DISASTER VULNERABILITY TO AGRICULTURE IN SELECTED COASTAL ECOSYSTEM OF TAMILNADU

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DISASTER VULNERABILITY TO AGRICULTURE IN SELECTED COASTAL ECOSYSTEM OF TAMILNADU

Thesis submitted in partial fulfillment of the requirements for the award of the degree of
DOCTOR OF PHILOSOPHY in AGRICULTURAL ECONOMICS *to the*
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CERTIFICATE

This is to certify that the thesis entitled "**DISASTER VULNERABILITY TO AGRICULTURE IN SELECTED COASTAL ECOSYSTEM OF TAMILNADU"** submitted in partial fulfilment of the requirement for the degree of **DOCTOR OF PHILOSOPHY IN AGRICULTURAL ECONOMICS** to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out **by Mrs. S. USHA NANDHINI** under my supervision and guidance and that no part of this project has been submitted for the award of any other degree, diploma, fellowship or other similar titles. However, part of thesis work has been published in peer reviewed scientific journal of national/international repute (copy enclosed).

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CHAPTER I

INTRODUCTION

The ecosystems act as productive engines of the planet and people at large depend on them for their livelihood. Among many possible viz., Agro ecosystem, Coastal ecosystem, Forest ecosystem, Freshwater ecosystem, Grassland ecosystem, the Coastal ecosystem differs widely from rest. World's coastal length covers an area of 356,000km, its area accounted for 70 percent of the earth's surface and almost two thirds of the world's population live within 400 km of the ocean shoreline (Hinrichsen 2007).

Though the coastal ecosystem provides plenty of goods and services to the society, occurrences of sea related natural disasters like cyclone, super cyclone, Tsunami, hurricane etc., are very common around the world which affects the economy. Agriculture dependent rural coastal regions in particular are mostly affected by these events to a larger extent. For example, recent disasters like Solomon Islands earthquake and tsunami (February 2013/14), Sichuan, China earthquake , Southern Africa drought, Uttarakhand, India, Floods, Colorado, U.S.., Floods, Southern Asia Floods (U.S, World Vision, 2013) caused serious damages to irrigation and drainage facilities, agricultural infrastructure and standing crops as well as marketing facilities resulting in considerable loss of lives and destructing capital.

Natural disasters

Disasters are highly disruptive events that cause suffering, deprivation, hardship, injury and even death, as a result of direct injury, disease, the interruption of commerce and business, and the partial or total destruction of critical infrastructure such as homes, hospitals, buildings, roads, bridges, power lines, etc. Natural disasters include hydro-meteorological disasters and geophysical disasters (world disaster report, 2003).

Hydro-meteorological disasters includes landslides/avalanches, droughts/ famines; extreme temperatures and heat waves, floods, hurricanes; forest /scrub fires; wind storms and other insect infestations. Geophysical disasters includes earthquakes and volcanic eruptions.

According to UNDP (2004), More than 7,000 major disasters have been recorded since 1970, causing at least $2 trillion in damage, killing at least 2.5 million people, and adversely affecting societies. And about 75 per cent of the world's population lives in areas affected at least once by natural disaster between 1980 and 2000. It was also reported by UN (2008) that the frequency and economic impacts of natural disasters have been increasing in recent years. According to centre for Research on the Epidemiology of Disasters (2012) report across the globe there were 310 natural disasters, 9930 deaths related to natural disasters; 106 million people victimized by natural disasters; 115 countries were affected by disasters; and $180 billion in damages.

Natural disaster in India

The Indian coastline stretches about 5700 km on the mainland and about 7500 km including the two island territories and exhibits most of the known geomorphological features of coastal zones. India has been identified as one amongst 27 countries which are most vulnerable to the impacts of global warming related accelerated sea level rise (UNEP, 1989).

Many of the natural disasters in India are related with climate of India and they causes massive damage to life and property. Indian sub-continent is the worst affected region of the world, having a coast line of 7516 kms (5400 kms along the mainland, 132 kms in Lakshadweep and 1900 kms in Andaman and Nicobar Islands) is exposed to nearly 10 per cent of the world's Tropical Cyclones (NCRMP,2014).

Every year, flooding and cyclone in India affects Tamil Nadu and other Indian states of Assam, Bihar, West Bengal, Gujarat, Orissa, Uttaranchal, and Maharashtra.

Disaster in Tamil Nadu

Tamil Nadu, the southernmost state of the Indian peninsula , is spread over 130,058 km^2; it lies between 8° 5" to 13° 35" N and 76° 15" to 80° 20" E, accounts for about 4 per cent of the total area of the country. The coastline of Tamil Nadu has a length of about 1076 km which accounts for about 15 per cent of the total coastal length of India and stretches along the Bay of Bengal, Indian Ocean and Arabian Sea. The Tamil Nadu coast is straight and narrow without many indentations except at Vedaranyam.

The geographical setting of Tamil Nadu makes the state vulnerable to natural disasters such as cyclones, floods and earthquake-induced tsunami. About eight per cent of the state is affected by five to six cyclones every year, of which two to three are severe (Mascarenhas & Jayakumar 2007). Cyclonic activities on the east coast are more severe than on the west coast, and occur mainly between April-May and October-November.

Indian Ocean tsunami during 2004 affected the coast of Tamil Nadu destroying much of the marine biology and severely damaging the ecosystem (Government of Tamil Nadu, 2009). Crops, settlements, trees, birds, fishes, wildlife, and properties were destroyed. Precious coral reefs and mangrove areas were crushed by the huge tsunami waves that devastated South India. Power and communications were totally disrupted. The damage to humans, especially women and children, and animal life, was tremendous, resulting in emotional and mental trauma (Kumar *et al.*, 2007).

Problem focus

Agricultural production is highly prone to natural disasters, and substantial parts of the population which are rural farmers depend on agriculture for their livelihood are mostly affected. Occurrence of natural disasters such as floods, droughts and cyclone have led to crop failure, famine, loss of property, mass migration and negative economic growth, and this in turn affects the household income of the rural farmers that depend on agriculture as their means of livelihood.

In India, out of 35 states and union territories in the country, 27 are prone to different disasters. Among 27 states TamilNadu is prone to multi hazard, higher than other states and is frequented by the hazards of various nature and different intensities.

Coastal districts of Tamil Nadu

There are 13 coastal districts in Tamil Nadu,i.e.Chennai,Thiruvallur, Kancheepuram, Villupuram, Cuddalore, Nagapattinam,Thiruvarur,Thanjavur, Pudukkottai, Ramanathapuram, Thoothukudi, Thirunelveli and Kanyakumari of which the most ecologically sensitive districts are Nagapattinam, Cuddalore, Ramanathapuram and Thiruvallore. Among these Nagapattinam is severely affected by natural disasters.

Natural disasters in Nagapattinam district

The study attempts to explore how the farmers of coastal areas of Nagapattinam respond to disaster events. The coastal agricultural communities of Nagapattinam have faced a number of disasters (Cyclone, flood and drought) over a period of time resulting in, reduced or total loss of production from the particular season, and reduced productivity of land due to salinization (during cyclone and floods) or lack of irrigation (during droughts). It has been found from the district profile of Nagapattinam (2011) that in last 20 years the area has suffered from 5 floods and 6 droughts. More than that, the Cauvery delta region of the district is known for occurrence of floods and droughts in the same year. Chandra Mohan (2005) reviewed that the cyclonic storm brings havoc normally once in 3 or 4 years and heavy downpour during Northeast monsoon leads to flooding of the district and damages field crops and wealth of soil.

Indian Meteorological Department, Chennai reported that during the period 1891 and 2000, nearly 26 per cent of cyclones that formed in the Bay of Bengal struck the coast of Tamil Nadu; of which 55 severe cyclones crossed the Nagapattinam region, mostly during the months of October and November. In addition to frequent cyclones, mid-season drought, floods, and water logging due to the flat topography, and improper/disturbed drainage systems, made the region more vulnerable. The soil resources in this region show fluctuating characteristics of soluble salt concentration and soil pH (P. Thamizoli et.al, 2006).

The extreme weather-events of cyclone, flood and drought that strike in the coastal regions of Nagapattinam often become disastrous for the large number of poor people who are mainly dependent on climate related livelihoods like agriculture. For example the district was severely affected recently by Neelam cyclone where the flood water totally inundated 51,486 hectares of directly sown farmland and 13,421 hectares of transplanted farmland; and partially submerged 4,404 hectares of directly sown area and 12,189 hectares of transplanted area. During the storm, 3,150 people were evacuated and kept in cyclone shelters (Ramakrishnan, 2012).

The impact of cyclone, flood and drought disasters on agriculture in Nagapattinam district has become a subject of increasing importance recently and this study would help in identifying the effect of cyclone, flood and drought disasters and its vulnerability on agriculture in Nagapattinam district.

Objectives of the study

1. To identify the frequency and impacts of natural disasters that affect the coastal farmers
2. To evaluate and quantify the socio-economic effects of disasters on the coastal farmers and
3. To assess the vulnerability of coastal farmers to natural disasters and to identify policy options to strengthen their adaptive capacity

Hypothesis of the study

1. There is significant difference between the levels of income earned by the farmers' before and after the occurrence of cyclone, flood and drought disasters.
2. Farmers adopt different practices to cope up disaster conditions.

Scope of the study

This study focuses on three prominent climate extremes that Nagapattinam is repeatedly affected by – namely, droughts, floods and cyclonic storms.The study would also concentrate on socio-economic effects of disasters on the coastal farmers. The result would be useful for researchers and policy makers in development of future plans for adopting new technology to help coastal farmers to overcome the disaster events. Also the study explores current knowledge regarding factors that can increase a region's vulnerability to disaster; and assesses how disaster mitigation and reduction might best be achieved through sound agricultural development and environmental practices. The purpose of this study also is to examine how natural disasters such as cyclone, flood and drought affect agricultural livelihoods and the implications of these natural disasters upon the coastal farmers in the agricultural sector.

Limitation of the study

The study was based on primary data collected through personal interview from the respondent farm families. The data were collected from the respondents individually based on the objectives mentioned. No records were maintained by farmers about their cropping pattern, yield, cost, returns, family expenditure etc. and the data were provided orally from their memory. However, cross checks were made to collect the correct information from the respondents. Survey conducted in three blocks of Nagapattinam district covers only 180 farmers. The findings of the study are relevant to the coastal area and hence generalisation for other coastal regions need due care.

Organization of Thesis

Chapter I: Introduction, problem focus, hypothesis, objectives, scope and limitation of the study are presented.

Chapter II: Concepts used in the study and brief review of the past work done are discussed.

Chapter III: The methodology and analytical techniques used in the study are presented.

Chapter IV: A brief profile of the study area is presented.

Chapter V: The results and findings of the study area are discussed.

Chapter VI: **Summary and conclusions:** Brief summary of the findings, conclusions and policy implications.

CHAPTER II

CONCEPTS AND REVIEW

Review of the past literature provides a detailed review, discussion on published work that contributes for the present study. It also helps in conceptualization, formulation of hypothesis and choice of tools for analysis to get a meaningful conclusion. With this in view, brief review of past studies and concepts relevant to the present study are presented in this chapter.

Review of concepts and past studies

- Natural Disaster
- Vulnerability to disaster events
- Impact of natural disaster
- Impact of flood disaster
- Impact of cyclone disaster
- Impact of drought disaster
- Disaster vulnerability impact on Agriculture
- Adoption of technologies
- Crop Insurance
- Cost concepts

Natural disaster

UNISDR (2004) defines Natural disasters as a serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the capacity of the affected society to cope using only its own resources.

World Health Organisation (WHO) defines disasters as “any occurrence that causes damage, ecological disruption, loss of human life, deterioration of health and health services on a scale sufficient to warrant an extraordinary response from outside the affected community or area. They are classified as “natural” disasters, or “human-made” disasters. For example, disasters caused by floods, droughts, tidal waves, earth tremors, land-slides are generally considered as “natural disasters.” Disasters caused by chemical, transportation or industrial accidents, environmental pollution, political unrest, conflicts between nations, terrorist activities and fires are classified as "man-made" disasters

According to the Centre for Research on the Epidemiology of Disasters (CRED 2010), generally, a disaster is defined as an unforeseen event that causes great damage, destruction and human suffering, which overwhelms local capacity, necessitating a national or international level assistance.

Summary of the above definitions

In general natural disasters are the event that occurs naturally that may cause loss of life, injury or other health impacts, property damage, loss of livelihood and services. Natural disasters includes earthquakes, tremors, volcanic eruptions, Landslides, mudslides, Tsunamis, Hurricanes, Droughts, Floods, Wildfires and Tornadoes.

Natural disasters identified for the present study

Natural disasters identified for the present study are cyclone, flood and drought. These natural disasters have negative economic and environmental impacts on the affected areas and the people who live there.

Vulnerability to disaster events

Definition

Blaikie *et al*., (1994) defined vulnerability as the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of natural hazards and states that vulnerability can be viewed along a continuum from resilience to susceptibility.

Watson *et al.*, (1996) defined vulnerability as the extent to which climate change may damage or harm a system, depending not only on a system's sensitivity but also on its ability to adapt to new climatic conditions.

Adger (1999) defined vulnerability as extent to which a natural or social system is susceptible to sustaining damage from climate change. It is generally perceived to be a function of two components. The effect that an event may have on humans, referred to as capacity or social vulnerability and the risk that such an event may occur, often referred to as exposure

Kasperson *et al*., (2000) defined vulnerability as the degree to which an exposure unit is susceptible to harm due to exposure to a perturbation or stress and the ability or lack of the exposure unit to cope, recover or fundamentally adapt to become a new system or to become extinct.

McCarthy et al., (2001) defined vulnerability as "a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity".

IPCC (2007) defined vulnerability as the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation

Review of past studies

Adger and Winkels (2007) pointed out in his study that the ultimate impact of a natural disaster on a household depends on the household's vulnerability to its effects. In the literature on vulnerability, it is often conceptualized as a function of three elements, i.e., exposure, sensitivity, and adaptive capacity.

According to Deressa *et al.*, (2008) the socio-economic vulnerability assessment approach focuses on the socioeconomic and political status of individuals or social groups. The characteristics of the individuals in a community often vary in terms of education, gender, wealth, health status, access to credit, access to information and technology, formal and informal (social) capital, political power, and so on, which are responsible for the variations in vulnerability levels .

Mansuri and Healy (2002) studied the vulnerability prediction in rural Pakistan and mentioned vulnerability as the probability that a household will experience a future period of poverty. It takes into consideration permanent and changing household characteristics.

Sharma and Patwardhan's (2007) analysis was on similar lines as Patwardhan et al. (2003) with the exception that they ranked the coastal districts by addressing the hazard, exposure and impact (human death) parameters, ignoring adaptive capacity and developed only five different indices of the three components. They found Jagatsinghpur and Kendrapada districts of Orissa and Krishna district of Andhra Pradesh to be the most vulnerable ones.

O'Brien and Mileti (1992) examined the vulnerability to climate change and stated that in addition to economic well-being and stability, being important in the resilience of population to environmental shocks, the structure and health of the population may play a key role in determining vulnerability. Age is an important consideration as the elderly and young persons are tends to be inherently more susceptible to environmental risk and hazard exposure. Generally populations with low dependency ratio and in good health are likely to have the widest coping ranges and thus be least vulnerable in the face of hazard exposure.

