drought. As a result, farmers gained very low yields. Last year, the average yield increased by only 2 Mt/ha compared to the previous year.

Groundwater is the main water source in Jaffna District, but it's under threat from both human activities and environmental stress. Prolonged drought has increased saline intrusion into farmland, and overuse of fertilizers has harmed soil quality. Since around 2007, oil contamination especially in *Chunnakam* and *Valikamam*—has become a serious issue with residents reporting oil waste in wells and ponds.

The Climate change and daily weather fluctuations have made drought a pressing concern in Jaffna District. Farmers often lack access to extension services and crop-saving strategies, and local authorities have not implemented effective drought mitigation measures or provided support to paddy cultivators. This lack of actionable support underscores the critical need for research to inform agricultural development and enhance resilience.

Followings are the objectives of the research:

- To identify the key factors that define crop drought vulnerability.
- To develop the crop drought vulnerability index for each Divisional Secretariat Division.
- To create a crop drought vulnerability map of the Divisional Secretariat Divisions based on the developed index.
- To analyse the problems faced by paddy farmers due to drought

1.1 Research Design

This study aims to map crop drought vulnerability using a GIS-based approach. It involves three stages: (1) creating a crop yield sensitivity index using historical data, (2) estimating drought exposure with rainfall and drought indices, and (3) assessing adaptive capacity using socioeconomic indicators, some of which are analyzed using SPSS.

1.2 Study Area

Jaffna district is located in Northern Province of Sri Lanka, about 410 km away from capital. It is a peninsula WHICH consists of seven inhabited Islands. North, East and West boundaries of the district are Indian Ocean and the South boundary is Jaffna Lagoon and Kilinochchi District. The total land area including Island is 1025 Sq.km. Jaffna District is divided into four sub divisions. There are Islands, Valikamam, Thenmaradchi and Vadamaradchi. The land in Jaffna District could be characterized as flat with less than 5% slop. There are more than 631 minor tanks and 2.433 ditches scattered all over the district with connected channels to conserve rain water. Excess water easily drained into the sea/lagoon. The elevation at Point Pedro is 15.24m. Myliddy is 10.8m. Chankanai is 3.04m and Kokuvil is 6.09m above the Sea level.

Jaffna District is further divided into 15 administrative divisions (11 Divisional Secretariat divisions and 4 Assistant Government Agent Divisions). There are 435 Grama niladhari divisions in Jaffna district. 17 local bodies (Municipal council – 01, Urban Councils – 03 and Pradeshiya Saba – 13) are functioning to perform some activities such as water supply and drainage, health and maternity clinics community centers, public libraries and maintenance of rural roads.... etc.

Table 1- Area of divisional secretary's divisions - Jaffna district

No	D.S Division	Area in Sq.km
1	Delft	**45.00**
2	Islands South	**78.00**
3	Islands North	**30.00**
4	Karainagr	**22.00**
5	Jaffna	**17.00**
6	Nallur	**38.00**
7	Valikamam South West	**45.00**
8	Valikamam West	**44.00**
9	Valikamam South	**30.00**
10	Valikamam North	**57.00**
11	Valikamam East	**102.00**
12	Thenmaradchi	**221.00**
13	Vadamaradchi South West	**88.00**
14	Vadamaradchi North	**29.00**
15	Vadamaradchi East	**179.00**
	Total	**1,025.00**

Source: District Secretariat Jaffna,2024

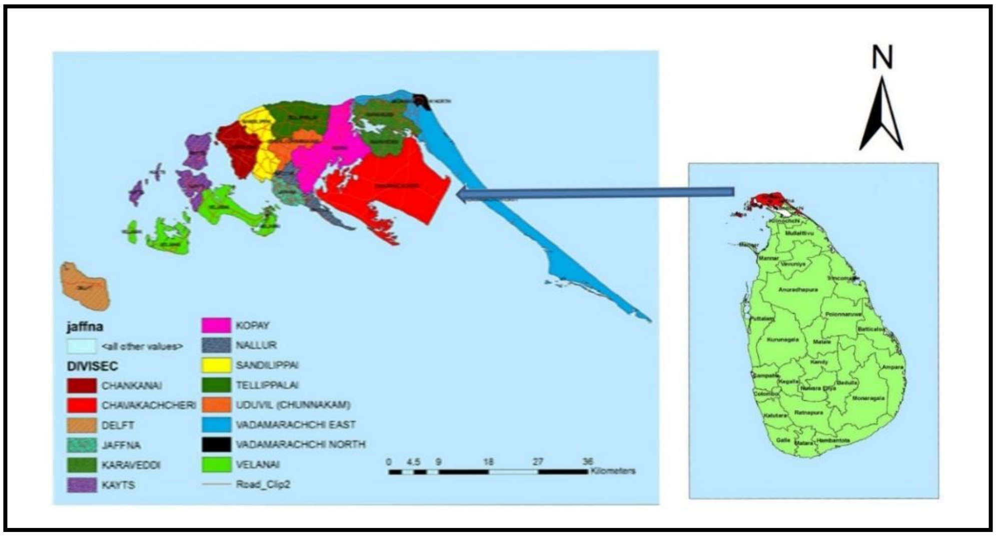


Figure 1- Study area
Source: District Secretariat Jaffna

2. Methods of data collection

Data were collected using two models.

- **Primary Data**

Primary data were collected through structured interviews with Agricultural Officers and questionnaires administered to farmers.

Ex: yield, present drought conditions, availability of water resources, land holding size, conservative agricultural drought techniques, cultivated paddy varieties, socio economic data.

- **Secondary Data**

Data were collected from the past records.

- Rainfall Data – collected from Colombo and Jaffna meteorological department
- Historical yield - Agriculture Research Station
- Farmers educational level and poverty range –Agrarian Service Centres in Jaffna
- Statistical Hand Book - Jaffna District,2023,2024

a. Sampling method

A cluster sampling method with proportional allocation was used for the analysis. Each Divisional Secretariat Division in the Jaffna District was considered as a cluster, and samples were allocated proportionally based on the number of paddy farmers in each division. Accordingly, a total of 250 paddy farmers were selected from the overall population of 26,572 paddy farmers in the district, representing approximately 0.05% of the total. This approach ensured that farmers from different geographical locations were adequately represented in the sample.

The table 2 shows the cluster sampling methods:

Sample size: probability samples– cluster

Total questionnaire = **26527** → **250**

Table 2- cluster sampling methods for each DS division wise.

No.	DS Division	No. of Paddy Farmers	Cluster sampling
1.	Karainagar	1062	**20**
2.	Delft	109	**05**
3.	Velanai	79	**05**
4.	Kayts	112	**05**
5.	Uduvil	565	**10**
6.	Chankanai	3160	**25**
7.	Kopay	2110	**20**
8.	Sandilipay	2540	**20**
9.	Point Pedro	480	**10**
10.	Karaveddy	3458	**25**
11.	Tellipalai	730	**15**
12.	Maruthenkerny	1160	**20**
13.	Thenmaradchchy	10217	**60**
14.	Nallur	790	**10**
	Total	**26572**	**250**

3. Data analysis

The general procedure was followed in this paper to describe the Figure 2. The framework has two different types of data. The research is designed to find out the relationship among crop drought vulnerability index and socio-economic indicator approach to map - out vulnerability in GIS environment. In addition, some of the data were analyzed during the collection of data by questionnaire survey. The following flowchart shows the process of analysis.

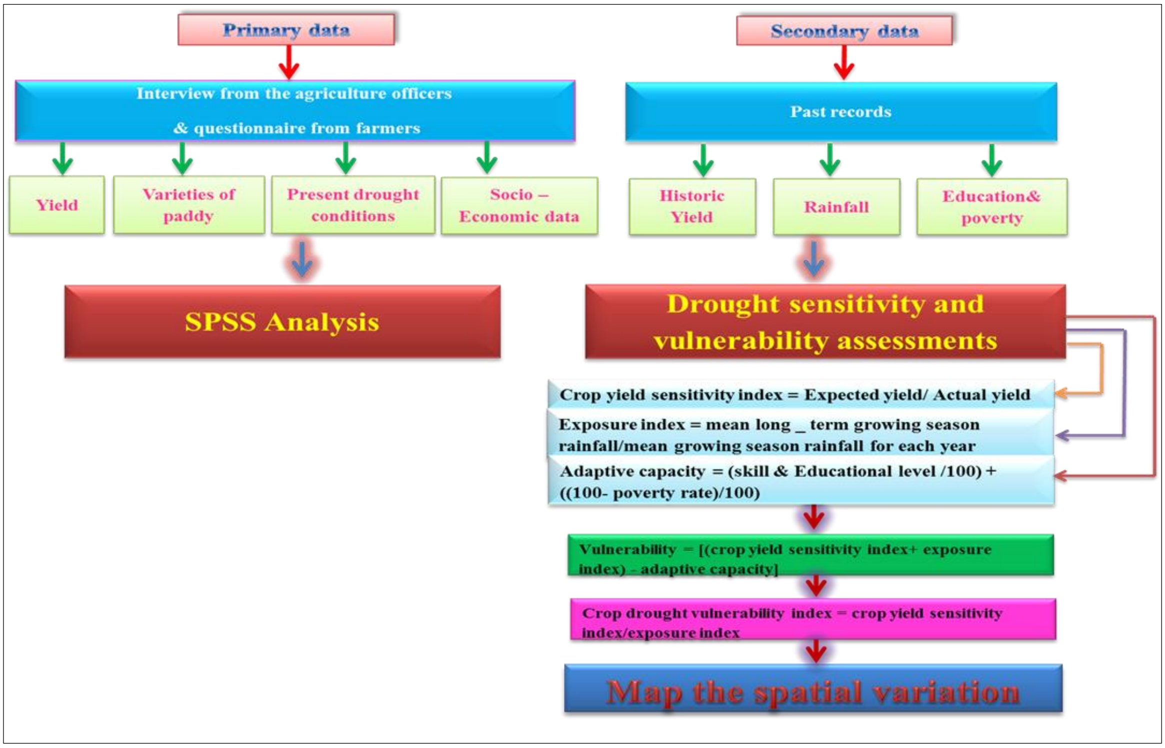


Figure 2-Methods of data collection & data analysis

These stages were categorized based on both primary and secondary data. Primary data were collected from paddy farmers and agricultural officers to develop the crop drought vulnerability index and the socio-economic indicator approach. Yield data, rainfall data, and socio-economic data were used to analyze sensitivity, exposure, and adaptive capacity. The main processes are described below.