Summary of reviews

Review of the above concepts indicates that the vulnerability is a function of Sensitivity, Exposure and Adaptive Capacity. Socio-economic vulnerability assessment approach had been used in assessing the vulnerability of individuals or social groups. The coastal districts were also ranked by addressing the hazard, exposure and impact (human death) parameters, ignoring adaptive capacity

Identification of model and variables

From the above concepts socio-economic vulnerability assessment approach was taken for the present study and vulnerability index in the present study uses the three major components of Adaptive capacity, sensitivity and exposure to analyse the vulnerability of farm households to disaster variability.

Impact of natural disaster

Prater & Lindell, (2000) defined impact as the number of affected social units (e.g., individuals, households, and businesses). The probability of occurrence (per unit of time) is another important characteristic that affects disaster impacts indirectly because more probable hazards are likely to mobilize communities to engage in hazard mitigation and emergency preparedness measures to reduce their vulnerability.

Mileti (1999) defined the impact of natural disaster as the contributing factor to casualties with pre-existing health conditions. Moreover, some casualties are indirect consequences of the hazard agent as, for example, with casualties caused by structural fires following earthquakes e.g., burns and destruction of infrastructure e.g. illnesses from contaminated water supplies. Losses of structures, animals, and crops also are important measures of physical impacts, and these are rising exponentially in the United States.

Review of past studies

It has been predicted by the World Meteorological Organization, Geneva (2011) that globally 100, 000 lives will be lost each year to natural disasters and the global cost could top $ 300 billion annually.

According to UN (2008) on an average, 78 disasters per year had occurred during the 1970s. This number grew to 351 per year during 2000 and 2006. Meanwhile, the average number of people killed in any single disaster has been declining, making the total number of casualties per year from disasters fairly constant. Oh and Reuveny (2010) in their study interpreted over the last decades there is an increased amount of observed natural disasters, from 30 per year in 1950, to more than 400 in 2000. The amount people affected increased from 25 million to about 300 million in 2000.

Cavallo *et al*., (2010) found that only extremely large disasters have a negative effect on output both in the short and long term. They asserted that, on average, natural disasters have a negative impact on short-term economic growth.

The World Bank Development Report (2000/2001) analysed that the damages from natural disasters across all countries averaged over $60 billion (US) a year with 50,000 lives lost, between 1988 and 1997. These direct losses, while staggering, still do not accurately depict the economic impact of such disasters, especially in developing countries.

Summary of the above concepts

The impact of natural disaster were found to be very severe globally and their effect was found to be terrific over 1950 and 2000. Apart from the human loss the economic loss was about $60 billion (US) a year all over the countries. The above concepts also reveals that extremely large disasters have a negative effect on economic growth.

Impact of flood disaster

According to Nott (2006:57) floods are the most costly and wide reaching of all natural hazards. They are responsible for up to 50,000 deaths and adversely affect some 75 million people on average worldwide every year. Disease outbreak is common especially in less developed countries. Malaria and Typhoid outbreaks after floods in tropical countries are also common. It has been estimated that in India and Bangladesh 300 million people live in areas that are affected by floods.

Crossman *et al*., (2006:41) pointed out that in the UK; flood risk represents a significant threat to many communities. Around 1.8 million households and 140,000 commercial properties in England and Wales are located in floodplain areas, affecting at least 4-5 million people. They further point out that a range of flood risk management activities are undertaken by operating authorities. These include emergency planning, awareness raising, provision of flood warning and creation of flood storage areas as well as the construction and maintenance of both conventional and innovative flood defences.

Zahiran, *et al*., (2008:537) observed that floods are the most lethal kind of hydro-meteorological disasters in the United Sates. According to data from the Spatial Hazard Events and Losses .Database for the United States (SHELDUS), floods claimed the lives of 2,353 people from 19702000. Over this period, fewer people were killed by hurricanes, tropical storms and tornados combined.

Brouwer et al., 2007:324) carried a study in 2005 in Southeast Bangladesh confirms the positive relationship between environmental risk, poverty and vulnerability. Poorer segments of society live closer to the river and therefore face a higher risk of flooding and are thus more vulnerable. Environmental risk exposure also goes hand in hand with income inequality and access to natural resources. Families living nearer to the river seem to have fewer opportunities to engage in multiple economic activities which make them more vulnerable to natural disasters and may keep them trapped in a poverty cycle.

Ninno *et al*., (2003:1221) stated that the 1998 floods in Bangladesh caused severe damage to the rice crop and threatened the food security of tens of millions of households. Government food transfers to the affected people helped limit the impact of the flood on household access to food. The flood led to major crop losses, losses of other assets and lower employment opportunities and thus affected household income as well as market prices

According to World Bank (2012) in 2010 and recently in 2011, an intense rainfall has resulted in the worst floods in half a century. The 2011 flood affected 13.6 million people, 65 provinces and over 20,000 km^2 of farmland. The estimated economic damages and losses equals to US$45.7 billion. The impacts of these natural disasters pose significant risks and burden to the development and the environment of the country and can seriously harm the local economy.

UN (2010) In July-August 2010, Pakistan experienced “the worst floods in its history. The floods have affected 84 districts out of a total 121 districts in Pakistan, and more than 20 million people — one-tenth of Pakistan’s population. More than 1,700 men, women and children have lost their lives, and at least 1.8 million homes have been damaged or destroyed”.

Impact of cyclone disaster

Das (2007) reported Indian coastal areas face maximum threats from tropical cyclones and associated storm surges compared to other climatic extreme events. Of the 65 coastal districts of the country, 24 are highly cyclone prone and Kendrapada district of Orissa is ranked as one of the top most cyclones-prone districts and is either the most vulnerable or the second most vulnerable district of India.

Climate Change Cell (2007) in their report mentioned that during 1990 to 2007, Bangladesh faced several deadly cyclones, causing death of 150,000 people and displacing millions. Kunreuther (2001), stated that in 1999 alone, approximately $100 billion (US) in losses and over 105,000 deaths were caused by natural catastrophes and man-made disasters, with approximately two thirds of these losses and 95 per cent of deaths borne by developing countries.

Kumar and Tholkappian (2005) in his report stated that the eastern states/districts in India are more adversely affected by the cyclonic storms than the western states/districts. Among the eastern states Orissa is most frequently affected by cyclonic storms and is chosen for vulnerability analysis.

Patnaik and Narayanan (2005) in their study pointed out that during the period 1877 to 1990 the frequency of severe storms, storms and depressions was highest in the districts of Puri.

Impact of drought disaster

According to UNDP (2009) Twenty three districts out of thirty districts in Tamil Nadu are drought prone. The primary impacts of drought relate to loss of crop, dairy and livestock production, reduced crop yields, wind and water erosion of soils and increased levels of poverty.

Paul (1998) said that droughts occur in different regions and at varying frequency, some suggest that the definition be region- and impact-specific.

Senbeta (2009) in his study in Ethiopia disclose the fact that drought and delay in the onset of rain led to poor grass regeneration/forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures.

Alabi *et al.,* (2002) in their study found that during the drought of 1972-1973, about 300,000 animals representing 13 per cent of the livestock population of North-Eastern Nigeria were estimated to have died Agricultural yields.

According to Panu & Sharma (2002), there were two main reasons that led to drought and these reason are closely associated with natural events. First, it is the occurrence of below normal precipitation, which is affected by various natural phenomena. Second, a causative factor of droughts is the oceanic circulations, which have average patterns of current and heat storage that affect the weather and climate.

According to Carvajal (2007) in the Human development report, the 2000-2006 period saw that per centage of droughts have had an increasing tendency in Africa and Asia as well as in Europe.

According to Thornton *et al*., (2007), increasing drought leads to the reduction of quality and development capacity of grass and crop-feed also indirectly, effects on feed resources could have significant impact on livestock productivity, ability of the ecosystems for grazing system, prices of stoves and grains, changes in feeding options and grazing management.

Cruz et al., (2007), said that in Asia, with an increase of $1^{0}{}_{C}$ temperature in June and August, farmers used more heat/drought-tolerant crop varieties in areas lacking water, especially in sandy and inland ones

Rathore (2002) denoted that the drought of 2002 was very different since crops could not be sown due to - 51% rainfall deficiency in July, and the procedure of estimating losses by crop cutting was meaningless. The normal practice of the past was waived off and most of the states adopted by unusual approach of declaring drought on the basis of 'eye estimation'.

Disaster vulnerability impact on agriculture

Review of past studies

Loayza, et al. (2009) found that, in contrast to the weak effects on overall GDP growth, droughts and storms have negative impacts on agriculture while floods have a positive effect.

Nyong (2005) reported that farmlands and houses have been washed off by erosion in the Northern and Southern parts of India and these rural farmers have more or less been rendered jobless too because of the effects of these natural disasters causing rural-urban migration.

According to Saldana-Zorrilla (2003) economic vulnerability makes presence through decrease in the income of rural farmers and the agricultural productivity as a whole.

Deressa *et al.,* (2008) worked out the vulnerability indices by applying Principal Component Analysis on the adaptive capacity, sensitivity, and exposure variables.

Dinar *et al*., (1998) measured the impact of disaster events on Indian agriculture and they suggested that climate change would have an overall negative impact on agriculture. A warming scenario of 2^{o}C rise in mean temperature and a 7 per cent increase in mean precipitation levels would create a 12 per cent reduction in net revenues for the country as a whole. Rising temperature is damaging and increasing precipitation is beneficial. These effects would vary by season and region. Coastal and inland regions of Gujarat, Maharashtra and Karnataka were most negatively affected. The high value agricultural regions of Punjab, Haryana, and western Uttar Pradesh showed a small loss. The agriculturally low value, hot and dry districts of Rajasthan and Central India were negatively impacted. However, districts in many eastern states of Andhra Pradesh, Orissa and West Bengal benefited mildly from warning. These regional outcomes were largely caused by initial climate differences between regions.

According to Department of Economics and Statistics (2011), in Tamil Nadu, about 49 per cent of workers depend on agriculture sector for livelihoods. Climate related hazards affecting agricultural sector directly impacts the production as well as livelihood of this huge population involved in agricultural sector

Summary of reviews

Climate change is the major factor for disaster events that affects and have negative impact on agriculture and in income of the rural farmers. In India due to climate change, loss were found to be severe in low value agricultural regions than high value regions.

Identification of variables

Understanding the above concepts, the impact of natural disaster before and after the disaster events on rural households were analysed for the present study and the deviation in income and expenditure of the rural farmers were also analysed.

Adaptation of technology to disaster events

Nhemachena and Hassan (2007) in their study mentioned that common adaptation methods in agriculture include use of new crop varieties and livestock species that are better suited to drier conditions, irrigation, crop diversification, adoption of mixed crop and livestock farming systems, and changing planting dates.

Deressa (2007) in his report mentioned that agriculture is the main sector of the Ethiopian economy. It contributes about 52 per cent of the GDP, generates more than 85 per cent of the foreign exchange earnings, and employs about 80 per cent of the population .Despite its high contribution to the overall economy, this sector is challenged by many factors, of which climate-related disasters like drought and flood (often causing famine), are the major ones. Knowledge of the adaptation methods and factors affecting farmers' choices enhances policies directed toward tackling the challenges that climate change is imposing on Ethiopian farmers.

According to Pryanishnikov and Katarina (2003), the decision on whether or not to adopt a new technology (an adaptation method in this case) is considered under the general framework of utility or profit maximization.

Kurukulasuriya and Mendelsohn (2006b) uses crops and livestocks as methods to adapt to the negative impacts of climate change. They uses multinomial logit model for analysing the choices of adaptation. The advantage of the MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories.

Maddison (2006) found different household and farm characteristics, infrastructure, and institutional factors influence the use of adaptation methods by farmers. The most commonly cited household characteristics include age, education, farming experience, marital status, gender of the head of household, and wealth. Farm characteristics include farm size, fertility, and slope; institutional factors include access to extension and credit; and infrastructure includes distance to input and output markets.

Igoden et al., (1990) stated that there is a positive relationship between the education level of the household head and the adoption of improved technologies. Therefore, farmers with higher levels of education are more likely to adapt better to climate change.

Male-headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households (Asfaw and Admassie 2004). Moreover, Tenge De Graffe and Heller (2004) argue that having a female head of household may have negative effects on the adaptation of soil and water conservation measures, because women may have limited access to information, land, and other resources due to traditional social barriers.

Knowler and Bradshaw (2007) in their study mentioned that farm and nonfarm income and livestock ownership represent wealth. It is regularly hypothesized that the adaptation of agricultural technologies requires sufficient financial wellbeing.

According to Wu and Babcock (1998) the most commonly cited multivariate choice models in unordered choices are multinomial logit (MNL) and multinomial probit (MNP) models. Multivariate choice models have advantages over their counterparts of binomial logit and probit models in two aspects.

Kurukulasuriya and Mendelsohn (2006) employed the multinomial logit model to see if crop choice by farmers is climate sensitive. Similarly Seo and Mendelsohn (2006) used the multinomial logit model to analyze how livestock species choice is climate sensitive.

Summary of reviews

In general, the common adaptation method used were new crop varieties and livestock adoption. Also there exist a positive relationship between levels of education with adoption of improved technologies. To analyse the choices of adaptation of different technologies multinomial logit models were used.

Identification of models and variables

For the present study multinomial logit model were used for analysing the farmer's choice of adaptation of new technologies. Educational status of the household, experience in farming, farm and non-farm income, crop and livestock are variables used.

Farmers perception of adopting technology during disaster events

Ishaya and Abaje (2008) showed that farm experience, which is most often associated with age, plays an important role in the perception of climate change.

Semenza et al. (2008) indicated that individuals with higher income are more likely to know that climate is changing than individuals with low income. Moreover, other factors such as sex, ethnic background, membership in environmental groups, newspaper readers

Maddison (2006) argued that adaptation to climate change is a two-step process, which involves perceiving that climate is changing in the first step, and a second step of responding through adaptation.

William and Stan (2003) employed the Heckman two- step procedure to analyse the factors affecting the awareness and adaptation of new agricultural technologies in the

United States and mentioned the first stage is the analysis of factors affecting the awareness of new agricultural technologies and the second stage is the adaptation of the new technologies.

Yirga (2007) and Kaliba et al. (2000) employed Heckman's selection model to analyse the two-step processes of agricultural technology adaptation and the intensity of agricultural input use.

Identification of variables

Present study adopts the Heckman's selection model to analyse the perception of the framers about the extreme events and the adaptation of new technologies to cope up the disaster situation.

Crop insurance

According to (AIC, 2008) Agricultural Insurance is a means of protecting the agriculturist against financial losses due to uncertainties that may arise agricultural losses arising from named or all unforeseen perils beyond their control. Bhende (2002) mentioned that a properly designed and implemented crop insurance programme will protect the numerous vulnerable small and marginal farmers from hardship, bring in stability in the farm incomes and increase the farm production.

Reddy (2004) mentioned that Comprehensive Crop Insurance Scheme (CCIS) for major crops was introduced in 1985, coinciding with the introduction of the Seventh-Five-year Plan and subsequently replaced by National Agricultural Insurance Scheme (NAIS) with effect from 1999-2000. Agriculture Insurance Company of India Limited (AIC) has been formed by the Government of India to serve the needs of farmers better and to move towards a sustainable actuarial regime. AIC has taken over the implementation of NAIS which until FY03 was implemented by General Insurance Corporation of India.