- **Exposure**

Exposure is the degree to which a system is subjected to meteorological drought (Fraser, 2007; Tilahun, 2006). It reflects climate stress through long-term changes or variability, including frequency and magnitude of extreme events (O'Brien et al., 2004). Exposure is characterized by two elements: frequency of climate extremes and predicted rainfall changes by 2050 (Gbetibouo & Ringler, 2009).

To measure exposure, an index was created using meteorological data. Following the method of Simelton et al. (2009) and Philip et al. (2011). In carrying this out the monthly rainfall data was obtained from the Colombo & Jaffna Meteorological department for 2001-2025.

Paddy cultivation period in Jaffna District is between the months from September to February. To develop the exposure index, the average of the 13-

year rainfall period for the 5-months period (October - February) from 2001-2025 was divided by each year's average rainfall for this period which represents the cultivating season of paddy as shown in equation below.

$$\textbf{Exposure index} \quad \frac{\textbf{Mean long-term growing season rainfall for 2001 - 2025}}{\textbf{Mean growing season rainfall for each year 2001 - 2025}}$$

Only one station is functioning to assess the rainfall to represents whole district. Because of that regional rainfall is not verified as high, medium, and low classes.

- **Sensitivity**

Sensitivity refers to the degree to which a system is affected by internal or external disturbances (Gallopín, 2003). In this study, it is measured through yield losses associated with droughts, using a crop yield sensitivity index adapted from Simelton et al. (2009). Paddy was chosen as the key economic crop for Jaffna due to its suitability, and yield data (2000–2024) for all DS divisions were obtained from the Department of Agriculture (Extension).

While crop simulation models can capture complex crop–climate relationships, their high cost, location specificity, and data requirements limit their use to a few major crops and areas. As a result, aggregate analyses often depend on limited sites and datasets; for example, in South Africa, the CERES-maize model is widely applied (Schulze et al., 1993; Du Toit et al., 2002).

Yields are actual indicators to reduce the influence of increased agricultural technology in order to highlight inter-annual yield variation as a result of rainfall (Easterling et al., 1996). To determine the crop yield sensitivity index, the linear trend for each yield for each division between 2000 and 2024 was calculated. The equation for this trend line was used to calculate the expected yield in each year. The expected yield was then divided by the actual yield for each year to generate a crop yield sensitivity index as per divisional analyses previously applied in China (Simeltonet al., 2009). The equation is shown below.

$$\textbf{Crop yield sensitivity index} = \frac{\textbf{Expected yield}}{\textbf{Actual yield}}$$

- **Adaptive Capacity**

Adaptive capacity is the ability of a region, system, or community to cope with climate change impacts (especially drought) and is measured using socioeconomic indicators. It is closely related to adaptability, coping capacity, resilience, and flexibility (Smit & Wandel, 2006; IPCC, 2001). Factors influencing adaptive capacity include wealth, technology, education, skills, infrastructure, and resource access.

It is often assessed through livelihood assets:

- Social capital – farm organizations and networks that provide financial support, technology information, and cooperation (Deressa et al., 2008).
- Human capital – literacy rate (reduces vulnerability) and HIV prevalence (increases vulnerability) (Leichenko et al., 2002; Drimie, 2002).
- Financial capital – farm income, holding size, assets, poverty levels, agricultural GDP share, and access to credit.
- Physical capital – infrastructure and market access, which lower transaction costs, spread risk, and strengthen resilience (Zhang et al., 2007).

Two proxy indicators of adaptive capacity were considered: human capital (represented by educational level (%)) and financial capital (represented by poverty rates (%)). These proxy socioeconomic indicators were obtained from the census data by the Ghana Statistical Service (2000).
In this study, two indicators of adaptive capacity were also considered. Human capital (signified by educational level for farmers (%)) and financial capital (signified by poverty rates (%) were considered. Data on poverty level were derived on the basis of the samurdhi rate. The equation is shown below

Adaptive Capacity = (Educational level /100) + ((100-Poverty Rate)/100)

Hence, the overall mean vulnerability of a particular region was estimated using the following:

Vulnerability = [(crop yield sensitivity index + exposure index) -adaptive capacity]

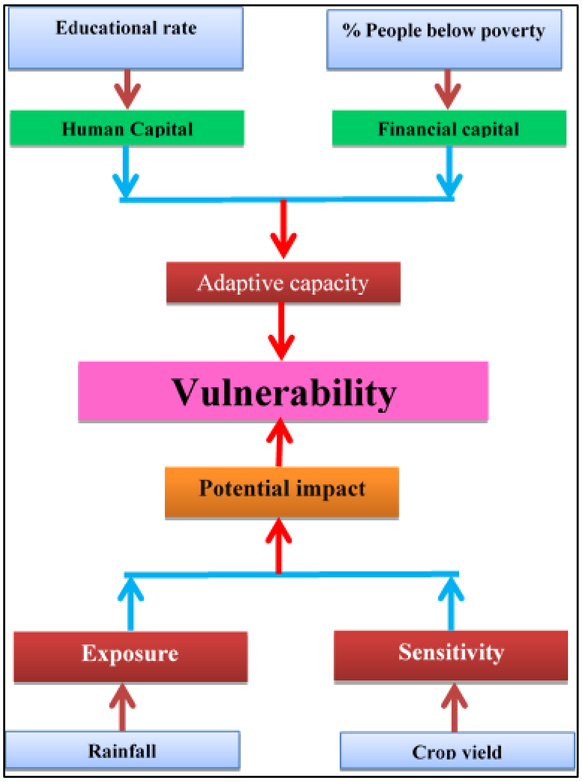
Crop drought vulnerability index = crop drought sensitivity/ exposure index

The above methods above were used to map vulnerability at the divisional scale using available proxy socioeconomic data. After identifying the most vulnerable divisions, crop production vulnerability was further analyzed at that level. Due to the absence of socioeconomic data at finer scales, crop drought vulnerability was assessed using the approach by Simelton et al. (2009).

The crop drought vulnerability index is effective in data-scarce regions, relying on rainfall and divisional crop harvest data to identify vulnerable areas. This study focused on paddy, the most impacted crop, to develop a yield sensitivity index at the divisional level. After calculating mean vulnerability, k-means cluster analysis (Levia & Page, 2000) was used to group DS divisions by vulnerability. Widely applied in geographical studies (Ahern et al., 2006; Kennedy & Naaman, 2008), k-means is a valuable tool for assessing spatial vulnerability in dynamic systems.

The utilized indicators and their inter-linkages, which are geared towards reflecting overall vulnerability, are clearly presented in Figure 3. The aggregation of the different indicators towards the overall vulnerability.

Figure 3-The aggregation of the different indicators towards the overall vulnerability



Source: Developed by Researcher

- **Analyzing Questionnaire data**

An exploratory analysis approach was employed, integrating both quantitative and qualitative methods. A probability cluster sample of 250 paddy farmers was selected from the total of 26,527 farmers in Jaffna District to represent its geographical diversity. Data were collected through face-to-face interviews using structured questionnaires, covering topics such as paddy land extent, cultivation periods, crop varieties, water sources, drought impacts, seasonal expenses, income, and profit.

For quantitative data, entry screens were developed, and the data were analyzed using SPSS and Excel, with percentages calculated and results summarized descriptively. Qualitative data from interviews were coded and similarly entered into SPSS and Excel. Key findings were presented in tables and charts to facilitate interpretation.

4. Results and Discussion

The results are shown in two different ways. One is the spatial patterns in crop drought vulnerability index. Other one is questionnaire analyzed result.

- **Spatial patterns in crop-drought vulnerability**

The results are divided into three sections. The patterns of crop vulnerability are first examined spatially across Jaffna, then as a trend over time and finally the socioeconomic characteristics of sensitive cases were identified

- **Crop yield sensitivity**

The crop yield sensitivity to drought in various divisions in Jaffna District is illustrated in Figure 04. The analysis reveals that the Kayts Division is highly sensitive to drought exposure, as evidenced by the significant crop failures associated with meteorological drought in this area. Farmers in this division rely predominantly on rain-fed agriculture, making their crops extremely vulnerable to rainfall variability. Moreover, the scarcity of freshwater and the salinity of available groundwater further exacerbate agricultural challenges. The Vadamarachchi North Division ranks as the second most sensitive area, while the Uduvil Division exhibits relatively low sensitivity to drought compared to other divisions. (The Jaffna Divisional Secretariat Division was excluded from this analysis, as it is primarily a settlement and built-up area with only limited home garden agricultural lands available.)