Review of past studies

A study by Horowitz and Lichtenberg (1993) found that in the US Midwest, crop insurance exerts considerable influence on maize farmers' chemical use decisions. Those purchasing insurance applies significantly more nitrogen per acre (19 %), spend more on pesticides (21 %), and treats more acreage with both herbicides and insecticides (7 % and

63 %) than those not purchasing insurance. These results suggest that both fertilizer and pesticides may be risk-increasing inputs.

Mishra (1994) analysed the impact of a credit-linked Comprehensive Crop Insurance Scheme (CCIS) on crop loans, especially to small farmers in Gujarat. It is observed that CCIS had a collateral effect as reflected through the increased loan amount per borrower and reduction in the proportion of non-borrowers among small farmers. The implications of credit expansion are that increased availability of credit can enhance input use and output and employment that increased share of small farmers in the total loan can have desirable effects on equity and efficiency considerations.

According to Financial Express (2012) the data released by Ministry of agriculture, crop insurance claims worth of Rs.22,135 crore have been settled till now for 4.86 crore farmers mostly from Andhra Pradesh, Gujarat, Rajasthan, Maharashtra, Bihar and Karnataka. With an insurance claim settlement of Rs.4099 crore, Andhra Pradesh tops list of states getting maximum benefit of the scheme followed by Gujarat (Rs.3917 crore), Rajasthan (Rs.2621 crore), Maharashtra (Rs.1873 crore), Bihar (Rs.1794 crore) and Karnataka (Rs.1635 crore).

Raju and Chand (2008) discussed and explored the problems and prospects of agriculture insurance in the country. They also empirically examined the perceptions of the farmers in Andhra Pradesh regarding the Agricultural insurance. Those who availed crop insurance mentioned financial security as the most important factor for getting their crop insured and wanted quick settlement of claims. The non loanee farmers mentioned lack of awareness as the major reason for not availing such insurance.

Mahajan and Bobade (2012) made an attempt to study the growth and development of NAIS and to examine the important features and performance of NAIS. As per the findings, even after the 10 rears of launching the program, there is lack of awareness of farmers about scheme. Further, NAIS is showing deficit on the ground that the premium received is always less than claims under NAIS.

Summary of reviews

Crop insurance is the most important contributing factor during disaster events in India. NAIS plays a major role in extending financial support to the farmers. Though

NAIS plays a major role but the premium received by the farmers were found to be less. In India Andra Pradesh is the state availing maximum financial support than other state.

Identification of variables

Crop loss during the disaster events and the financial support by the NAIS to the affected farmers were analysed in the present study.

Cost concepts

The Commission for Agricultural Cost and Prices (CACP) defined the cost concepts as: Cost A1 = all variable cost on human labour, bullock labour, machine labour, seed, manures, fertilizers and chemicals + depreciation on building, machinery + land revenue, other taxes and interest on working capital. Cost A2 = Cost A1 + Rent paid for leased- in land. Cost B1= Cost A1 + Interest on value of owned capital assets (excluding land), Cost B2 = Cost B1 + Rental value of owned land and rent paid for leased- in land. C1= Cost B1 + Imputed value of family labour, Cost C2 = Cost B2 + Imputed value of family labour, Cost C3 = Cost C2 + 10 per cent of Cost C2.

According to Mauraya et al., (1994), the cost of production included the cost of production inputs like seeds, manures, fertilizers, irrigation, plant production chemicals, human and bullock labour, rental value of land at the prevailing market price and overhead cost comprising of interest on working capital and fixed capital, repairs and depreciation.

In the present study, the cost of cultivation includes both variable costs and fixed costs. The total variable costs include labour costs such as human, animal and machinery usage cost, seed, manures and fertilizer, irrigation, plant protection chemicals and interest on working capital at 12.5 per cent.

Rohit et al., (2006) worked out a gross return by multiplying the total output with price received by farmers and net returns was calculated by deducting the total costs from gross returns.

Ram Singh and Abhey Singh (2008) calculated the gross return based on the actual prices received by the growers. Net returns was obtained by deducting the respective cost from gross returns.

Mathi (2009) calculated net income earned from elephant foot yam production by estimating gross income from yam production, minus cost C_3 by considering value of management input of the farmers as 10 per cent value of the total cost C_2.

In the present study, gross income is calculated by multiplying the total output with the price received by the farmers during the time of harvest is considered for calculating the gross income of the farmers. Net farm income was calculated over the variable cost.

CHAPTER III

DESIGN OF THE STUDY

For a systematic analysis of any economic problem the designing of proper methodology is important. This chapter presents a brief description of the methodology covering the details of the study area, method of sampling, collection of data and tools of analysis.

Choice of the study area

Tamil Nadu state is divided into 32 districts and the coastal length of Tamil Nadu is 1076 km which comprises 12 per cent of the entire coastal stretch of the country. There are 13 districts located along the eastern coast of Tamil Nadu Viz., Chennai, Kancheepuram, Tiruvallur, Villuppuram Cuddalore Nagapattinam, Tiruvarur Thanjavur, Pudukkottai, Ramanathapuram, Thoothukkudi, Tirunelveli and Kanyakumari. Among these coastal districts, the present study focuses on Nagapattinam district of Tamil Nadu which was selected purposively because of the continuous exposure of the district to natural disasters such as cyclone, flood and drought. Fig.3.1 shows the area affected in the district.

Nagapattinam district comprises 11 blocks and 519 revenue villages. The study was conducted in three coastal blocks of the district namely Nagapattinam, Thalainayir and Vedaranyamn which are severely affected by the natural disasters as shown in Fig.3.1.The blocks were selected purposively on the basis of the area intensely affected by cyclone, flood and drought disasters respectively. In each of the three blocks the two villages affected by cyclone, flood and drought respectively were identified for the study. The study population comprised of rural farmers from each of the affected six villages. The list of farmers was obtained from the Agricultural department and the sample farmers were selected at random. From each village 30 farmers were selected, 60 farmers each from cyclone,flood,drought region and the total sample size was 180.The identified blocks and the villages are presented in Table 3.2.

Figure 3.1 Map showing the disaster affected area in Nagapattinam district

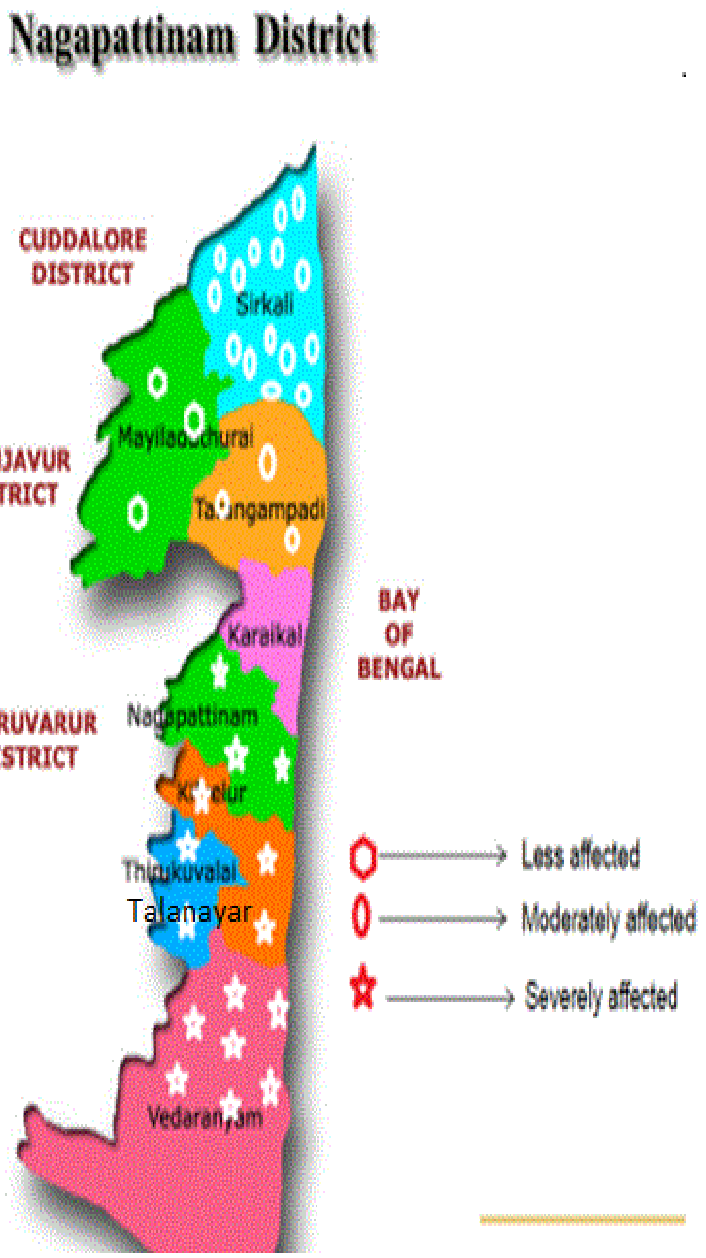


Figure 3.2 Map showing Blocks of Nagapattinam district

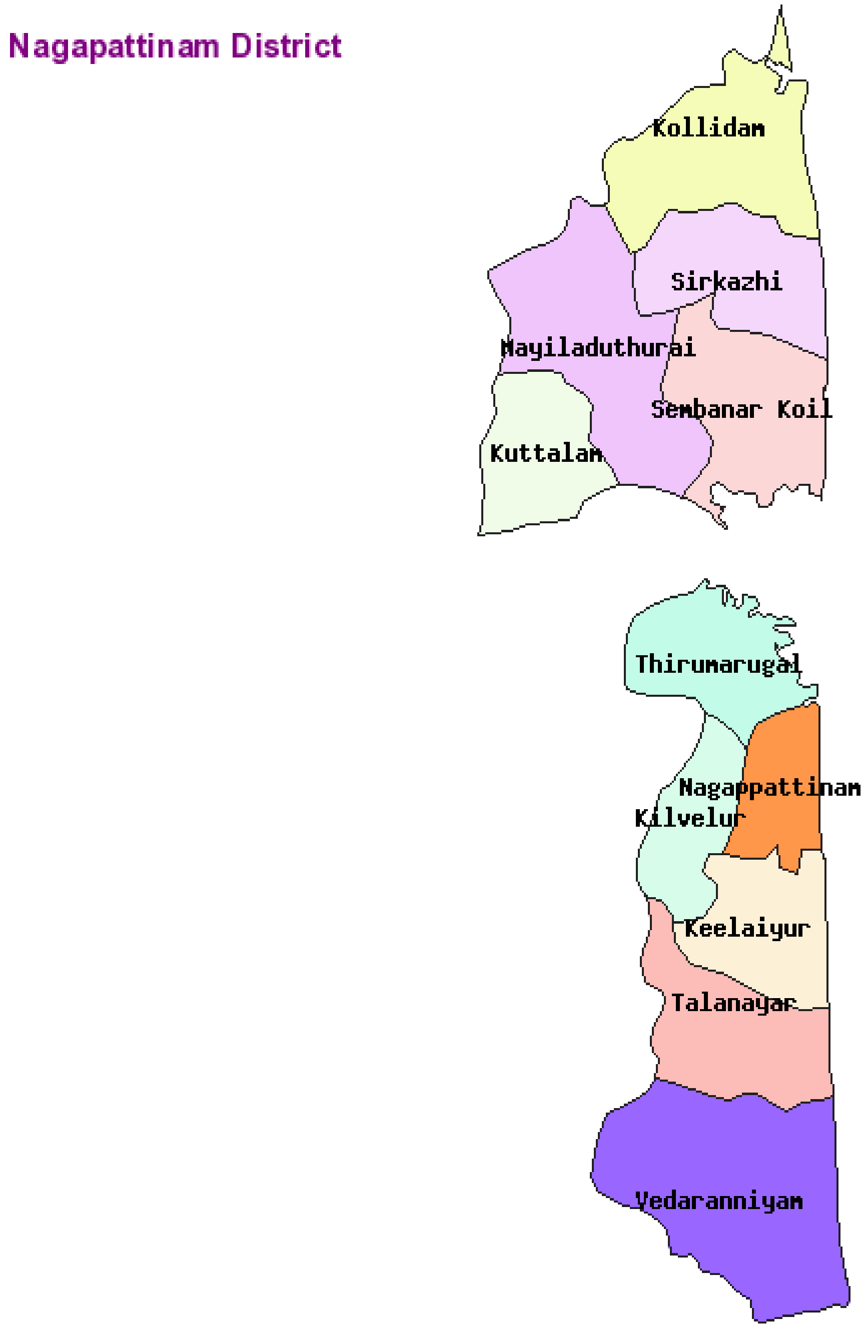


Table 3.1 Selection of sample farmers in Nagapattinam district

S.No	Name of the villages	Number of respondents
Cyclone affected (Nagapattinam block)		
1.	Vadagudi	30
2.	Melvanoor	30
Flood affected (Talanayar block)		
3.	Kadanethi	30
4.	Yogarajapuram	30
Drought affected (Vedaranyam block)		
5.	Vedaranyam	30
6.	Vaimedu	30
Total		180

Period of study

The data collected pertains to the Agricultural year 2012 which was a cyclone and flood year and 2013 was a drought year and the survey was conducted during November –December 2013 using a pretested interview schedule.

Method of data collection

Primary data

The data related to the objectives of the study were gathered from the chosen villages. Farmers were interviewed personally using interview schedules. The data on composition of the family, educational status, land holding pattern, investment pattern, cropping pattern, cost and returns, for farming activities were collected.

Income earned from agricultural and other sources were collected. Data were provided from the memory of the sample farmers. Cross checks were also done to test the validity of the information gathered.

Secondary data

General socio-economic and geographic features of the study area such as agro-climatic factors, cropping pattern, working population, rainfall particulars, disaster and mitigation related particulars and other related information were collected from the G return published by Directorate of Economics and Statistics, Assistant Director of

Statistics, Assistant Director of Agriculture, Agricultural Development Officer and Collectorate office of Nagapattinam district , Indian Meteorological Department, Chennai, and also data gathered from Journals, Newsletters and websites, etc.

Tools of analysis

Assessment of vulnerability indices

For the analysis of vulnerability in the study area, both physical and social vulnerability perspectives were integrated. The first stage of analysis of vulnerability in the present study area involved descriptive analysis of the socioeconomic and environmental characteristics, particularly adaptive capacity, sensitivity, and exposure to disasters. Second, the vulnerability indices were obtained by applying Principal Component Analysis on the adaptive capacity, sensitivity, and exposure variables. Principal component analysis is frequently used in research that constructs indices for which there are no well-defined weights, such as asset based indices used for the measurements of wealth across different social groups. The first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information common to all the variables. Accordingly, the first component scores from the principal component analysis measured the weighted sum of score of all variables.

The model specification is given as:

Vulnerability= (adaptive capacity) – (sensitivity + exposure)………………. (3.1)

In this case, vulnerability is the difference between adaptive capacity of a household and its sensitivity and exposure to climate change induced hazards. When adaptive capacity of the area exceeds that of sensitivity and exposure, the area becomes less vulnerable to disaster impacts. As explained above, each set (adaptive capacity, sensitivity and exposure) are composed of different variables (Deressa *et al.*, 2008 and Fussel, 2007).