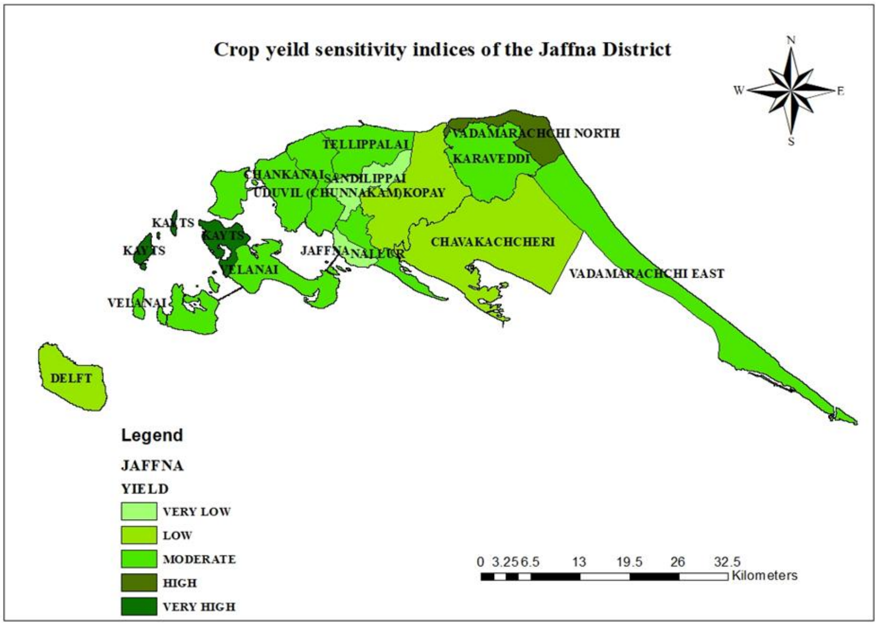


Figure 4- Crop yield Sensitivity indices of the Jaffna district
Source: Developed by researcher

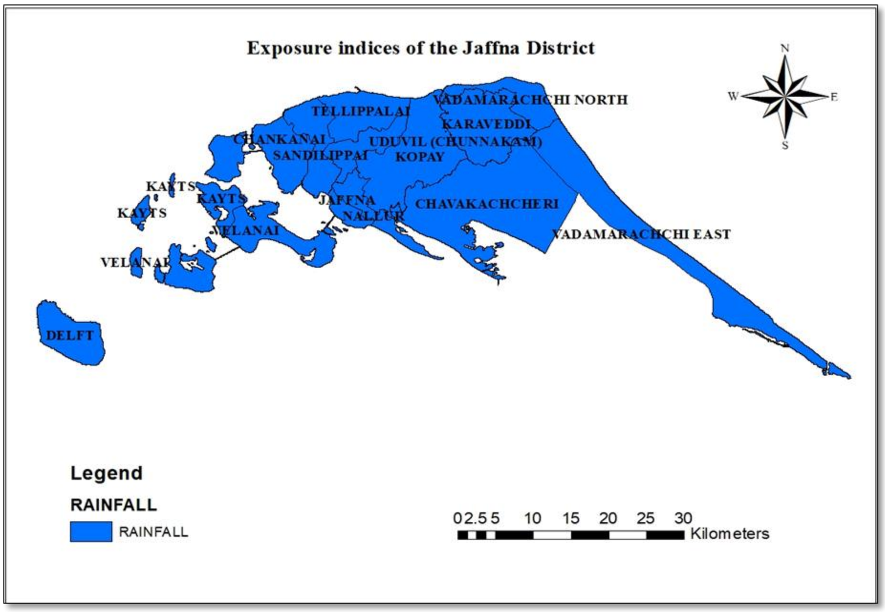


Figure 5-Exposure indices of the Jaffna district
Source: Developed by researcher

Figure 05 presents the exposure indices for the Jaffna District. Only one rainfall station has been operational from 2001 to the present. According to the Colombo Meteorological Department, the Jaffna District is characterized by an entirely flat terrain with minimal elevation differences. Therefore, spatial variation in rainfall across the district is assumed to be limited, and the data from this single station were considered representative of the entire district. Nevertheless, it is acknowledged that relying on one rainfall station may not fully capture localized micro-climatic variations.

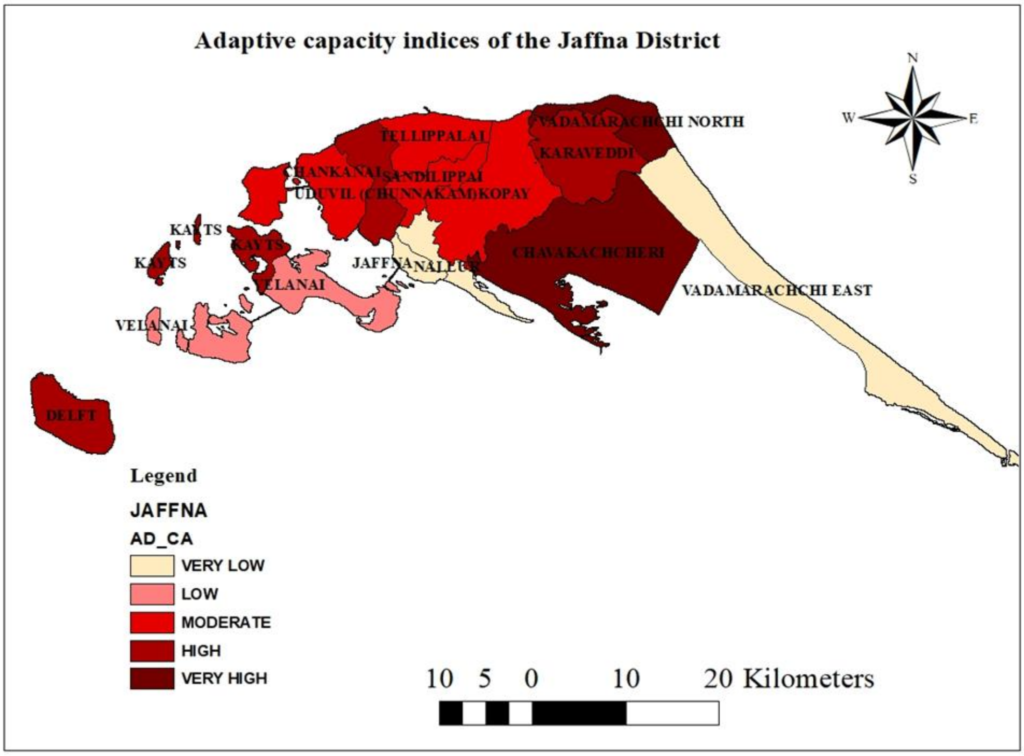


Figure 6-Adaptive capacity indices of the Jaffna district

Source: Developed by researcher

Figure 06 shows the overall adaptive capacity of the various divisions in the Jaffna District. Two regions—Nallur and Vadamarachchi East—exhibit the lowest values, indicating a very low capacity to cope with drought. Additionally, Velanai also shows low adaptive capacity. In contrast, the Chavakachcheri division demonstrates the highest adaptive capacity, suggesting that this is the best equipped division to recover crops from drought. The Chankanai, Tellippalai, and Kopay divisions show moderate levels of adaptive capacity. The analysis also indicates that the Kayts, Delft, Karaveddi and Sandilipay divisions have relatively high adaptive capacity in relation to drought.

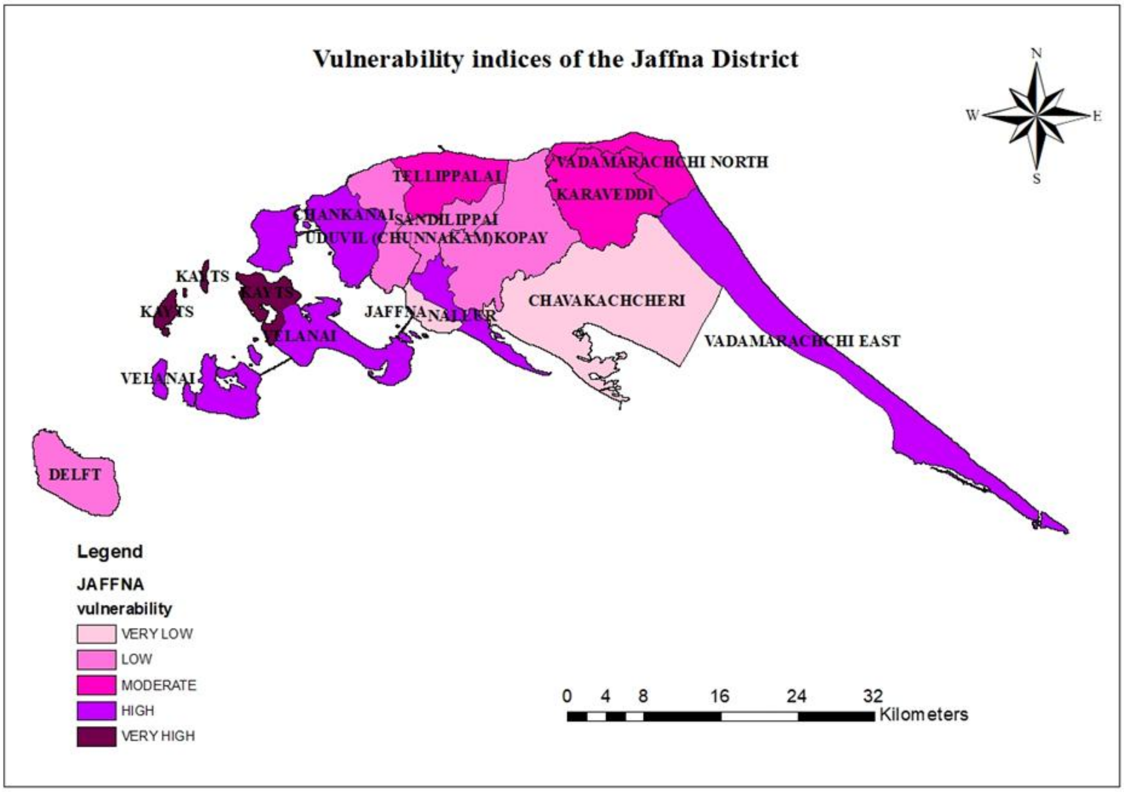


Figure 7-Vulnerability indices of the Jaffna district

Source: Developed by researcher

Figure 07 presents a spatial analysis showing that the Kayts DS Division is highly vulnerable to drought. This vulnerability is driven by a combination of very high sensitivity and exposure indices, along with low adaptive capacity. Other significantly vulnerable divisions include Velanai, Nallur, Chankanai, Uduvil, and Vadamarachchi East. In contrast, the Chavakachcheri division shows very low vulnerability, largely due to its strong adaptive capacity. Contributing factors include higher levels of education, greater knowledge of agricultural practices, and higher income levels among farmers, which enhance their ability to protect crops from drought impacts.

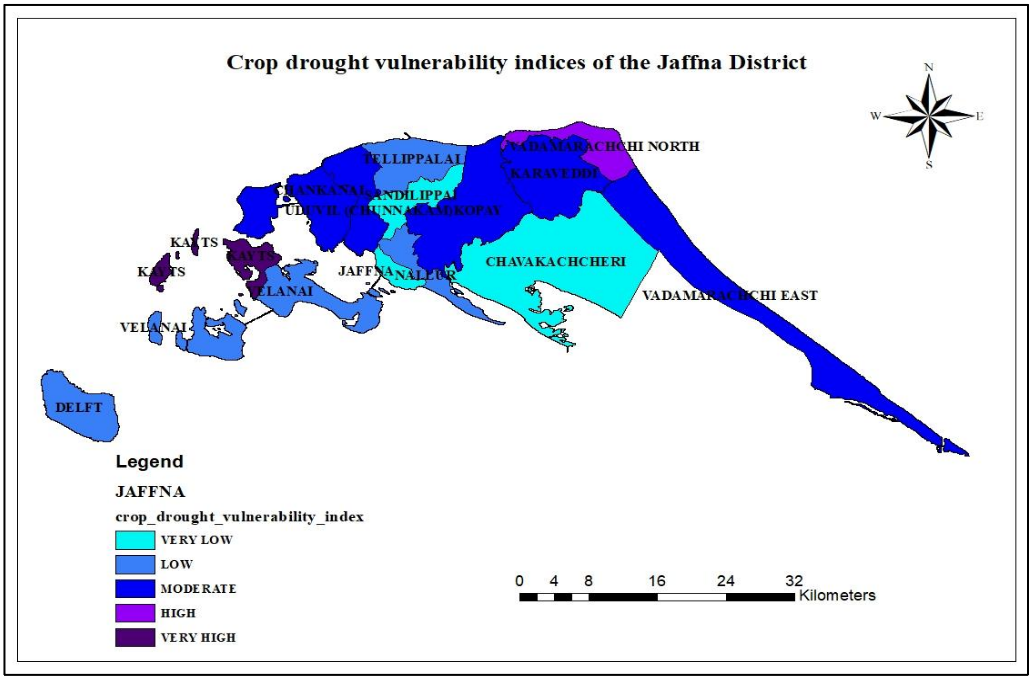


Figure 8- Crop drought vulnerability indices of the Jaffna
Source: Developed by researcher

The crop drought vulnerability analysis indicates that the Kayts division has a very high level of vulnerability. This is evident from the significant extent of crop failure associated with meteorological drought in the area. Farmers in this division rely heavily on rain-fed agriculture, making them particularly susceptible to drought impacts. Three DS divisions show moderate levels of crop drought vulnerability. Among all divisions, Chavakachcheri and Sandilipai are the most resilient, exhibiting the lowest crop drought vulnerability. Figure 08 illustrates these findings spatially on the map.

- **Questionnaire result**

From the Questionnaire for paddy farmers following are main answers:
Main cause for the drought in Jaffna.

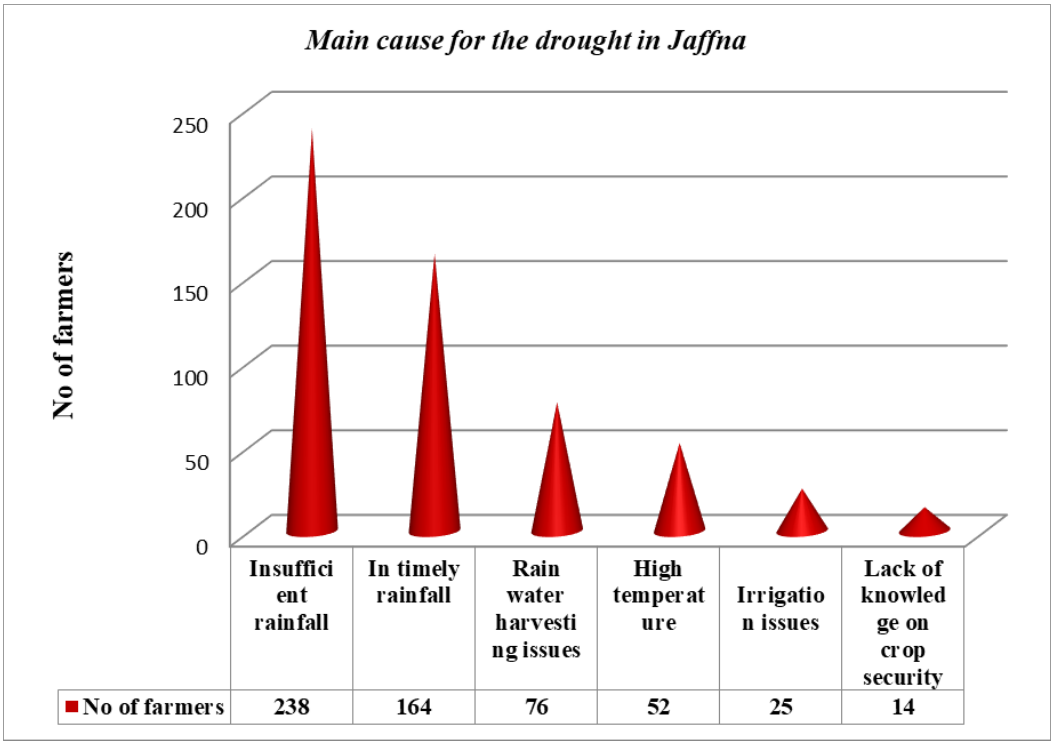


Figure 09-Main cause for the drought in Jaffna

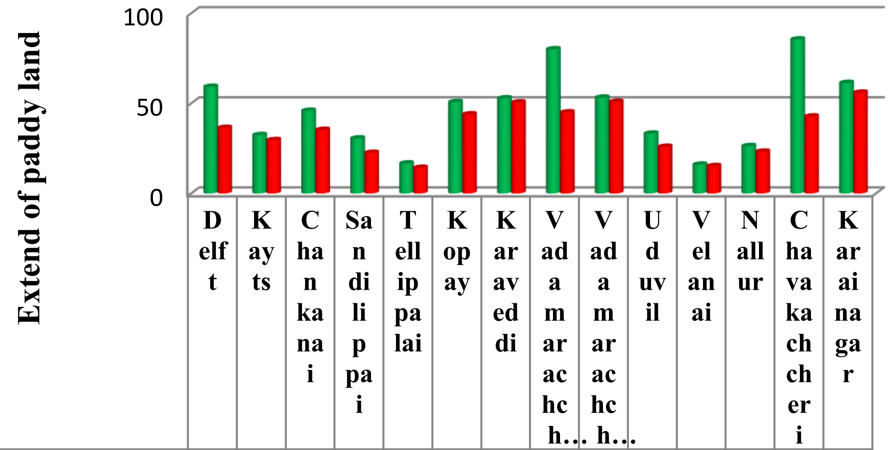
Source: Field Survey

Figure 09 shows that most farmers identified insufficient rainfall as the main cause of drought. Out of the 250 farmers surveyed, 238 mentioned this factor, along with several other causes. Irregular or untimely rainfall was also highlighted as a significant issue. Since Jaffna District lacks major irrigation systems and relies primarily on rainfall, small tanks and ponds are the main sources of water. Consequently, another challenge reported by farmers was the inability to maintain these ponds properly, which limits their capacity to harvest and store rainwater.

- **Extend & affected paddy land.**

Figure 10 shows the total extend of paddy land and affected paddy land. As per the observation based on the data, drought is the main cause for crop destruction in 14 DS divisions in Jaffna district. Chavakacheri is the place where paddy is grown in vast extent of land than other DS divisions in Jaffna district. In this division, the average area of land used for agriculture last year was 85.46ha and 42. 73ha land area was destroyed due to drought condition. Nearly 75% of land in the whole DS division was destroyed.