The model specification is as follows:

$$VI = (A_1X_{1j} + A_2 X_{2j} + \ldots + A_nX_{nj}) - (A_{n+1} Y_{1j} + A_{n+2} Y_{2j} + \ldots + A_{n+n}Y_{nj}) \ldots (3.2)$$

where VI is vulnerability index, while Xs, are elements of adaptive capacity, and Ys are exposure and sensitivity. The values of X and Y are obtained by normalization using their mean and standard errors. For instance; $X_{1j} = (x_{1j} - x_1^*) / s_1^*$; where x_1^* is the mean of x_{1j} across the disasters affected regions, s_1^* is its standard deviation. In this regard, the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information common to all the variables. The whole matrix of X_{1j} appears as follows:

$$X_{ij}/Y_{ij} = \begin{Bmatrix} (X_{11} + X_{12} + \cdots \ldots \ldots X_{1n}) & - & (Y_{11} + Y_{12} + \cdots \ldots \ldots Y_{2n}) \\ \vdots & \vdots & \vdots \\ (X_{m1} + X_{m2} + \cdots \ldots \ldots X_{mn}) & - & (Y_{m1} + Y_{m2} + \cdots \ldots \ldots Y_{mn}) \end{Bmatrix} \ldots\ldots (3.3)$$

The i and j in the above notation implies the number of rows (disasters affected regions) and the number of columns (in this case variables of adaptive capacity, exposure and sensitivity) respectively. In equation 3.2, the A_s, are the first component score of each variable computed using Principal Component Analysis in STATA. Finally, the vulnerability index of each location is obtained using Eq.3.4:

$$VI = \begin{pmatrix} A_1 \\ A_2 \\ \vdots \\ A_n \end{pmatrix} \times \begin{pmatrix} (X_{11} + \cdots + X_{1n}) & - & (Y_{11} + \cdots + Y_{1n}) \\ \vdots & \vdots & \vdots \\ (X_{m1} + \cdots + X_{mn}) & - & (Y_{m1} + \cdots + Y_{mn}) \end{pmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.4)$$

For the construction of vulnerability indices, indicators of adaptive capacity, which are positively associated with the first principal component and all the indicators of sensitivity and exposure that are negatively associated with first principal component were selected. However, in constructing the indices, the scale of analysis is important. For this study, the scale of analysis was village level.

Table 3.2 Major components and sub-components of Agricultural Vulnerability Index

Major components	Sub-components	Explanation of sub-components
Adaptive capacity	Livestock ownership	Percent of household who owned livestock
	Non-farm income	Amount of income derived from non-farm sources
	Farm income	Gross income earned from crop cultivation
	Farm holding size	Hectares of land owned by sample farmers
	Cropping intensity	Percent of gross area cultivated by the farmers to the net area under cultivation
	Drought resistance crop	Percent of household growing drought resistant crop variety

Major components	Sub-components	Explanation of sub-components
	Access to credit	Percent of household which had access to institutional credit
	Illiterate sample respondent	Percent of sample households for which the heads of the households reported that they have attended 0 years of schooling.
	Dependence solely on agriculture as a source of income	Percent of households which reported only agriculture as a source of income.
	Percentage of households with well irrigation	Percent of households which used only well irrigation for cultivation purpose.
	Percentage of households buying well water	Percent of households buying well water during non-tank season.
Sensitivity	Average crop diversification	Number of crops cultivated by the sample respondents
	Share of cultivable waste to the total land area	Area not cultivated continuously for the last five years or more in succession
	Percentage of households that do not stock crop produce	Percent of households that did not store paddy obtained from each harvest.
	Percentage of households that utilize irrigation source	Percent of households that reported a river, lake, pond and tank as their irrigation source.
Exposure	Cyclone period	Total number of cyclone years that were reported by households in the past 5 years
	Drought period	Total number of drought years that were reported by households in the past 5 years.
	Flood period	Total number of flood years that were reported by households in the past 5 years.
	Variation in monthly average rainfall	Standard deviation of the average monthly rainfall between 2007 and 2011 for each district.

Regression model

Regression model was used to determine the relationship between factors that accelerate the effects of natural disasters and the income of the rural farmers. Ordinary Least Squares (OLS) Multiple Regression Model is implicitly specified as follows:

$Y= f(X_1, X_2, X_3, X_4, X_5, X_6, X_7,)$

According to Anthony Ojonimi Onoja1 *et al*., (2012) explicit form is shown as: -

1. The Linear Regression form is explicitly modeled as follows;
   $Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + U_i$
2. The Double-log Functional form is explicitly modeled as follows;
   $LnY = b_0 + b_1 LnX_1 + b_2 LnX_2 + b_3 LnX_3 + b_4 LnX_4 + b_5 LnX_5 + U_i$
3. The Semi-log Functional Form is explicitly expressed as follows;
   $Y = b_0 + b_1 LnX_1 + b_2 LnX_2 + b_3 LnX_3 + b_4 LnX_4 + b_5 LnX_5 + Ui$
4. The Exponential functional Form is explicitly modeled as follows;
   $LnY = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + U_i$

Where Y = Dependent variable

X's = Independent variables

U = error term

The dependent variable is the income level of the rural farmers during the period of natural disasters while the independent variables are the factors that accelerate the effects of natural disasters and they include the following: -

Y = Income level of the rural farmers
X_1 = Land degradation
X_2 = climatic factor
X_3 = diversification in agricultural activities
X_4 = Standard of living of rural farmers
X_5 = Adoption of new technologies

Measurement of variables

Farmer's income (Y)

The income of the farmers were measured by the amount of money earned by the farmers during disaster period

Land degradation (X_1)

The low lying nature of the study district's coastline makes it prone to coastal erosion and flooding very often. Present study uses 3-point Likert type scale of measurement as low (1), moderate (2) and high (3) on the basis of perception and yield of the farmers over the years It is expected that land degradation has a negative influence over the income of the farmer.

Climatic factor (X_2)

For the present study climatic factor was measured using a dummy variable, 1 if there exist a good weather favourable for better yield and zero if otherwise. It is expected that climatic factor has a positive influence over the income of the farmer.

Diversification in agricultural activities (X_3)

In the study area the diversification of crops is limited due to climate induced natural disaster. For diversification in agricultural activities a dummy variable, 1 was used if diversified and zero if non-diversified. It is expected that diversification in agricultural activities has a positive influence over the income of the farmer.

Standard of living of the farmer (X_4)

Rural farmers are the most affected during the disaster period and they mostly experience reduction in safe drinking water and food security. Standard of living of most of the small and medium farmers in the study area were found to be poor. Present study uses 3-point Likert type scale of measurement as low (1), moderate (2) and high (3) by measuring the yield of the farmers by cumulative score.

Adoption of new technologies (X_5)

If the farmers adopt new technologies, then a dummy variable, one was used and zero if otherwise. It is expected that adoption of new technologies has a positive influence over the income of the farmer. Farmers with large farm size in the study area adopts new technology and invested high on farm machineries to cope up with the disaster situation.

Wilcoxon matched pairs signed-ranked test method

Wilcoxon Matched pair's Signed-Ranked test was employed to determine whether differences exit in the income of the rural farmers before and after the occurrence of natural disasters.

Model specification

Following Walker and Lev (1953), the test is mathematically represented as

$$Z = \left(\frac{\frac{T-n\,(n-1)}{4}}{\frac{\sqrt{n\,(n+1)\,(2n+1)}}{24}} \right)$$

Where: -

Z = the value by which the statistical significance of the difference between the two periods would be determined.

T = Ranking the difference scores. Then, add up the rankings of both the positive scores and the negative scores and finally taking the smaller of those two values is the "T" used to calculate the Z statistics.

N= Number of sample size

The procedure for this test entails first obtaining the difference between each pairs of income values before and after disasters with the signs indicated, then ranking the difference without regard to the sign, so that the smallest absolute difference is assigned rank 1 (the lowest range). A difference of -3 is assigned a lower rank than a difference of -5 or +5. Then the appropriate signs are once more affixed to the ranked differences. The sign that is less frequent in occurrence is listed and summed up. This sum is the value of the Wilcoxon test statistic, T. If the computed Z is less than the critical value of Z in a table of distribution the (Z table of distribution was used with a critical value of 1.64), we reject the null hypothesis and accept the alternative. If there is no change in income in both the situation then the null hypothesis is rejected and accept the alternative hypothesis if there is a change in income in both the situation.

Analysis of the determinants of farmers' choice of adaptation methods

The decision on whether or not to adopt a new technology (an adaptation method in this case) is considered under the general framework of utility or profit maximization (Pryanishnikov and Katarina 2003). It is assumed that economic agents, including smallholder subsistence farmers, use adaptation methods only when the perceived utility or net benefit from using such a method is significantly greater than is the case without it. Although utility is not directly observed, the actions of economic agents are observed through the choices they make. Suppose that Y_j and Y_k represent a household's utility for two choices, which are denoted by U_j and U_k, respectively. The linear random utility model could then be specified as:

$$U_j = \beta_j X_i + \varepsilon_j \text{ and } U_k = \beta_k X_i + \varepsilon_k \quad \text{---------------------------------------} \ (3.5)$$

where U_j and U_k are perceived utilities of adaptation methods *j* and *k*, respectively, X_i is the vector of explanatory variables that influence the perceived desirability of the method, B_j and B_k are parameters to be estimated, and ε_j and ε_k are error terms assumed to be independently and identically distributed (Green 2000).

If farmer i chooses option j instead of k then it means that the perceived utility derived from this option is greater than that of the latter. This can be expressed as

$$U_{ij} > U_{ik}, k \neq j \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \ (3.6)$$

Utility derived from an adoption strategy cannot be observed. However what is observed is the discrete choice of the adoption strategy which can then be related to this unobservable (latent) and continuous variable.

$$Y_i = 1 \text{ if } U_{ij} > U_{ik}$$
$$\Rightarrow U_{ij} - U_{ik} > o$$
$$\Rightarrow (\beta`_j x_i + \varepsilon_j) - (\beta`_k x_i + \varepsilon_k) > 0$$
$$\Rightarrow Y_i = 1 \text{ if } (\beta`_j - \beta`_k) x_i + (\varepsilon_j - \varepsilon_k) > 0$$
$$\text{and } Y_i = 0 \text{ if } (\beta`_j - \beta`_k) x_i + (\varepsilon_j - \varepsilon_k) \leq 0$$

A multinomial logit model analyses the relationship between a more than two dependent variable and a set of independent variables. Several studies have used this method to study farmers adaptation to climate change (Seo and Mendelsohn, 2006; Apata et al, 2009 and Fosu- Mensah et al, 2010).

This model uses a logistic cumulative distribution function to estimate probabilities as shown in equations (3.7) and (3.8). The function is presented as follows:

$$P = e^{\beta`x} / 1 + e^{\beta`x} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.7)}$$

$$1 - P = 1 - e^{\beta`x} / 1 + e^{\beta`x} = 1/1 + e^{\beta`x} \ldots\ldots\ldots\ldots\ldots \text{(3.8)}$$

Where, P is the probability of success or failure given Xi
e denotes the base of natural logarithms
X_i represents the ith independent variables; and
β represents the vector of parameters to be estimated

Empirical Model

The multinomial logit (MNL) model is used for this analysis using STATA. The advantage of the MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories emphasizes the usefulness of this model by describing the ease of interpreting estimates from this model.

To describe the MNL model, let *y* denote a random variable taking on the values {1, 2... *J*} for *J* , a positive integer, and let ***x*** denote a set of conditioning variables. In this case, *y* denotes adaptation options or categories and ***x*** contains household attributes like age, education, income levels, and so forth.

Let ***x*** be a 1×*K* vector with first element unity. The MNL model has response probabilities:

$$P\,(Y - j/x) = \exp\,(x\beta_j) / [1+\Sigma^{j}_{n=1} \exp(x\beta_n),\ j = 1\ldots j]$$

Where β_j = K x 1, j=2…………]

For this study, the adaptation options or response probabilities are five:

1. No adoption
2. Adopted tolerant varieties
3. Crop diversification
4. Soil conservation and new land management practices
5. Early / late sowing of seeds

The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable, but estimates do not represent either the actual magnitude of change nor probabilities. Differentiating equation (3.5) with respect to the explanatory variables provides marginal effects of the explanatory variables given as:

$$\partial Pi/\partial xi = [e\beta' x / (1 + e\ \beta'_i x_i)^2]\ \beta_i$$

$$= F\ (\beta' x\ [1- F(\beta' x]\ \beta_i$$

Justification of model variables

Age

Age is the proxy to farming experience and it increases the probability of uptake of all adaptation options. The older the farmer, the more experienced he is in farming and the more he is exposed to past and present conditions of disaster event

Education

Many research works have shown that education increases one’s ability to receive, decode, and understand information relevant to making innovative decisions (Wozniak, 1984). On the contrary, Clay *et al.*, (1998) found that education was an insignificant determinant of adoption decisions.

Farm size

Adoption of an innovation will tend to take place earlier on larger farms than on smaller farms. Daberkow and McBride (2003) showed that given the uncertainty and the fixed transaction and information costs associated with innovation, there may be a critical lower limit on farm size that prevents smaller farms from adopting. As these costs increase, the critical size also increases. It follows that innovations with large fixed transaction and/or information costs are less likely to be adopted by smaller farms.

Household size

According to Nhemachena and Hassan (2008), household size had mixed impacts on farmers’ adoption of agricultural technologies. Larger family size was expected to enable farmers to take up labor intensive adaptation measures. Alternatively, a large family might be forced to divert part of its labor force into non – farm activities to generate more income and reduce consumption demands.

Livestock ownership

The ownership of livestock is positively related to most of the adoption options.

Credit

Access to credit is another important factor affecting adoption of agricultural technologies. Access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want o take (Nhemachena and Hassan, 2008).

Non/off farm income

Household engaged in off farm or non-farm activities as a major support for livelihood. This additional income increases farmers' financial capacity and is expected to increase the probability of investing in new technologies.

Temperature and rainfall

Temperature and Rainfall is one of the major component which influence in the effect of natural disasters .Increase of temperature leads to the condition of dryness and increase in rainfall will leads to cyclonic flood.

Assessment of adaptation to disaster events

Change of climate and occurrence of disaster events will affect the livelihoods of vulnerable farmers. The ill effects of disasters can be reduced through appropriate adaptation measures. Before identifying the adaptation options to be followed by the farmers, it needs to be confirmed whether the farmers have perceived that there was variability in disaster events. Descriptive statistics like counts and percentages were used to provide insights into farmers' perceptions of disasters. After assessing the perception of farmers about disaster events, they were asked if they have responded through adaptation to counteract the impact of these disaster events. Accordingly, those who responded that they have adapted to such changes were requested to indicate different adaptation strategies they followed, which included use of different crop varieties, crop diversification, changing planting dates etc.,

The awareness of farmers about these changes and the decision to select adoption measures was considered to be a two-stage process. First stage was whether the farmers were aware of occurrence of disaster events or not. The second stage involved whether farmers adopted any technologies after being aware and selecting some adaptation measures. The second stage, known as the "outcome" stage, was considered a sub-sample of the first stage *i.e.*, the "selection" stage. Since the outcome stage was a sub-sample of the selection stage, it was likely that the outcome stage sub-sample will be non-random and different from those farmers who did not become aware of changes in the full sample. A sample selection bias was then created which was to be corrected by the maximum likelihood *Heckman's two-step* or *Heckit* selection procedure.