Below data shows the evidence of the destruction. 16ha land area was used for paddy cultivation in velanai. In this division, 15.2ha land met destruction. 90% land was mostly affected in Tellipalai, Karaveddi, Vadamarachchi east, Kayts, and Nallur DS divisions.



	Delft	Kayts	Chankanai	Sandilippai	Tellippalai	Kopay	Karaveddi	Vadamarachch…	Vadamarachch…	Uduvil	Velanai	Nallur	Chavakachcheri	Karainagar
Extend of paddy land	59	32	46	31	17	51	53	80	53	33	16	26	85	61
Extend of Affected paddy land	36	30	35	23	14	44	51	45	51	26	15	23	43	56

Figure 10-Extend & affected paddy land
Source: Field Survey

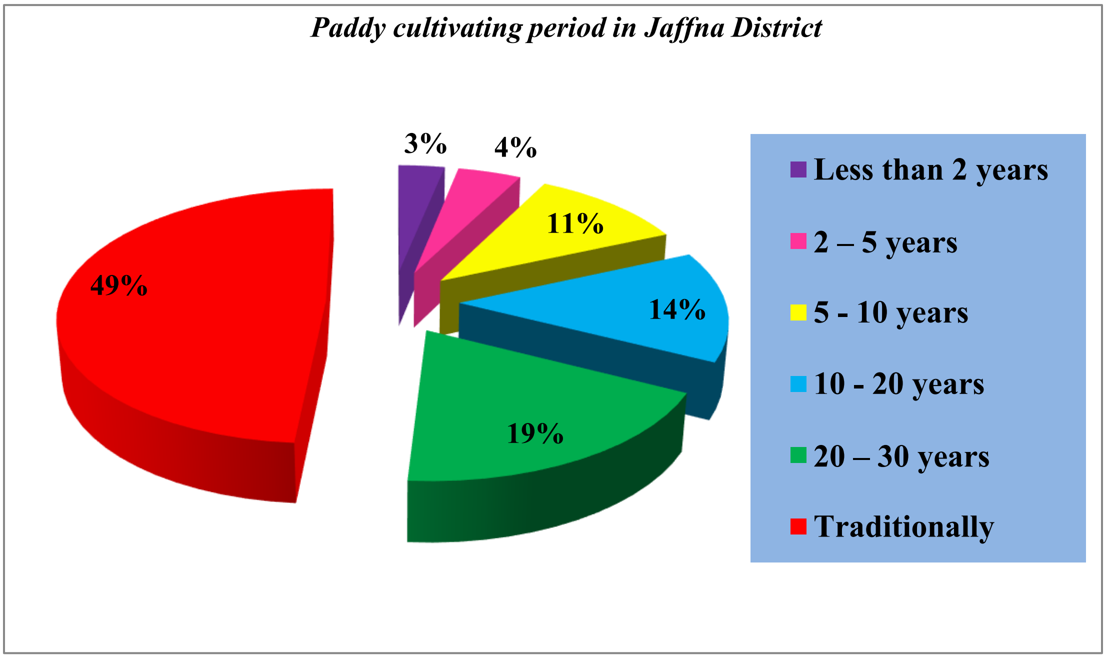


Figure 11-Paddy cultivating period in Jaffna District

Source: Field Survey

The figure 11 shows the information about the period of time that the farmers have engaged in agricultural activities. Most of the farmers engage in paddy cultivation traditionally in Jaffna DS divisions. There are 49% of the farmers who depend on this cultivation traditionally. Only 3% of the farmers are involved in short term paddy cultivation.

- **Varieties of paddy in Jaffna District**

As per the data analysis, BG 406 variety of paddy is mostly cultivated in Jaffna district. Among 250 farmers, it was found that 103 persons use BG 406 as their paddy variety. The next popular paddy variety is BG 501. H4, sampa, BG 456 are cultivated in small percentage of land. Mottaikarupan, Aattakkari are some types of paddy that is cultivated in large scale. 67% out of 250 farmers cultivate Mottaikarupan and another 68% from the same amount (250) cultivates Aattakkari. Some farmers also cultivate the varieties which are mixed with one another. This type of paddy is sustainable for drought. Most people favour these types of paddy. They said that these types of paddy give them economic benefits. Therefore, farmers like these varieties.

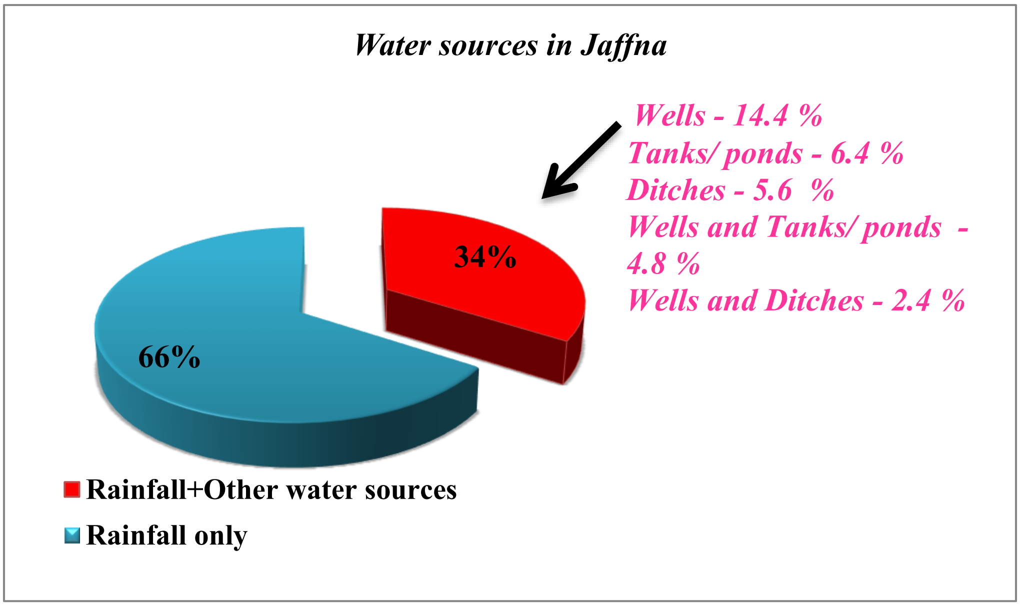


Figure 12-Water sources in Jaffna

Source: Field Survey

In the Jaffna District, the majority of farmers depend primarily on rainfall for paddy cultivation. However, due to changing weather patterns, some farmers have begun utilizing supplementary water sources such as wells, ponds, and ditches to sustain irrigation. Survey data indicate that 66% of farmers rely exclusively on rainfall, while the remaining proportion combine rainfall with alternative water sources, particularly in areas such as Kopay, Chankanai, Sandilipay, and Tellipalai. Figure 12 illustrates the distribution of irrigation practices among farmers in the study area.

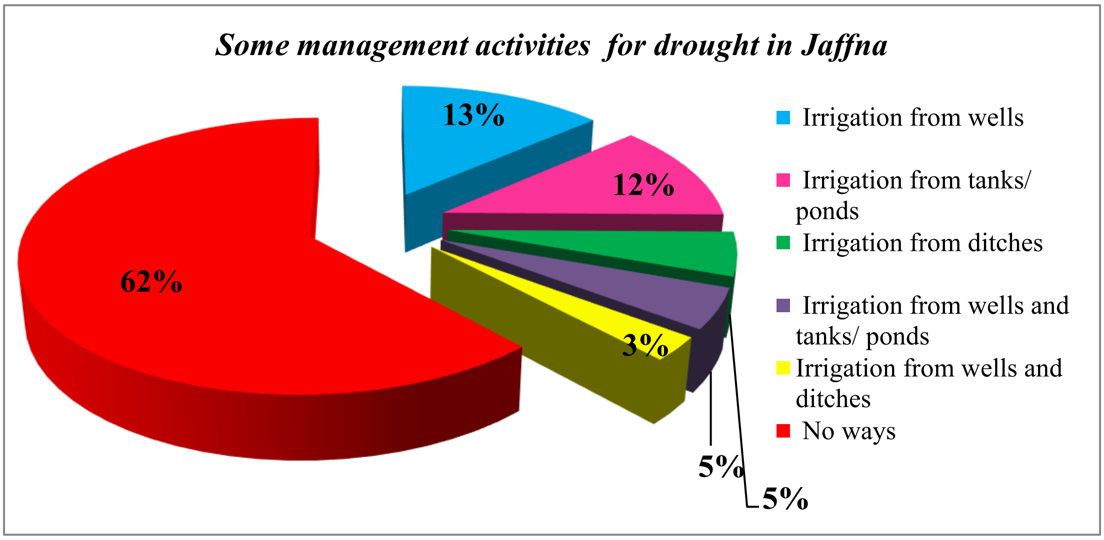


Figure 13-Management activities for drought in Jaffna

Source: Field Survey

Figure 13 illustrates the management practices adopted by farmers to cope with drought conditions. The results show that 62% of farmers reported having alternative water sources other than rainfall, highlighting their high level of vulnerability to drought. The remaining farmers indicated that they use wells, ponds, or ditches for irrigation, which provides a certain degree of resilience during dry periods. This variation suggests that access to local water resources plays a critical role in reducing crop losses and enhancing adaptive capacity in drought-prone areas.

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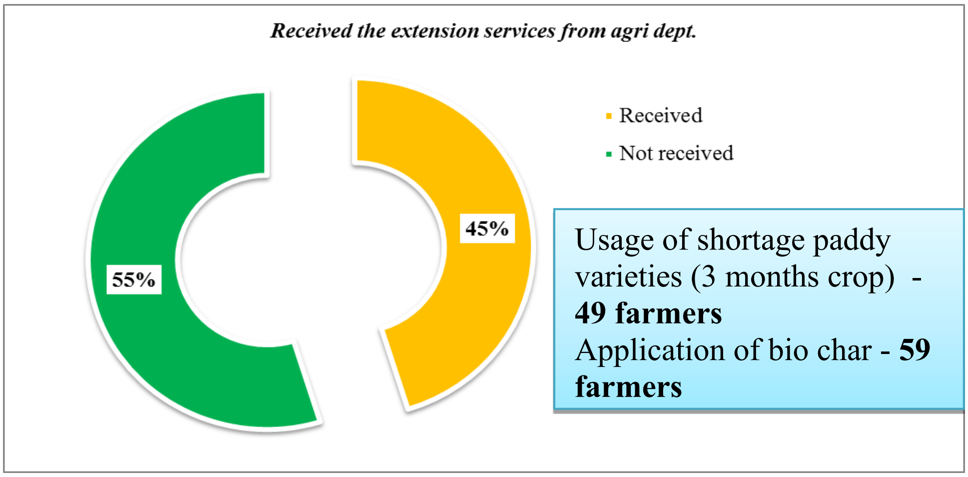


Figure 14-Received the extension services from agriculture Department

Source: Field Survey

Figure 14 illustrates the farmers get very little service from the Department of Agriculture or relevant farmer organizations. Most of them are traditional farmers. They cultivate in their traditional ways. They hesitate to follow the modern ways and new varieties. 45% of farmers from 100% get considerable help from department of agriculture.

They get the following helps:

1. Usage of short paddy varieties (3 months crop)
2. Application of bio char
3. Seed treatment
4. Technic of land preparation

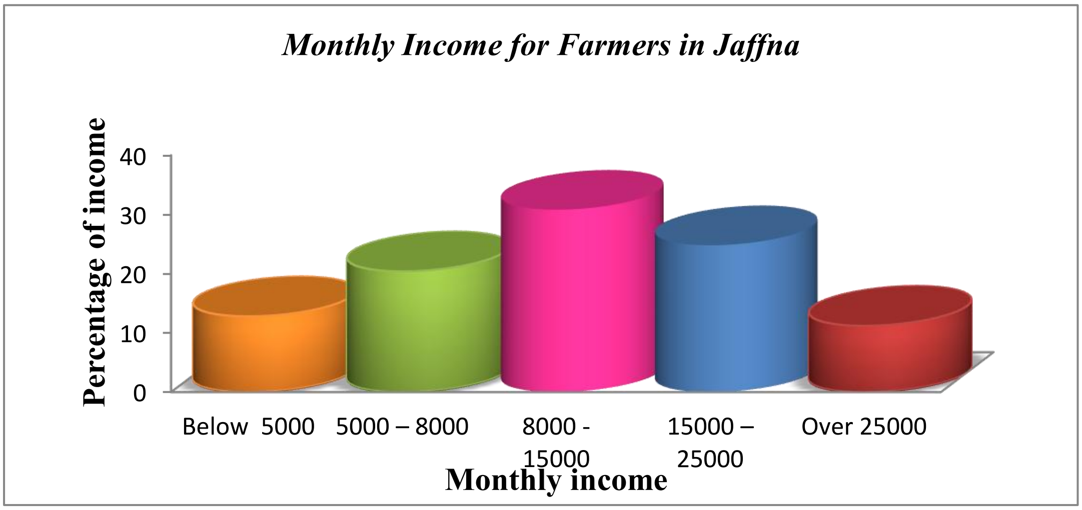
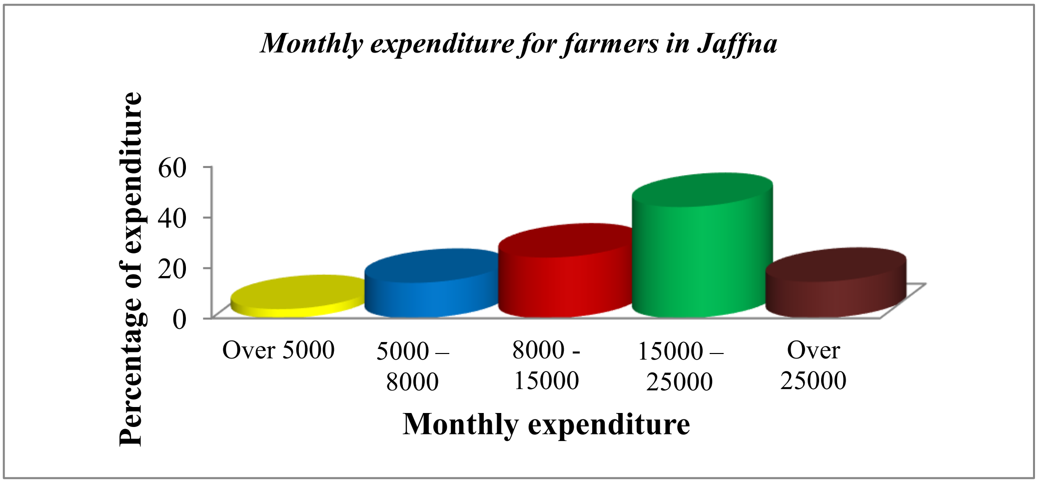


Figure 15-Monthly Income for Farmers in Jaffna

Source: Field Survey

Figure 15 shows the monthly income of the farmers. The highest range of monthly income is 8000 – 15000. Only a limited number of farmers get 20000 as their monthly income.

Figure 16-Monthly expenditure for farmers in Jaffna



Source: Field Survey

The figure 16 shows the farmer's monthly expense. The monthly expense varies from 15,000 to 25,000rs. Only 3.6% farmers spend below 5000.

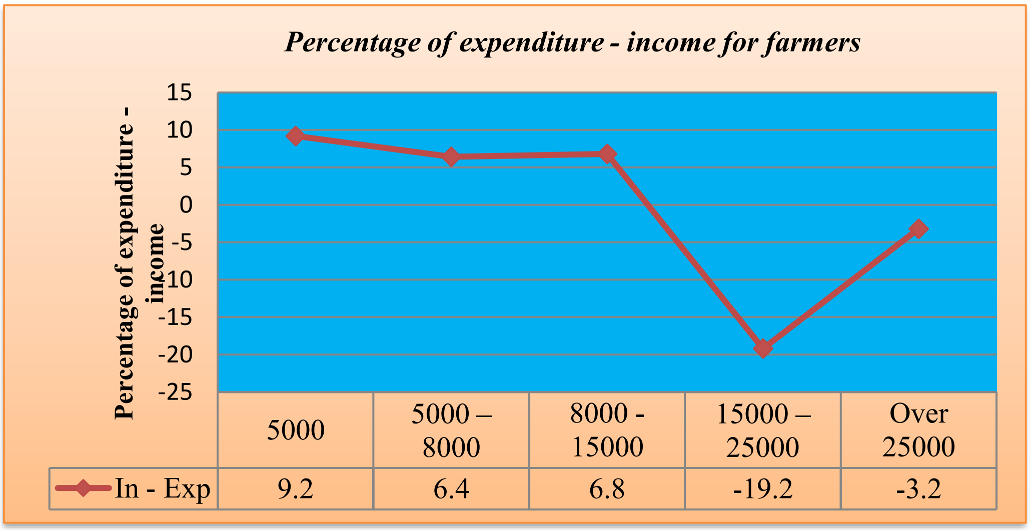


Figure 17-Monthly expenditure for farmers in Jaffna

Source: Field Survey

Above figure 17 explains that lower-income farmers (below rs15,000/month) are spending more than they earn, indicating financial stress. Farmers earning

Rs.15,000–25,000 show the best financial health with a significant surplus. High-income farmers also have a surplus, but smaller. Financial stability improves notably with higher income.

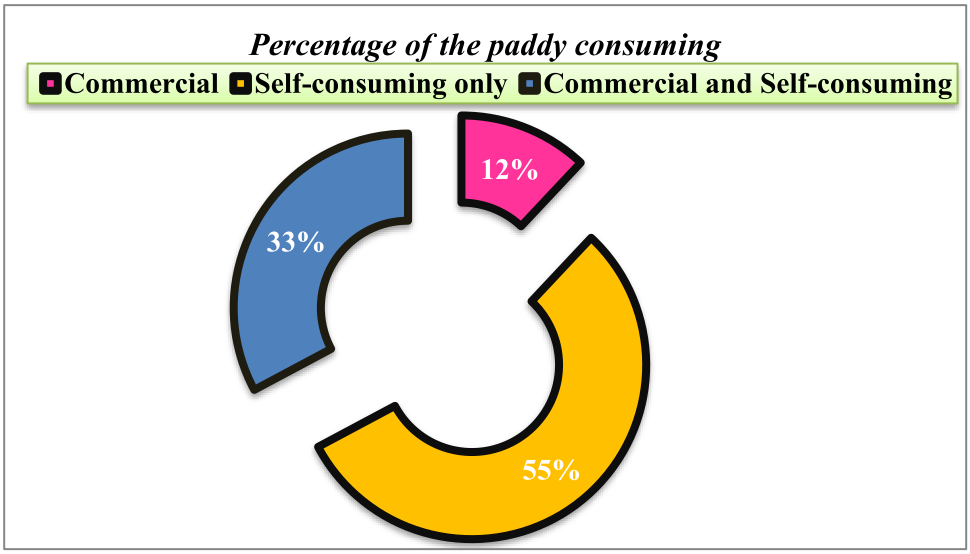


Figure 18 - Percentage of the paddy consuming
Source: Field Survey

The figure 18 shows the purpose of engaging in agricultural activities of paddy. There are 2 main purposes – self-consuming and commercial. Most of them have the idea of satisfying their self- consuming need. Only 12% of farmers perform agricultural activities for Commercial purposes. And 33% of farmers have both needs in their mind.