Heckman probit model

The Heckman two-step estimation is a way of estimating treatment effects when the treated sample is self-selected. The application of this model in this study was to estimate the determinants of an individual farmer's decision to select adoption. And estimated using STATA .The first step was to create a model with a group of farmers who were aware of disaster events (selection), and then given that model, the outcome (adoption).

Heckman's sample selectivity probit model is based on the following two latent variables:

$Y_1 = b'X + U_1$ …………………………………………… .. (3.9)

$Y_2 = g'Z + U_2$ …………………………………………….. (3.10)

where Y_1 was the farmers' choice between adoption and non-adoption, Y_2 was the farmers' awareness to the occurrence of disaster events and those that were not aware. *X* is a *k*-vector of regressors in adoption equation; *Z* is an *m*-vector of regressors in awareness equation and the error terms U_1 and U_2 are jointly normally distributed, independently of *X* and *Z*, with zero expectations.

The size of farmers who choose to adopt was observed only if the farmer was aware of disaster events and chose to adapt. The size of non-adoption farmers was observed only if the farmer was aware of changes and chose not to adapt. These two selection processes can be considered as non-random and the model should explicitly consider this selection in order to produce unbiased estimates. To address the multiple sample selection problems inherent in the size of the adoption equation, the following model was specified.

Let Y_2^* represent the propensity of a farmer being aware of disaster events rather than not. Then the relationship between the observed outcome Y_2 and the response propensity can be written as:

$Y_2 = 1$ if $Y_2^* > 0$, Y_2 is a missing value, if $Y_2^* < 0$………………. (3.11)

Let Y_1^* be the corresponding propensity to choose adaptation measures versus non-adaptation measures as a result of awareness to climate change. This variable is only observed when $Y_2 = 1$, *i.e.*, Y_1 is a choice between adaptation and non-adaptation, if the farmer was aware of disaster events and takes the value of 1 for adaptation and 0 for non-adaptation.

$Y_1 = 1$ if $Y_1^* > 0$, Y_1 is a missing value, if $Y_1^* \leq 0$…… …. (3.12)

The variable Y (size of adopter farmers) is only observed when $Y_2 = 1$ and $Y_1 = 1$ (aware and adoption), while Y_N (size of non-adopter farmers) is only observed when $Y_2 = 1$ and $Y_1 = 0$ (aware but not adopt).

Although the researchers are primarily interested in the first model, the latent variable Y_1 is only observed if $Y_2 > 0$. Thus, the actual dependent variable is:

$Y = Y_1$ if $Y_2 > 0$, Y is a missing value, if $Y_2 \leq 0$ …………………… (3.13)

Consequently, without loss of generality, U_2 could be normalized such that its variance is equal to 1. If the sample selection problem is ignored, and Y is regressed on X using the observed Y's only, then the ordinary least squares (OLS) estimator of b will be biased, because

$E [Y_1|Y_2 > 0, X, Z] = b'X + rs\, f(g'Z)/F(g'Z)$ …………………………. (3.14)

where F is the cumulative distribution function of the standard normal distribution, f is the corresponding density, 's' is the variance of U_1, and 'r'is the correlation between U_1 and U_2. Hence,

$E [Y_1|Y_2 > 0, X] = b'X + rs\, E[f(g'Z)/F(g'Z)|X]$ ………………………… (3.15)

The latter term causes sample selection bias, if r is non-zero. In order to avoid the sample selection problem, and to get asymptotically efficient estimators, the model parameters are estimated by maximum likelihood method.

The first stage of the Heckman's sample selection model is the perceptions of changes to disaster and this is the selection model (Equation3.11). The second stage, which is the outcome model (Equation 3.10), is whether the people adopted to disaster condition, conditional on the first stage that she/he perceived a change in the situation.

The variables included in the selection as well as outcome model are detailed in Table 3.3.

Table 3.3 Description of model variables for the Heckman probit model

S.No	Outcome equation	Selection equation
A	**Dependent variable**	**Dependent variable**
1	Adoption to disaster events (dummy: takes the value of 1 if adopted and 0 otherwise)	Farmers' perception towards disaster events (dummy: takes the value of 1 if perceived and 0 otherwise)
B	**Independent variables**	**Independent variables**
1	Adaptation to disaster events	Education of the household head in years (continuous)
2	Education of the household head in years (continuous)	Age of the household
3	Experience in farming	Farm income from crop cultivation in Rs.(continuous)
4	Non-farm income(continuous)	Non-farm income
5	Size of the household(continuous)	Information on disaster events
6	Farm size(ha)	Education of the household head in years (continuous)
7	Livestock ownership(dummy:1 if livestock owned and 0 otherwise)	
8	Extension on crop and livestock	
9	Credit(dummy:1 if there is access and 0 otherwise)	
10	Temperature	
11	Rainfall	

Crop loss assessment

Crop loss is assessed for the disaster year by using the following formula:

$$CL = \frac{\text{Normal Yield (N)} - \text{Actual Yield (A)}}{\text{Normal Yield (A)}} \times 100$$

Where,

CL- Crop loss in percentage

N-refers to the average yield in kg/ha for the past three years as recorded by agricultural department.

A – refers to the actual yield in kg/ha realized by the sample farmer

Crop loss restorability

Crop loss restorability is calculated based on the indemnity paid. Indemnity is a crop insurance in which the insurance claim is calculated by measuring the percentage damage in the field soon after the damage occurs. The damage measured in the field, expressed as a percentage, is applied to the pre assured sum insured. The sum insured may be based on production costs or on the expected revenue. Crop Loss Restorability (CLR) is done by using the following method:

$$CL = \frac{\text{Indemnity paid (Rs.)}}{\text{Value of crop loss (Rs.)}} \times 100$$

where,

Value of Crop Loss (VCL) =Value of normal yield (Rs.)-Value of actual yield (Rs.)

Cost and returns

Variables included in the model

Cost of cultivation

The cost, returns and profits of crops cultivated in the study area were computed and compared for pre and post disaster periods. The percentages and averages of variable costs and fixed costs were computed based on the methodology followed by the Commission on Agricultural Costs and Prices.

Measurement of variables

The variables used in the analysis were measured as given below in Table.3.4

Table. 3.4 Variables included in cost concept and measurement

Variables	Measurement
Seeds	The cost of the seed was calculated at the local market price for the farm produced seeds and actual expenditure incurred in the case of purchased seeds.
Human Labour	Human labour was estimated in terms of eight hours of work per day. The women labour days were converted into man days on the criterion that one woman day was equal to 0.60 man days equivalent and one child labour was equal to 0.50 man days on the basis of market wage rate.
Machine Power	The cost of machine power both owned and hired was calculated at the different rates for the different type of operations prevailed in the study area.
Fertilizers and Plant Protection Chemicals	Cost of fertilizers and plant protection chemicals were based on the actual prices paid by the sample farmers including the cost of transportation and other incidental charges.
Irrigation Charge	Total charges paid for irrigating the crop during entire crop period was considered.
Land Revenue and Cess	Land revenue and cess charges were the existing charges levied by the government.
Rental Value of Land	It was imputed by taking the local average rental value for one year period.
Interest on Working Capital	Interest on working capital was calculated at the rate at which banks were advancing short-term loans. The prime lending rate during the agriculture year was 7.00 per cent for crop loan. It was charged for a period of duration of a particular crop.
Interest on Fixed Capital	Interest charges on fixed capital were calculated at the rate of 11 per cent per annum as it was the rate of interest charged on long-term loans by commercial banks. This interest was worked out on the values of fixed assets, after deducting depreciation for the

Variables	Measurement
	year. It was apportioned on the basis of the area of land under each crop grown by the farmer during the study period.
Depreciation	Depreciation was calculated by the straight line method. The charges on account of minor repairs of implements and machinery during the year were added to the depreciation charges. It was apportioned on the basis of area of land under each crop grown during the year.
Total Cost of Cultivation	Cost of cultivation included variable and fixed costs. Variable costs included the cost of human labour, bullock labour, machine power, seeds, farm yard manure, plant protection chemicals, irrigation charge and interest on working capital. Fixed costs comprised of depreciation, land revenue, rental value of land and interest on fixed capital.
Gross return	Gross return was computed by multiplying the quantity of main product and by-products obtained with their respective prices received.

CHAPTER IV

DESCRIPTION OF THE STUDY AREA

A comprehensive detail of the study area would enable systemic inquiry. Under this context a brief description of the different geographical and climatic factors and other socio-economic factors that would influence directly and indirectly the income and livelihood of the rural farmers in the disaster prone area are presented.

Nagapattinam district

The District of Nagapattinam has been carved out as a separate district due to bifurcation of Thanjavur district. According to this division, six taluks namely Sirkazhi, Tharangampadi, Mayiladuthurai, Valangaiman, Nagapattinam and Vedaranniyam were detached from their parent district (Thanjavur) to form this new district. The earlier history of this district is more or less the same as of its parent district, Thanjavur being its part till recently. Tamil and Telugu are the main languages spoken in the district.

Geographical location

The Nagapattinam district lies on the east coast to the south of Cuddalore district and another part of the Nagapattinam district lies to the south of Karaikkal and Tiruvarur districts. Its northern boundary is about 75 km southwards from the Head Quarters of the Cuddalore district. Thanjavur district and Tiruvarur district flank it on the west and on the south and east it is bordered by the Bay of Bengal. The district lies between 10.25^0 and 11.40^0 North Longitude and 76^0 49^0 and 80.01^0 East longitude. The general geological formation of the district is plain and coastal. The Cauvery and its offshoots are the principal rivers. Rising in the Coorg Mountains, this river bifurcates about nine miles at the west of Trichy into two branches, of which the northern one takes the name of Coleroen and the southern one retains that of the Cauvery.

There are no less than eleven ports on the coast Nagapattinam district, of which eight are open to foreign trades. The coastline has a number of harbors of which mention may be made of Nagore, Point Calimere, and Nagapattinam. The significant small ports are Kilvellore, Thirumulaivasalam, Nagapattinam, Velankanni, Topputturai, Muttupet and Adiramapatnam. The Nagapattinam district is made up the 6 Taluks of Nagapattinam, Kilvellore, Vedaranniyam, Mayiladuthurai, Sirkali and Thrangampadi. The East Side faces the Bay of Bengal. The district is the most part of a flat plain, slopping very gently to the sea on the east. The total geographical area of the district is about 2715.83 km^2 and has a population of 14, 87,005. Fig 4.1 shows the profile of Nagapattinam district.

Administrative arrangement in the district

Community development blocks in the district are: Sirkazhi, Kollidam, Sembanarkoil, Kuttalam, Mayiladuthurai, Thirumarugal, Nagapattinam, Kilvelur, Thalanayar, and Vedaranniyam. The Nagapattinam district comprises 8 Taluks, 11 Blocks and 523 revenue Villages. As regards the hierarchy of administrative arrangement, there are 3 Municipalities, 10 Town Panchayats and 434 Village Panchayats in the district.

Weather and climate

The climate in the district ranges from semi-arid to sub humid. It experiences hot dry summer from March to May when temperature is fairly high going up to an average of 35^{o}c and cold weather in December and January when a minimum of 24.6^{o}c has been recorded. In general, the district has high relative humidity during October to March, when winds blow from north easterly and easterly directions. Average annual rainfall of the district is 1326.7 mm.

The season wise distribution of rainfall of the district over years is presented in Table 4.1. The district receives bimodal rainfall. . The southwest and northeast monsoon account for 20.60 percent and 66.80 percent respectively of the average annual rainfall in the region. Winter rains account for 6.5 percent while summer showers account for 6.1 percent of the annual rainfall in the district.

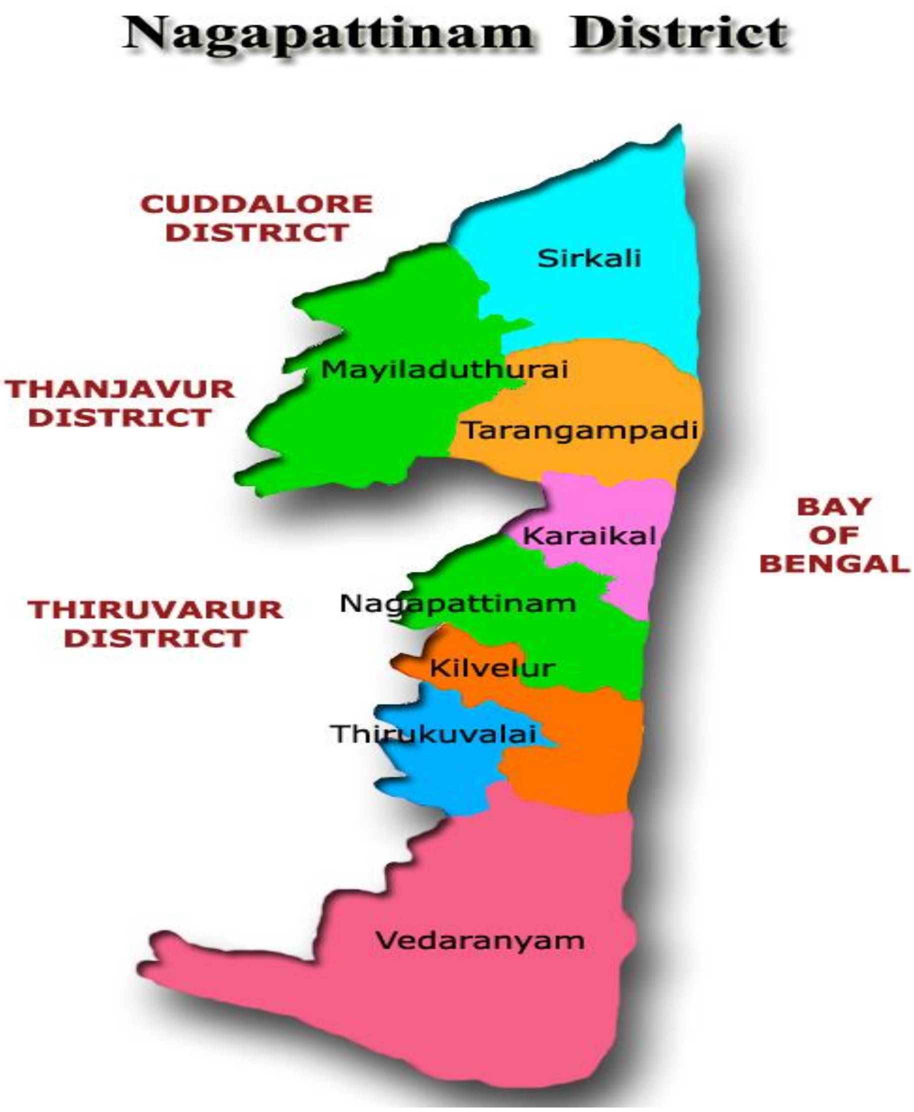
Table 4.1 Distribution of rainfall - 2012(mm)

SW Monsoon (June – Sep)		NE Monsoon (Oct-Dec)		Winter (Jan-Feb)		Hot weather (March – AApril May)		Whole year (Jan-Dec)	
Actual	Normal	Actual	Normal	Actual	Normal	Actual	Normal	Actual	Normal
386.2 (24.9)	274.1 (20.6)	1041.6 (67.1)	886.4 (66.8)	45.3 (2.9)	85.7 (6.5)	78.9 (5.1)	80.5 (6.1)	1552.0 (100.00)	1326.7 (100.00)

(Figures in parentheses indicate percentage)

Source: Office of the Assistant Director of Statistics, Nagapattinam.