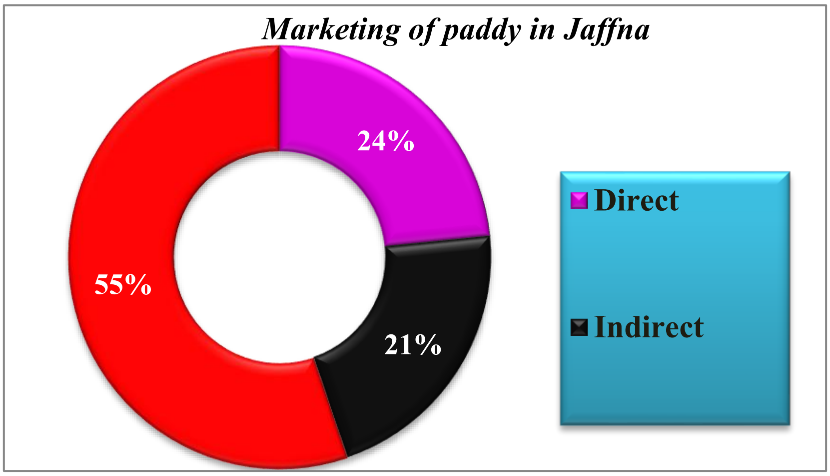


Figure 19-Marketing of paddy in Jaffna

Source: Field Survey

The figure 19 shows the paddy marketing. 24% of farmers in Jaffna district market their product directly. And 21% use indirect ways to market their product. In addition, the remaining percentage of people wants to satisfy their own needs. So, they don't have any idea of marketing their product.

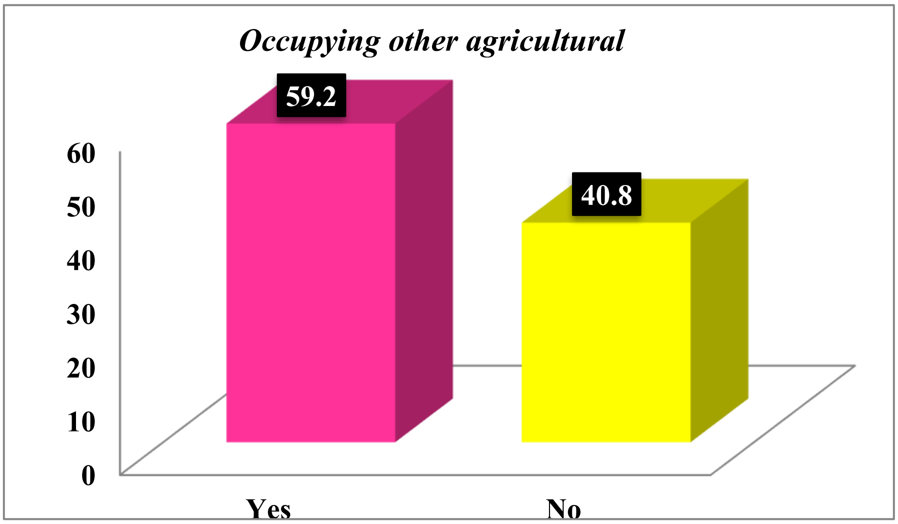


Figure 20-Occupying in other agricultural activities
Source: Field Survey

Figure 20 shows the other agricultural activities besides paddy cultivation during the off season. 59.2% farmers involve in other cultivations during the off season. Such as: onion, chilli, tobacco, and vegetables during off season. The remaining percentage of farmers engage only in paddy cultivation during on season (Maha).

Getting financial support or loans, fertilizer.

Figure 21 shows the government provides loan and fertilizer facilities to encourage the cultivation. Only 72% of farmers get these facilities. The remaining percentage of farmers mentioned that they could not get the facilities.

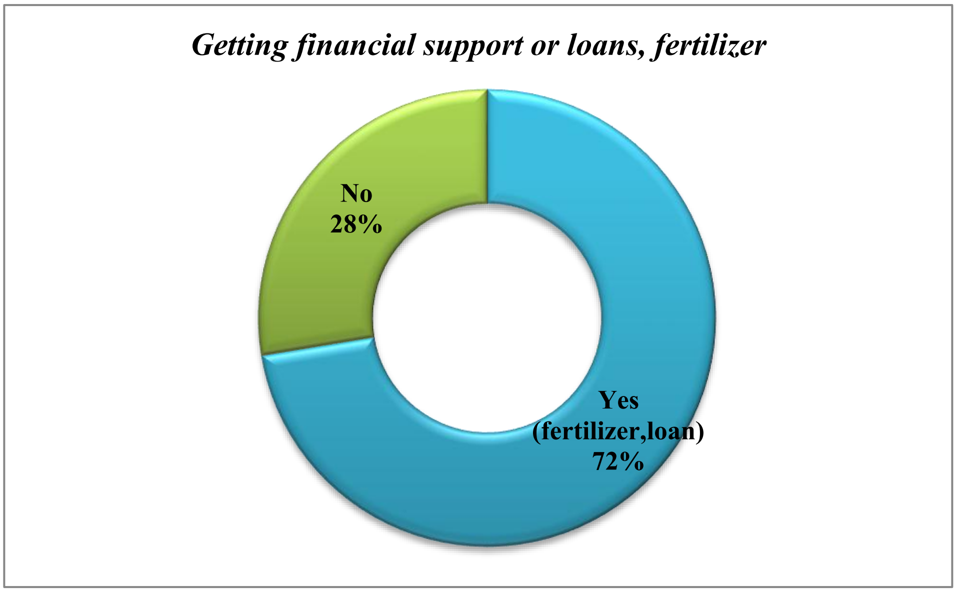


Figure 21-Getting financial support or loans, fertilizer
Source: Field Survey

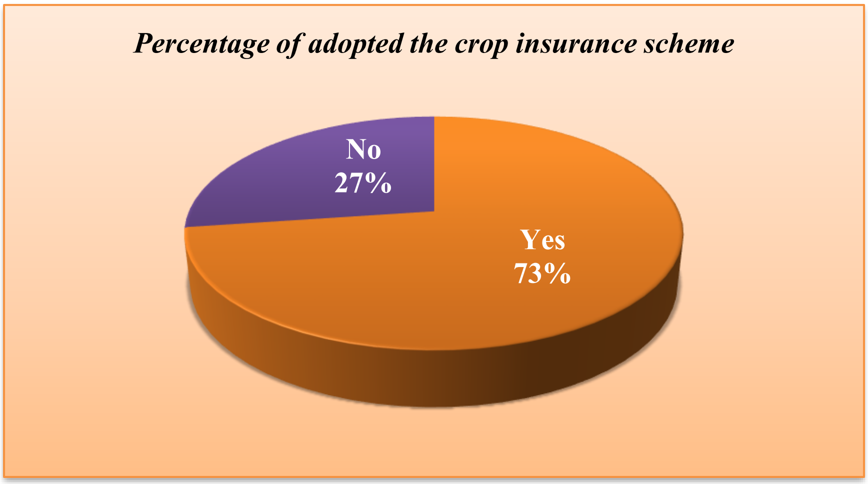


Figure 22-Percentage of farmers who had adopted the crop insurance scheme
Source: Field Survey

Figure 22 shows the number of farmers who are benefited from paddy insurance scheme. Only 73% of farmers adopt this scheme.

Knowledge on weather forecasting.

Figure 23 presents responses to the question regarding farmers' knowledge of weather forecasting to protect their crops from drought impacts. Only 52% of the farmers reported being aware of weather forecasting, and most of them were traditional farmers.