Figure 4.1 Profile of Nagapattinam district



Land use pattern

Acknowledge on the allocation of land among various uses would throw light on the potential for developing farming and allied economic activities. Details on the land utilization pattern in Nagapattinam district is presented in table 4.2

Table. 4.2 Land use pattern - 2012- 13

Sl. No	Details	Area (ha)	Percentage
1.	**Total geographical area**	**2,71,583**	**100.00**
2.	Forests	4,633	1.71
3.	Barren and Uncultivable Land	33,419	12.31
4.	Land put to non-Agricultural use	47,493	17.48
5.	Cultivatable wastes	3,836	1.41
6.	Permanent pastures and other grazing land	964	0.35
7.	Land under miscellaneous crops and groves not included in net area sown	10,616	3.91
8.	Current fallows	2747	1.01
9.	Other Fallow Lands	19232	7.08
10.	Net area sown	1,31,546	48.44
11.	Area sown more than once	52,223	19.22
12.	Total cropped area	1,83,769	67.70

Source: 'G' Returns register, Assistant Director of Statistics, Nagapattinam.

The geographical area of Nagapattinam district is 2,71,583 ha. It could be discerned from the table that gross cropped area accounted for 67.7 percent of the total geographical area in the district. The net sown area occupied 48.44 percent and land put to non-agricultural uses for 17.48 percent. Barren and uncultivable land, total fallows and cultivable waste accounted for 12.31, 8.09 and 1.41 percent respectively of geographical area of the district. The land under miscellaneous tree crops and forest area accounted for 3.91 and 1.71 percent respectively of the total geographical area of the district.

Land holding pattern

The details on the distribution of operational land holdings of Nagapattinam district are furnished in table 4.3. It could be observed from the table that about 60 percent of the cultivated area is being owned by about 90 percent of the small and marginal farmers and 40 percent of the area being operated by the medium and large size group of farmers. It shows there exists wide disparity in the ownership and the operatorship of the farm holdings.

Table 4.3 Land holding pattern of farmers during 2011-12

Sl. No	Category	Numbers	Percentage	Area (Ha)	Percentage
1.	Marginal (< 1 ha)	1,39,144	76.06	55,598	35.85
2.	Small (1-2 ha)	27,759	15.17	38,789	25.01
3.	Semi Medium (2-4 ha)	11,989	6.55	32,653	21.05
4.	Medium (4-10 ha)	3,598	1.96	20,131	12.98
5.	Large (> 10 ha)	439	0.26	7,914	5.11
Total		**182929**	**100.00**	**155085**	**100.00**

Source: Office of the Assistant Director of Statistics, Nagapattinam.

Irrigation

The major determination of the production performance of agriculture is the availability and intensity of irrigation. Nagapattinam district is predominantly irrigated by Cauvery and Vennar river basin system and are called the old delta region. River Coleroon also acts as an irrigation source for this district. Canal water is the major source of irrigation. The water supply is dependent upon the water release of Cauvery. Besides, there are six streamlets and all of them depend on monsoon rains for their replenishment. The area irrigated and the major sources and their relative contribution to net irrigated area are shown in table 4.4.

Table 4.4 Source wise area irrigated during 2011-12

Source	Number	Area (Ha)
Tube wells	8,430	10,215
Bore wells	6,435	13,168
Filter points	1,743	2,115
Open wells	2,118	2,736
Total wells	**18,726**	**28,234**
a. Electric Motor	12,321	
b. Diesel engine	5,428	
Canals	9 (548 Km)	1,23,906
Gross irrigated area	-	1,52,140
Percentage to gross cropped	-	59.13

Source: Season and Crop Report (2011-12)

Nagapattinam district, as a whole, has nine canals and 18,726 wells in total. Canals form the principal source of irrigation accounting for 81.44 percent of the gross irrigated area indicating the predominance of canal irrigation in the district. Overall, the district has 59.13 percent of the gross cropped area being irrigated through canals and wells.

Cropping pattern

A study of the crop pattern would provide an idea of the decision behaviour of the farmers of the crop-mix prevalent in the region. The distribution of area under major crops in Nagapattinam district is furnished in table 4.5

Table 4.5 Cropping pattern during 2011-12

Sl. No	Crop	Area(ha)	Percentage
1.	Rice – Kuruvai	42848	
2.	Rice – Samba	94658	
3.	Rice – Thaladi	39792	
4.	Rice – Summer	1385	
Total Rice		178677	**66.38**
5.	Black Gram	51177	
6.	Green Gram	32439	
Sl. No	**Crop**	**Area(ha)**	**Percentage**
Total Pulses		**83596**	**31.06**
7.	Cotton	262	0.10
8.	Sugar cane	3298	1.23
9.	Gingelly	740	0.27
10	Groundnut	2598	0.97
11.	Maize	-	-
Total		**141651**	**100.00**

Source: Office of the Joint Director of Agriculture, Nagapattinam.

Paddy was the dominant crop in Nagapattinam district accounting for about 66 percent of the gross cropped area followed by pulses with 31.06 percent and sugarcane with 1.23 percent. The oilseeds accounted for about 1.24 percent of the gross cropped area.

Farm machineries

The details on the availability of farm machineries with the Government and Private sources are furnished in table 4.6 along with the projected machinery requirement for 2012-13.

Table 4.6 Details on farm machinery

Year / Machinery	2008-09	2009-10	2010-11	2011-12
Tractor with Rotavator	45	138	326	546
Power Tiller	24	154	258	316
Transplanter	2	21	60	77
Combine Harvester	2	16	39	69
Weeder	13	34	62	188
Laser Leveler	-	2	18	58
Power Sprayer	16	71	162	528
Fully Automated	-	-	4	18

Source: Office of the AEE, Nagapattinam

Demography

The demographic details of Nagapattinam district is furnished in table.4.7 As per 2011 – 12 census, the total population of district was 16, 14,069 with a population density of 617 per Km^2. Rural population accounted for 75.81 percent and urbanites for 24.19 percent of the total population of the district. Literates constituted 76.04 percent of the total population. The total working population in the district is 44.52 percent. Cultivators accounted for 4.08 percent of the total population and 13.68 percent of the workers depend on agriculture.

Table 4.7 Demography of Nagapattinam district during 2011-12

Particulars	Total	Percentage
Total households	**3,72,515**	**100.00**
Rural	2,83,484	76.10
Urban	89,031	23.90
Total population	**16,14,069**	**100.00**
Rural	12,23,625	75.81

Particulars	Total	Percentage
Urban	3,90,444	24.19
Total Male	**7,97,214**	**100.00**
Rural	5,67,124	73.92
Urban	2,30,090	26.08
Total Female	**8,16,855**	**100.00**
Particulars	**Total**	**Percentage**
Rural	6,09,047	74.56
Urban	2,07,808	25.44
Sex Ratio	1,025	-
Density	617	-
Total Literates	12,27,311	76.04
Total Workers	7,18,583	44.52
Total Main Workers	5,43,618	33.68
Total Main Cultivators	65,854	4.08
Total Main	**2,20,804**	**13.68**
Male	1,33,644	8.28
Female	87,160	5.40

Source: Directorate of census operations, Tamil Nadu.

Literacy level

The literacy level of the Nagapattinam district according to figures available for the year 2011-12 is 76.04 per cent with male literacy level being more than the female literacy level.

Soil types

Deep black soil and very deep black Soil types cover 45.7 per cent and 61.7 per cent respectively in this district. .

Soil problems

The soil of the district is mostly alluvial but varies greatly in quality. The rich soil is found in the north and the south of the railway line between Mayavaram and Thiruthuraippundi. The worst land in the delta is found in the Tirutturaippundi and Nagapattinam taluks where the soil is saline and erinaceous and drainage is very defective. The chief sources of irrigation in the district are the rivers, a few tanks and wells. These tanks and wells occur mostly in the upland regions.

Water recourses

The district is situated in the deltaic region of the famous river Cauvery and criss-crossed by lengthy network of irrigation canals. Kollidam River forms the northern boundary of the district, whereas Arasalar, Tirumalairajanar, Vettar and Vennar rivers drained the other parts of it. These all rivers are tributaries and branches of the river Cauvery.

Irrigation by different sources

Nearly canals serve 80 percent of the total net area irrigated and only the river Cauvery feeds these canals. The Cauvery Delta system is the most ancient of all irrigation schemes in the undivided Thanjavur. This comprises mainly of three important projects. They are the famous Grand Anicut, the Upper Anicut and the Cauvery Vennar Regulator Project. Tanks and wells are rarely used for irrigation in the district. Therefore canal irrigation constituting 99.64 percent of the total irrigated area which remains the predominant source of irrigation. Among the crops cultivated the area irrigated is more for paddy of about 157057.235 out of the total irrigated area 164184.935 ha.Table.4.8 below shows the cropwise area irrigated in the district.

Table 4.8 Crop wise area irrigated in Nagapattinam district (2011-12)

S.No	Crop	Area (Ha)
1	Paddy	157057.23
2	Maize	17.22
3	Black gram	9.00
4	Chillies	97.88
5	Sugarcane	3079.32
6	Fruits and Vegetables (including root crops)	1219.28
7	Groundnut	1445.61
8	Cotton	316.56
9	Flowers	326.53
10	Other crops	624.73
	Total	**164184.93**

Source: 'G' Return, Department of Statistics, Nagapattianam, 2011-12

Energy resource

The total consumption of electricity in agricultural sector is 126.51 kw/h and the industrial type has the maximum consumption accounting for nearly 20.74 kw/h of the total consumption followed by Commercial type (54.42kw/h) and domestic usage is 273.15 kw/hand public lighting and water is about 131.76 kw/h respectively.

Electrification of villages

Total number of villages electrified in Nagapattinam district is 573 and number of hamlets electrified is 1550. Apart from this the number of pump sets energised is 27112.

Transportation

The composite Nagapattinam district has State highways, major district roads and other district roads. The length of the roads in all the categories has increased in the district. The same situation is observed in the case of major and minor bridges and culverts and hence the real progress made in the development of roads and bridges could be seen. There has been a significant increase of two, three and four wheeler vehicles in the district over the past 10 years. Increase of vehicles may increase air pollution emitted from them. Table.4.9 below shows the transport facilities available in the district.

Table 4.9 Transport structure in Nagapattinam district (2011-12)

S.No	Road Length(in km)	Km
1	National Highways	190.10
2	State highways	283.42
3	Corporation and Municipal Roads	741.83
4	Panchayat unions and panchayat roads	2637.77
5	Town panchayat and Township roads	197.13

Source: Office of the Assistant Director of Statistics, Nagapattinam.

Number of primary health centres

There are about 51 primary health centres and 258 sub centres were found in the district.

Communications

It could be seen from the table.4.10 that 338 post offices were functioning in the district.

Table 4.10 Communications of Nagapattinam district

S.No	**Particulars**	**Numbers**
	Post and telegraphs	
1	Post offices	338
2	Post office and Telegraph	-
	Telephones	
	No.of Telephone Exchange	12015
	No of Telephone in use	434

Source: Office of the Assistant Director of Statistics, Nagapattinam.

Cooperatives and rural developmental banks that provides credit to the farmers are listed in the table 4.11

Table 4.11. Co-operative credit facilities in Nagapattinam district

S.No	Particulars	Numbers
1	Primary Agricultural and Rural Developmental banks	122
2	Tenant co-operative farming society	6
3	C.W.S. store	1
4	C-operative marketing society	3
5	District co-operative union	1
6	Employee co-operative societies	27
7	Labour contract co-operative societies	1
8	Vedaranyam salt producer marketing co-operative societies	1
9	Primary co-operative stores	3
10	PCARDB	3
11	Co-operative urban credit society	2

Source: Office of the Assistant Director of Statistics, Nagapattinam.

Disaster effect on agriculture and mitigation in Nagapattinam district

Table 4.12 Area, production & productivity of paddy during flood disaster event in Nagapattinam district

Crop	Paddy		
Year	**Area(ha)**	**Production (L.MT)**	**Productivity(kg/ha)**
2000-01	167314	5.47	3272
2001-02	168265	4.27	2541
2002-03	137724	1.59	1158*
2003-04	136039	2.59	1910*
2004-05	153482	2.29	1493*
2005-06	158100	7.51	4752
2006-07	166042	7.07	4263
2007-08	157519	3.60	2285*
2008-09	172393	3.36	1949*
2009-10	158454	7.16	4422
2010-11	160106	5.03	2976*
2011-12	178677	9.89	4455
2012-13	148361	3.52	4426

Source: Office of the Assistant Director of Statistics, Nagapattinam.
*Flood year

Table 12. shows that there exists a decline in the productivity of paddy during flood period than normal period.

Effect of drought and drought relief

Table 4.13 Taluk wise details of area affected by drought and drought relief 2012-13

Sl.No.	Name of the Taluk	Area Cultivated (in Acres)	No. of Farmers affected	Area affected (in Acres)	Relief Fund (Rs.in crores)
1.	Nagapattinam	45934.59	18611	35087.71	52.63
2.	Vedaranyam	47937.78	30563	37482.05	56.33
3.	Kilvelur	39663.25	16566	29761.24	44.64
4.	Thirukkuvalai	26668.59	11131	22616.75	33.92
5.	Mayiladuthurai	32622.10	12444	2316.86	3.47
6.	Sirkali	62933.13	27601	29560.89	44.34
7.	Tharangambadi	37250.07	14198	13173.57	19.76
8.	Kuthalam	27597.31	10208	1835.00	2.75
	Total	**320606.82**	**141322**	**171834.07**	**257.75**

Source: Office of the Assistant Director of Statistics, Nagapattinam.

Table 4.13. shows that the drought relief fund allotted to the Vedaranyam farmers were found to be higher which accounted about 56.33 crores.

Special package during Disaster period

Table 4 14 Samba special package given by the Tamil Nadu government during the disaster period

S.No	Component	Acres/mt	Achievement		No.of farmers benefitted (nos)
			Physical	Financial(Rs in lakhs)	
1	Ploughing for direct sown paddy	Acre	86051.6	412.966	36020
2	Seed subsidy for direct sown paddy	Acre	60543	180.129	11631
3	Weedicide for direct sown paddy	Acre	38200	28.2102	7650
4	Community nursery	Acre	2626.5	498.885	2647
5	Chemical fertilizer	Acre	9778.1	43.9373	3914
6	Gypsum	Acre	8660	27.2326	2768
7	Znso4	Acre	30200	71.8499	9226
8	MN mixture	Acre	15250	14.3736	6195
9	Bio-fertilizer	Acre	35231.8	16.7777	8068
10	Advertisement	Lakh	0	11.5	0
	Total			**1305.86**	**88119**

Source: Office of the Assistant Director of Statistics, Nagapattinam.

Total amount of financial support allotted to the Nagapattinam district were found to be Rs. 1305.86 lakhs.

Table 4.15 Tsunami Relief and Rehabilitation activities in Nagapattinam

S.No.	Particulars	Amount sanctioned (Rs in Crores)
1	Office of Prime Minister	111.39
2	Rajiv Gandhi Rehabilitation Package for house construction and basic amenities	81.13
3	BSNL for construction of 1020 permanent houses	26.02
4	Chief Minister Public Relief Fund for payment to loss of life and injured	148.46
5	Calamity Relief fund	160.70
6	Government of Tamil Nadu for debris clearance and road development	46.67
7	MPLADS for creation of old age home, school buildings	6.25
8	Asian Development bank for creation of infrastructures	133.47
9	World bank	112.49
10	IFAD for livelihood assistance	49.83
11	NGO	300
	Total	**1176.41**

Source: Office of the Assistant Director of Statistics, Nagapattinam.

Tsunami relief fund allotted to the district were found to be Rs.1176.41crores.

Table.4.16 Cyclonic relief centres in Nagapattinam

S.No	Particulars	Numbers
1	No of relief centres opened	241
2	No of people in relief centres	86,475

Source: Office of the Assistant Director of Statistics, Nagapattinam.

Apart from the relief centres mentioned cyclone shelters in 28 locations, along with 13 multi-purpose buildings have been set up to provide shelter in the event of evacuation. Further, all coastline school buildings would also serve as shelters.

CHAPTER V

RESULTS AND DISCUSSION

In the previous chapters, brief introduction and objectives of the study, review of past studies, methodologies used for the study and general description of the study area were presented. Finally, the data collected during the survey were statistically analysed to draw inference based on the objectives of the study. The results of the study are presented and discussed in this chapter under the following sub headings.

- Impact of Disasters
- Socioeconomic Characteristics of Respondents affected by Natural disasters
- Rural people's perception about extreme events
- Assessing the Vulnerability of Farm Households to Disasters
- Effects of the Disaster Events in the study area
- Income of the coastal farmers before and after the occurrence of natural events
- Farmer's choice of adaptation at farm level during the disaster event
- Crop Loss and Crop Insurance Impact studies
- Cost and Returns from paddy cultivation before and after the disaster period

Impact of disasters

Natural disasters in Nagapattinam district

Nagapattinam is a multi-hazard prone district where the entire coast of the district is vulnerable to cyclone, flood and drought hazards with varying frequency and intensity. In a year, as many as five to six cyclones or floods hit these areas along the south-eastern coast of India. Every year these natural disasters in Nagapattinam district challenge agricultural production and these natural disasters have a devastating effect on the economy and most commonly include the agricultural impacts like contamination of water bodies, loss of harvest or livestock, increased susceptibility to disease, and destruction of irrigation systems and other agricultural infrastructure. Due to its long coastline and peculiar location the district is the worst affected among 13 coastal districts in Tamil Nadu. Table 5.1.below shows the years of incidences of cyclone, flood and drought that severely affected in the study area.

Table 5.1 Incidence of cyclone, flood and drought in Nagapattinam district

Cyclone	Flood	Drought
1952	1984	1996
1967	1991	2003
1977	2004	2004
1993	2005	2011
2004	2008	2013
2005	2009	
2008	2010	
2009	2012	
2010		
2011		
2012		
2013		

(Source: Department of Statistics, Nagapattinam)

It could be observed from the table that there exist a frequent incidence of cyclone, flood and drought in the district. Cyclonic floods have been affecting the livelihoods of farmers, particularly those whose lands are close to water bodies.

Table 5.2 Frequency of cyclones between 1952 and 2013 in Nagapattinam district

S.No	Frequency	Years
1	Once in a year	1952,1993,2004,2008,2009,2011,2012,and 2013
2	Twice in a year	1977 and 2010
3	Three times in a year	1967

(Source: Department of Statistics, Nagapattinam)

Frequency of cyclone disaster that crossed Nagapattinam coast are presented in Table 5.2. It shows that the number of cyclones reported during the year 1967 was three times in a year and during 1977 and 2010 it was twice. In rest of the years the frequency was only once in a year. Severe damage was occurred during years mentioned in the table 5.2.

Damages due to disasters in Nagapattinam district

Damages during disasters in the district are presented in table.5.3

Table 5.3 Damages due to disasters in Nagapattinam district

Sl. No.	Date of occurrence	Calamity	Damages caused
1	30-11-1952	Storm waves in land upto 5 miles	400 lives.
2	08-12-1967	Cyclone	7 lives and 15000 rendered homeless.
3	12-11-1977	Cyclone	560 lives and 196 missing and damages to Port, Irrigation systems, road, Power supply and communication including large number of houses.
4	01-12-1984	Floods due to heavy rain.	Crops damaged in large scale and affected normal life of people.
5	15-11-1991	Heavy rainfall	Crops damaged
6	04-12-1993	Cyclone speed 188 Kmph.	1100 people lost their livelihood and heavy damage to crops.
7	26-12-2004	Tsunami waves	6065 life loss, 12821 cattle loss, 791 missing, 1922 injured. Houses loss and damages to shops and building affected the business people.
8	27-11-2008	Nisha Cyclone speed 80 Kmph.	20 Life Loss, 1174 cattle loss, 4,58,949 houses were damaged.
9.	11/2010 and 12/2010	Heavy rain fall	10 Life loss, 1492 Cattle loss, 56025 Huts, Pucca and Katcha houses were damaged. Paddy 76419.00.0 ha, 461.00.0 ha Horticultural crops and 28 ha Ground Nut crops were also damaged.

Source: Department of Statistics, Nagapattinam.

Among these disasters (Table 5.3), 2004 disaster event of Tsunami and cyclone flood was the worst one which left around 6065 people dead and the entire coastline devastated in the district. Around 73 habitations in 38 Revenue Villages and 5 Taluks were affected. Out of these, 1776 were children (887 male, 889 females) which was approximately one-third of the total dead and 2406 were women. Apart from this cattle lost was 12821 numbers and large number of house, boats and other infrastructures were damaged.

Impact of cyclone disaster in Nagapattinam district

The cyclonic event in Nagapattinam district are presented in Tables 5.4 to 5.6

Table 5.4 Damages during Thane cyclone (2011)

S.No	Particulars	Damages
1	Area of crop damaged due to heavy rain(ha)	3170.2
2	No.of Livestocks	1214
3	No. of Boats and Nets	822
4	No.of Houses	626
5	Others	108

Source: Department of Statistics, Nagapattinam.

Cyclone ‘Thane' the strongest tropical cyclone of 2011 severely affected the livelihood activities of people. It could be seen from the table 5.4 that the estimated damage of crops was 3170.20 hectares. Apart from crop damages, the storm damaged houses, livestock and fishing equipment etc.

Table 5.5 Damages during Nisha cyclone (2008)

S.No	Particulars	Damages
1	Area of crop damaged due to heavy rain(ha)	95,152
2	No.of lives lost	8
3	No.of livestock lost	58
4	No.of houses fully damaged	99

Source: Department of Statistics, Nagapattinam.

During this cyclonic period heavy rainfall and stormy winds heavily affected the district in Nagapattinam and over 78,000 people accommodated in 308 cyclone-relief centres.

Table 5.5 shows that cyclone Nisha destroyed 58 numbers of livestock and about 95152 hectares of crops. Also extensive damage has been caused to huts and tiled houses.

Table 5.6 Crop area affected due to Nilam (2012)

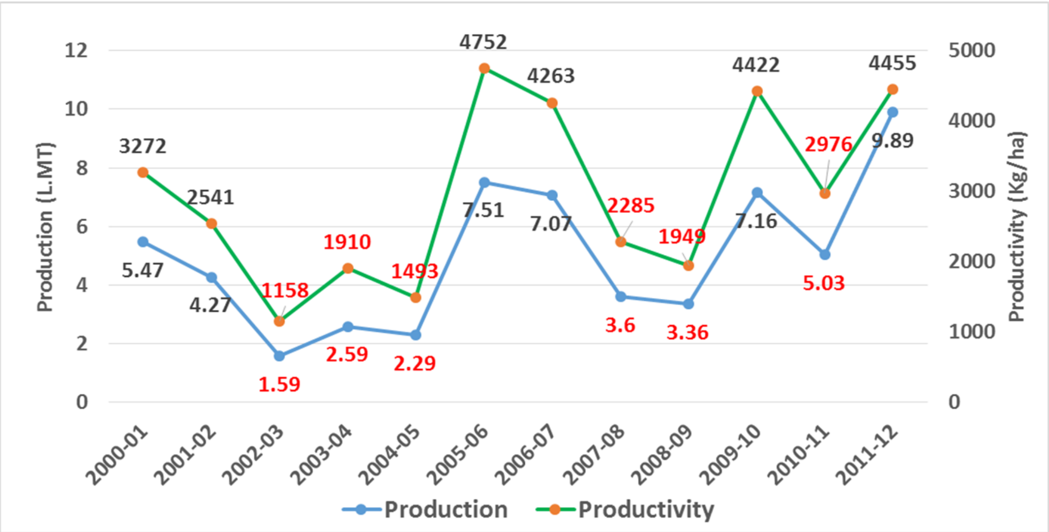
S.No	Particular	Damages
	Flood water total inundated (ha)	81500
1	Directly sown farmland	51486
2	Transplanted farmland	13421
3	Partially submerged	4404
4	Directly sown area	12189

Crop area affected due to Cyclone Nilam are presented in Table.5.6. It is obvious from the table the .Total crop area damaged due to flood in the district was found to be 81500ha.

Impact of flood and drought disasters on agriculture in Nagapattinam district

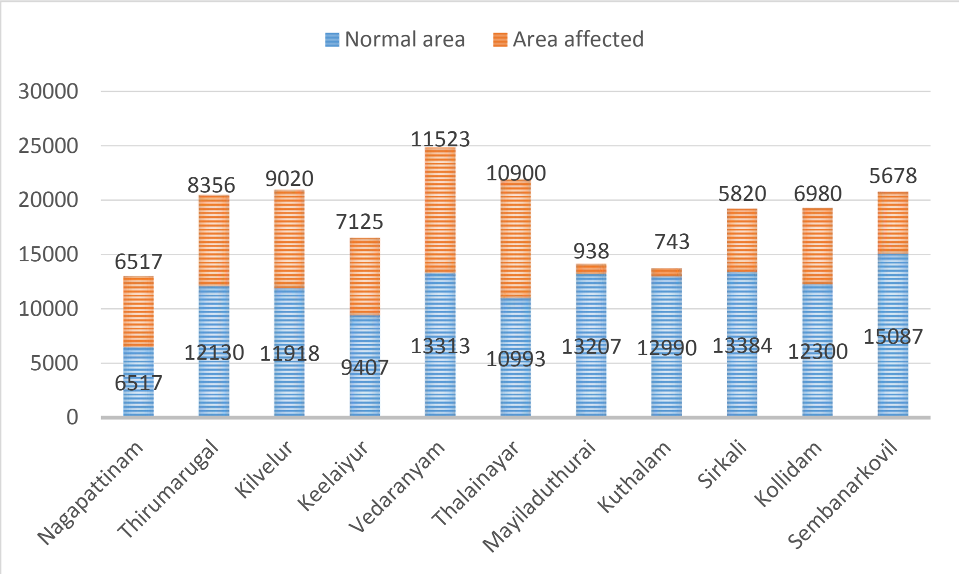
Impact of flood disaster on Agriculture in the study area are presented in Fig. 5.1.which shows that the productivity of paddy was found to be high during the period 2000-01, 2001-02, 2005-06, 2006-07 and 2009-10 and 2011-12 and was about 3272 kg/ha, 2541 kg/ha, 4752 kg/ha, 4263 kg/ha, 4422 kg/ha, 4455 kg/ha and 4426 kg/ha respectively. The total damage to agriculture due to flood disaster decreased from 2002-03, 2004-05, 2007-08, 2008-09 and 2010-11.The affected yield was 1158 kg /ha, 1493 kg/ha, 1910 kg/ha, 2285 kg/ha, 1949 kg/ha and 2976 kg/ha respectively.

Figure 5.1 Impact of flood disaster on productivity of paddy in Nagapattinam district (Kg/ha)



Area affected by drought during the year 2013 in Nagapattinam blocks are presented in Fig.5.2

Figure 5.2 Block wise paddy area affected by drought during 2013 (ha)



Among the blocks in Nagapattinam district, paddy area affected was high in Vedaranyam block which accounted for 11523 hectares.

With the background of this impact of disaster in the study district the data collected from the sample respondents of the study area were analysed and the results are discussed below.

Socioeconomic characteristics of affected by natural disasters

The sample respondents were classified into three categories, viz., Cyclone region farmers, flood region farmers and drought region farmers. A brief description of the socioeconomic characteristics of the sample respondents provides a necessary background for discussing the results of the study.

The following socioeconomic characteristics were analysed: age, educational level, farm size, farming experience, irrigation facility, total farm receipts, income and employment during normal year and in disaster year etc., are presented and discussed.

Age wise distribution of sample farmers

Age of the head in sample households is one of the essential factor, which influences the way of farming and adoption of new technologies. Hence, the same is analysed and the results are reported in table 5.7.

Table 5.7 Age wise distribution of sample farmers

(in numbers)

S.No	Age of Farmer	Cyclone Region	Flood Region	Drought Region
1	Upto 30	3 (5.00)	0	0
2	31-40	18 (30.33)	15 (25.00)	15 (25.00)
3	41-50	18 (30.00)	33 (55.00)	9 (15.00)
4	51-60	11 (18.33)	12 (20.00)	15 (25.00)
5	Above 60	10 (16.67)	0	21 (35.00)
	Total	60 (100.00)	60 (100.00)	60 100.00)

(Figures in parentheses are percentages to respective total)

From the results in Table 5.7, it could be seen that 18.33 per cent of the farmers belong to the age group of 51 to 60 years and 30 per cent to the age group of 31-40 and 41-50 years in cyclone region.

In Flood region and drought region, the percentage of farmers fall under the age group 31 to 40 years constitute 25 per cent in each region and 55 per cent of the farmer fall under the age group of 50 years in flood region which is higher than that of the drought region.

The results revealed that the farmers above 60 years was 16.67 per cent in cyclone region and 35 per cent in drought region.

Literacy level of sample farmers

Educational status of the sample farmers is very much important in decision making process. Therefore the educational level of the farmers were analysed and are presented in table 5.8

Table 5.8 Literacy level of sample farmers

(in numbers)

S.No	Literacy level	Cyclone Region	Flood Region	Drought Region
1	Illiterate	1 (1.67)	0 (0.00)	4 (6.67)
2	Primary	17 (28.33)	6 (10.00)	14 (23.33)
3	Middle School	16 (26.67)	31 (51.67)	17 (28.33)
4	High School	19 (31.67)	13 (21.66)	15 (25.00)
5	Higher secondary	6 (10.00)	7 (11.67)	4 (6.67)
6	College	1 (1.66)	3 (5.00)	6 (10.00)
	Total	60 (100.00)	60 (100.00)	60 (100.00)

(Figures in parentheses are percentages to respective total)

It could be seen from the table 5.8 that in cyclone region, the illiterates and the farmers completed the college level were in same proportion (1.67 per cent each). The percentage of farmers educated upto high school was highest 31.67 per cent followed by primary school 28.33 per cent. Middle school and higher secondary level educated farmers were 26.67 per cent and 6 per cent respectively.

Similarly in flood region, results reveals that there was no illiterate farmers and the proportion of farmers educated middle school was high i.e. 51.67 per cent when compared to other educational level.