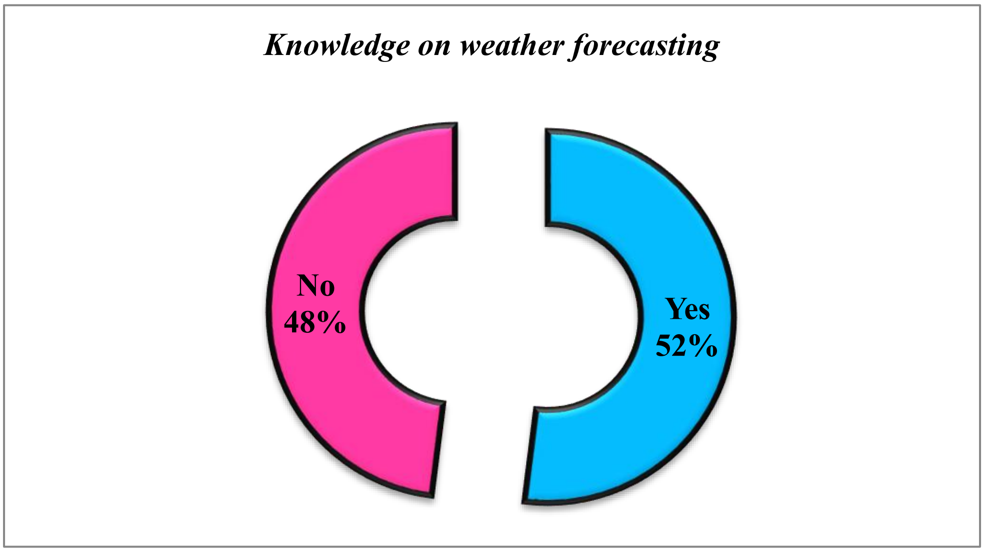


Figure 23-Knowledge on weather forecasting

Source: Field Survey

Overall, the analysis reveals that drought vulnerability in the Jaffna District is determined not only by climatic variability but also by underlying socio-economic factors. Divisions with lower income levels, limited educational attainment, and inadequate infrastructure such as Kayts and Velanai exhibit higher levels of vulnerability. In contrast, divisions with stronger socio-economic development, such as Chavakachcheri and Kopay, demonstrate greater adaptive capacity to withstand drought impacts. Findings from the farmers' questionnaire further reinforce this pattern, indicating that communities with high poverty rates, poor irrigation access, and limited agricultural support experience the most severe crop losses during drought events. These results highlight that disparities in income, education, water access, and institutional support collectively shape the spatial distribution of drought vulnerability across the district, emphasizing the need for targeted socio-economic interventions to strengthen resilience in the most affected areas.

5. Conclusion

The study reveals that drought vulnerability in Jaffna District varies spatially and is closely linked with socio-economic development. Divisions with lower income, limited education, and poor infrastructure such as Kayts and Velanai show higher vulnerability, while areas with better socio-economic conditions, like Chavakachcheri, experience lower vulnerability.

Recently, all DS divisions experienced drought. As per the crop yield sensitivity indices, among the various divisions, Kayts Division is the most sensitive, experiencing severe crop failures due to reliance on rain-fed agriculture and saline drinking water. Vadamarachchi North ranks as the second most sensitive, while Uduvil and Nallur are the least sensitive divisions, reflecting a stronger capacity to withstand drought impacts.

Nallur and Vadamarachchi East show the lowest adaptive capacity, while Velanai also ranks low. Chavakachcheri has the highest capacity to recover from drought, whereas Chankanai, Tellippalai, and Kopay show moderate levels. Kayts, Delft, and Sandilipay divisions demonstrate high adaptive capacity.

Overall vulnerability analysis shows that Kayts DS Division is highly drought-prone due to very high sensitivity, very high exposure, and low adaptive capacity. Velanai, Nallur, Chankanai, Uduvil, and Vadamarachchi East are also highly vulnerable. Chavakachcheri has very low vulnerability, supported by high farmer knowledge, better education, and higher income levels.

According to the analysis of the crop drought vulnerability, Kayts Division has very high crop drought vulnerability due to extensive crop failures from meteorological drought and reliance on rain-fed agriculture. Vadamarachchi North is highly vulnerable, six DS divisions are moderately vulnerable, while Chavakachcheri and Uduvil have the lowest vulnerability.

Questionnaire findings further support these results, revealing that the Kayts and Velanai Divisions are the most affected by drought. Rainfall scarcity is the main contributing factor, as these areas lack irrigation facilities and most wells contain saline water. In addition, a majority of farmers live below the poverty line and have limited educational attainment. Therefore, these divisions are the most vulnerable to crop yield loss due to drought. Chavakacheri is the place where paddy is grown to vast extent than other DS divisions in Jaffna district. Last year, half percentage of land area was destroyed due to drought. Nearly 75% of land in the whole DS division was destroyed. 90% of land was affected in Tellipalai, Karaveddi, Vadamarachchi east, Kayts, and Nallur DS divisions. Most of the farmers engage paddy cultivation traditionally in Jaffna DS divisions. They said that

insufficient rainfall is the main cause for drought. In addition, untimely rainfall is also another main cause. Jaffna district doesn’t have any major irrigation supply except rainfall. In Jaffna farmers totally depend on rainfall for their paddy cultivation. However, due to changing weather pattern farmers have to depend on other water sources to irrigate paddy cultivation. Therefore, drought issues are continuing up to now.

6. Recommendation

Nowadays continuing seasonal changes in Sri Lanka affects agricultural production. Particularly, lots of crop losses occur due to drought and it makes the vulnerable to issue farmers. The frequently changing crop yield trend suddenly decreases the farmer's income level. Therefore, they became poor. The following recommendations are considered to decrease the effects of drought.

- Introduction of paddy varieties that give benefits within short time period and provide information about their benefits. Short-duration and drought-tolerant paddy varieties can help farmers cope with irregular rainfall. Currently, new paddy varieties that mature within two to three and a half months are available in Sri Lanka, but most farmers in the Jaffna District are unaware of them. Therefore, awareness programs should be conducted to inform farmers about their benefits. In India and the Philippines, for example, the introduction of early-maturing varieties such as Sahbhagi Dhan and IR64 has improved crop productivity in drought-prone regions. These varieties could be introduced and distributed free of charge to poor farmers in Jaffna to enhance drought resilience. (IRRI -International Rice Research Institute, 2019) Traditional paddy varieties like Mottaikarupan, Aattakkari, Pachchaiperumal, Periyavellai, and Morunkan have the power to bear drought. So, farmers should be advised to grow them during the period of insufficient rainfall or untimely rainfall.
- Introducing drought-tolerant rice varieties, including traditional types such as Mottaikarupan, Pachchaiperumal, and Periyavellai, which are naturally resistant to drought and can be reintroduced through local seed banks, as practiced in Thailand and India. Modern improved varieties like at 362 and Bg 250 can also enhance yield stability under water-scarce conditions. (Jearakongman, S., et al. (2015), Atlin, G. N., Lafitte, H. R., & Fukai, S. (2017)
- Reconstruction of ruined ponds and canals can help farmers irrigate their crops, thereby reducing drought-related crop losses. In countries such as India and Nepal, the restoration of small-scale water bodies and check dams has significantly improved water availability for agriculture. (Pant, D. R., & Bhattarai, M, 2013), Central Water Commission – India, 2015) Implementing similar initiatives in Jaffna could help minimize crop losses during drought periods.
- Most of the farmers in Jaffna district live below poverty level. Therefore, they are not able to recover from their loss immediately. In addition, they have to spend lot of money for purchasing their fertilizer. And they are unwilling to get loans due to the high interest

rate. So, steps should be taken by concerned farmers' associations to provide loans with less interest. It helps the farmers extensively. steps should also be taken to reduce the price of fertilizer.

- Most farmers in Jaffna still depend on traditional cultivation methods, which make them more vulnerable to drought. Awareness programs and extension services should promote improved land preparation techniques, seed treatment, and short-term paddy varieties suitable for dry conditions. Farmer field schools, such as those implemented in Vietnam and Indonesia, have proven effective in increasing farmers' adaptive capacity to climate change.
- Educational qualification and knowledge of farmers should be taken into consideration. Each year before starting their paddy cultivation, farmers should be informed to participate in seminar, workshops and training. Department of Agriculture must have connection with farming associations.
- The farmers who meet crop devastation continually should get compensation for their lost and action should be taken to encourage farmers who hesitate to continue their agricultural activities.
- Farmers whose main idea of farming is self – consuming, should be encouraged to involve in farming for commercial purposes. They must be informed that they could earn more income from commercial farming. In addition, they should be informed that they can get profit easily from this way.
- Encourage the farmers with the help of agricultural organizations to cultivate the other crops in other season particularly Yala seasons. And also, untimely rainfall seasons are suitable for the other cultivation crops based on the irrigations. For example: vegetable crops. So, if motivated, the farmers have more possibility to earn.
- Insurance facilities should be arranged to all affected paddy farmers with the contribution of the government. Weather-indexed crop insurance models in India, Kenya, and Ethiopia have provided financial stability to farmers facing climatic risks.
- Most farmers believe they do not earn even half of what they spend on crop cultivation, which reduces their interest in agriculture. Many continue farming only because it is their traditional livelihood. They spend large amounts of money on ploughing, levelling, bund making, seed preparation, transplanting, fertilizers, pesticides, weeding, irrigation, and harvesting among which fertilizer and pesticide costs are the highest. If the government addresses these issues and provides better support, farmers will benefit will and their attitudes toward farming will improve.

- Weather changes occur frequently. Farmers should be educated to interpret weather forecasts and plan their cultivation accordingly. In countries like Australia and the United States, agricultural extension programs provide seasonal climate forecasts that help farmers make timely decisions. Introducing such services in Jaffna would reduce uncertainty and crop risk.
- Most of the paddy lands are used for other purposes. For example: building needs for housing and business and other development activities. So relevant authority should take legal action.
- When agricultural production is increased, more labourers are needed to perform the work. Facilities should be provided for marketing the products in local and outside markets. It will give economic benefits to farmers.
- The mostly affected region in Jaffna district is the islands. People in this area are unable to get water even for drinking purpose. In addition, drought also affect their lives. So, action should be taken to solve their drinking water problems.
- Drought forecasting should be done by using appropriate technology.

  The use of modern technologies such as remote sensing and GIS should be expanded for drought forecasting and monitoring. Successful examples include the U.S. Drought Monitor and India's National Agricultural Drought Assessment and Monitoring System (NADAMS). (WMO-World Meteorological Organization, 2020). Establishing a similar system in Jaffna would help in early warning and proactive drought management.

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