In drought region, the percentage of farmers educated upto college level was only six per cent and higher proportion of farmers educated were middle school with a percentage rate of 28.33 per cent. Only 6.67 per cent of the farmers were found to be illiterates and the per cent of farmers educated upto primary school, high school and higher secondary school was 23.33 per cent, 25 per cent and 6.67 per cent, respectively.

These results reveals that majority of the farmers in all the three regions were educated upto middle school and high school. It is learnt during survey that in general the overall literacy rate of the farmers in all the three regions was due to the involvement of several extension activities.

This implies that if the farmers are educated they will be fast to adopt new technologies to cope up and to seek up-date information during the occurrence of natural disasters. Also educational activities increases the annual income through non-farm income source during the disaster period.

Land Particulars of sample farms

The details of land particulars of the sample farmers were analysed and are presented in table 5.9.

Table 5.9 Land particulars of sample farms

(average in ha)

S.No	Classification of land	Cyclone region	Flood region	Drought region
1	Wetland	2.52	2.03	-
2	Garden land	-	-	0.30
3	Dryland	-	-	2.13
4	Total	2.52	2.03	2.43

It could be seen from the table that in cyclone region and flood region wet land constituted the entire total area and the average farm sizes were 2.52 and 2.03 respectively. Similarly in drought region the average farm size was 2.43 of which 2.13 hectares was dry land and 0.30 hectare was garden land.

The above results showed that the farm size was higher in cyclone region than in flood and drought regions. In drought region some of the farmers owned coconut farms which the area accounts only 0.30 hectares and the farms are irrigated through wells available in their farms.

Farm size distribution of the sample farms

The size of the farm decides the level and pattern of farm production. The details on farm holdings is presented in table 5.10.

Table 5.10 Size distribution of sample farms

(in ha)

S.No	Particulars	Cyclone region		Flood region		Drought region	
		No.of farmers	Area operated	No.of farmers	Area operated	No.of farmers	Area operated
1	Small (<-2.0)	57 (95.00)	53.56 (83.21)	50 (83.33)	74.80 (59.75)	53 (88.33)	79.60 (62.19)
2	Medium (2.01-5.0)	3 (5.00)	10.80 (16.79)	6 (10.00)	18.40 (14.69)	3.0 (5.00)	16.40 (12.81)
3	Large (>5.0)	0	0	4 (6.67)	32 (25.56)	4.00 (6.67)	32.00 (25.00)
4	Total	60 (100.00)	64.36 (100.00)	60 (100.00)	125.2 (100.00)	60 (100.00)	128 (100.00)

(Figures in parentheses are percentages to respective total)

Based on the recommendation of National Agricultural Research System the farms with an area less than or equal to two hectares were categorized as small farmers and the farms with an area of greater than 2 hectares and less than/equal to 5 hectares) were categorised as medium farmers and greater than five hectares were categorised as large farmers. Accordingly, out of the total sample size in cyclone region, it could be seen from the table 5.10. that 57 numbers of small farmers had operated 83.21 per cent of area and only three numbers of medium farmers owned 16.79 per cent of total operated area. There exist no large farmers.

In flood region, out of total sample size, 50 numbers of farmers fall under the category of small farmers and the area operated was 59.75 per cent. Medium farmers and large farmers were six and four in numbers operating an area of 14.69 per cent and 25.56 per cent, respectively.

Similarly in drought region, small farmers were 53 in numbers and they had 62.19 per cent of the operated area whereas three medium farmers and four large farmers possessed 12.81 per cent and 25 per cent of the operated area.

This shows that small farmers were high in all the three regions when compared to medium and large farmers. In general, socio-economic condition of the small farmers in the study area was found to be poor and this is risky mainly during disaster period. This situation could lead not only to a loss in farm produce but a total loss in income of the rural farmer during the occurrence of natural disasters and moreover poor farmers may not be able to withstand the effect of natural disasters. Size of the farm also plays a major role in adopting new technologies during disaster events.

Asset position of the sample farms

The financial condition of farmers is indicated by the asset position of farms. Farm assets included land, buildings, machineries, implements and tools, livestock's. These are the basic resources with which farming community run the farm business. The asset position of sample farms were analysed and are presented in table 5.11.

Table 5.11 Asset position of sample farmers

(Average value in Rs/farm)

S.No	Assets	Cyclone region	Flood region	Drought region
1	Land	195733.3 (81.36)	370750.00 (71.05)	171166.00 (61.11)
2	Buildings	14945.65 (6.21)	25653.52 (5.47)	15966.95 (5.70)
3	Machineries(Tractor, power tiller, power sprayer)	13708.33 (5.69)	45939.16 (9.79)	49706.66 (17.74)
4	Implements & tools	987.12 (0.41)	1101.23 (0.23)	1213.45 (0.43)
5	Irrigation structure(Borewell, electric motor)	8679.13 (3.60)	15834.14 (3.37)	28385.11 (10.13)
6	Livestock	6510 (2.70)	9696.66 (2.06)	13642.83 (4.87)
	Total	240563.60 (100.00)	468974.70 (100.00)	280081.70 (100.00)

(Figures in parentheses are percentages to respective total)

The total asset value per farm was Rs.240563.60, Rs.468974.70 and Rs.280081.70 cyclone, flood and drought region respectively. Land accounted for 81.36 per cent in cyclone region, 71.05 per cent in flood region and 61.11 per cent in drought region. The percentage share of buildings, livestock and irrigation structures in cyclone region is 6.21, 2.70 and 3.60 per cent respectively. The value of machineries and implements accounted for 5.69 per cent and 0.41 per cent respectively.

Similarly in flood region percentage share of buildings accounted for 5.47 per cent, machineries 9.79 per cent, irrigation structures 3.37 per cent and livestock was 2.06 per cent respectively. In drought regions the percentage share of buildings accounted for 5.70 per cent, machineries 17.74 per cent, irrigation 10.13 per cent, livestock 4.87 per cent and livestock 0.43 per cent respectively.

It is evident from the table 5.11. that the total value of asset per farm in Flood region and drought region was higher than cyclone regions. Though livestock population is found in all the region, its contribution to the income level of farmer were found to be less. When the income level of the farmers happens to decrease during the occurrence of cyclone, flood and drought, livestock population can be increased to increase the income level of the farmer in order to meet out the immediate need at household level.

Cropping pattern in sample farms

Cropping pattern of the sample farms are presented in the table 5.12. below.

Table 5.12 Cropping pattern in sample farms (ha)

(Average/farm)

S.No.	Crop	Cyclone Region	Flood Region	Drought Region
1	Paddy	0.93 (85.78)	1.98 (100.00)	2.12 (80.50)
2	Pulses	0.15 (14.29)	0 (0.00)	0 (0.00)
3	Groundnut	0	0	0.36 (14.49)
4	Total area cultivated	1.06 (100.00)	1.98 (100.00)	2.48 (100.00)
5	Cropping Intensity (%)	117.71	95.00	116.40
6	Current fallow	0.13	0.10	0.01

(Figures in parentheses are percentages to respective total)

The traditional cropping pattern of cultivation in the study area is kuruvai as the first crop of paddy during June to September followed by thaaladi during October to November. In cyclone region, farmers raise pulse crop after samba / thaladi using the residual moisture in the paddy field and in the drought region farmers raise groundnut.

It could be observed from the table 5.12. that the cropping pattern in all the three regions was dominated by paddy accounting for 85.78, 100.00 and 80.50 per cent of the gross cropped area followed by pulses (Rice fallow) with 25.60 per cent in cyclone region and groundnut with 14.49 per cent in drought region. Cropping intensity worked out to 117.71 per cent in cyclone region, 95.01 per cent in Flood region and 116.40 per cent in drought region.

As the district is frequently exposed to cyclone, flood and drought, majority of the farm holdings practices monocropping where paddy is the main crop cultivated. Continuous monocropping affects the soil health and moreover soil salinity due to sea water intrusion during cyclonic period also affects the farm land to larger extent.

P. Arul, (2007) reported that in Nagapattinam district 7.09 per cent of the land is affected by water logging and marshy land and 56.21 per cent are prone to floods. About 3.49 per cent of the land available for cultivation suffers from salinity/alkalinity and 17.69 per cent of the lands are coastal sand.

As observed in the study area, due to salinity and other degradation caused by flood and drought, some of the small and marginal farmers left their land as fallow. Out of the total cultivated area in the study region 0.13 hectares of the land was left as current fallow in cyclone region, 0.10 hectares of the land in flood region and 0.01 hectares of the land in drought region. This was mainly due to lack of fund at the right time for the maintenance of land before cultivation.

Owing to soil type and quality of irrigation water soil salinity can be tolerated if salt tolerant crops like green manures, vegetable crops like chilli, pumpkin and oil seed crops like sunflower, fruits like watermelon etc., are grown in the affected regions.

Table 5.13 Consumption pattern of farm households

(Amount spent (Rs/yr)

S.No	Particulars	Cyclone Region	Flood Region	Drought Region
1	Food Items	11520 (68.25)	17880 (77.95)	17040 (77.14)
2	Medical	850 (5.04)	744 (3.24)	400 (1.81)
3	Education	2400 (14.21)	2714 (11.83)	2800 (12.68)
4	Cloths and Festival	2110 (12.50)	1600 (6.98)	1850 (8.37
Total		16880 (100.00)	22938 (100.00)	22090 (100.00)

(Figures in parentheses are percentages to respective total)

Table 5.13 shows consumption pattern of farm households. Expenditure on food items was found to be higher in flood region which accounts 77.95 per cent followed by drought region 77.14 per cent and cyclone region 68.25 per cent. Apart from that expenditure on education was found to higher with the percentage share of 14.21 in cyclone region, 11.83 in flood region and 12.68 per cent in drought region and shows farmers in cyclone region spends more than other regions due to the fact that, as the region is very close to Nagapattinam town, the households items are bit costlier than other regions and hence expenditure were also found to be higher.

Farmer's perception about extreme events

Farmer's perceptions about the natural disasters / extreme events are important for future planning to reduce such vulnerability.

The common perception of rural households in the study area is that climate has changed for the worse with increased frequency in recent years. According to the statistical data collected from department of statistics, Nagapattinam (Table 5.1) it was found that cyclone, flood and drought occurred many times over 10 years and hence perceptions relating to extreme variations and severity in the occurrence of disasters were asked individually and are presented in table 5.14.

Table 5.14 Farmers perception on disaster vulnerability over 10 years

(in per cent)

Frequency of events	Cyclone region		Flood region		Drought region	
	Increased	Decreased	Increased	Decreased	Increased	Decreased
Cyclone	92	8	16	84	13	87
Flood	96	4	98	2	0	100
Drought	57	43	72	28	89	11

As seen from table that more than 90 per cent of the respondents felt that the frequency of cyclone and flood have increased in recent years in the study area which was almost drought free in the cyclone regions. However, though the study area had faced a continuous cyclonic period the tsunami induced cyclone during 2004 was the worst in the memory of people which affected almost the entire coastal area.

In the flood region though 98 per cent of the respondents felt increased incidence of flood, some of them mentioned that the intensity has reduced mainly due to construction of embankments and three fourth of the respondents said that the frequency of flood has increased significantly in recent years due to the low lying area of the farm land in the study area.

Similarly, in the drought region 89 per cent of the respondents felt decline in rainfall that led to drought while 11 per cent of the respondents felt that not only there has been a secular decline in the quantity of rainfall but also the pattern of rainfall has become erratic.

The coastal farmers who live with natural disasters expressed that not only the frequency but the intensity of the events had increased over the years.

Assessing vulnerability of farm households to disasters

Disaster events due to climate induced factor may affect agriculture in the coastal area and simultaneously livelihoods of the rural people. Vulnerability depends on its ecological and socio-economic characteristics.

Vulnerability Index in the present study uses the integrated assessment approach to analyse vulnerability of farm households to disaster variability which mainly focuses on the economic status of individuals or social groups. This index was formulated with a number of separate variables that reflect socio-economic and bio-physical indicators which contribute to vulnerability of the farm households to natural hazards.

According to IPCC, Vulnerability is understood as a function of three components —exposure, sensitivity and adaptive capacity. In the present study the vulnerability index was estimated with 18 sub components and their values are presented in Table 5.15. The sub components were normalised by using their mean and standard deviation and the normalized values are given in Table.5.16. From the indexed sub component values, the major component values were worked out and the results are presented in Table 5.16. From the major component values, household vulnerability index were estimated for all the three blocks selected and the results are presented Table 5.18.

Adaptive capacity: Adaptive capacity mostly depends on a number of resources which constitute the asset base forms the foundation for initiating adaptation. It could be observed from table 5.15 that the major components of adaptive capacity were indicated

Table 5.15 Sub–Component values of livelihood vulnerability index for the study area

Major Components	Sub-Components	Units	Cyclone Region	Flood Region	Drought Region
Adaptive Capacity	Livestock ownership	Per cent	31.66	58.33	76.66
	Non-farm income	Rupees / farm	18053	12708	31968
	Farm income	Rupees / farm	-25447.18	-31098.45	-18705.70
	Farm holding size	Hectare	2.52	2.03	2.43
	Cropping intensity	Per cent	117.71	95.00	116.40
	Adoption of Tolerant variety	Per cent	21.67	33.33	30
	Access to credit	Per cent	100	95	85
	Illiterate sample respondents	Per cent	1.67	0	6.67
	Dependence solely on agriculture as a source of income	Per cent	70	80	86
	Share of cultivable waste to the total land area	Hectare	8	6	0.6
	Percentage of households that do not stock crop produce	Per cent	22	15	19
	Percentage of households that utilize rain water source	Per cent	100	100	100
Exposure	Cyclone period	Count	5	3	2
	Flood period	Count	4	4	0
	Drought period	Count	1	2	4
	Variation in monthly rainfall	Mm	154.91	124.95	138.68

Table 5.16 Normalized index sub component for the study area

Major Component	Sub-Components	Standard Deviation	Mean	Normalized value		
				Cyclone Region	Flood Region	Drought Region
Adaptive Capacity	Livestock ownership	22.63	55.55	-1.06	0.12	0.93
	Non-farm income	9942.70	20910	-0.29	-0.82	1.11
	Farm income	6204.36	-25084	-0.06	-0.97	1.03
	Farm holding size	2.33	0.26	0.74	-1.14	0.40
	Cropping intensity	31.15	109.71	1.14	-0.39	-0.74
	Adoption of Tolerant variety	6.01	28.33	-1.11	-0.83	0.28
	Access to credit	7.64	93.33	0.87	0.22	-1.09
	Illiterate sample respondents	3.47	2.78	-0.32	-0.80	1.12
	Dependence solely on agriculture as a source of income	8.08	78.67	-1.07	0.16	0.91
	Percentage of households with well irrigation	0.00	0.00	0.00	0.00	0.00
	Percentage of households buying well water	0.00	0.00	0.00	0.00	0.00
Sensitivity	No.of crops cultivated by respondents	0.58	1.67	0.58	-1.15	0.58
	Share of cultivable waste to the total land area	3.83	4.87	0.82	0.30	-1.11
	Percentage of households that do not stock crop produce	3.51	18.67	0.95	-1.04	0.09
	Percentage of households that utilize a natural water source	0.00	100.00	0.00	0.00	0.00
Exposure	Cyclone period	1.53	3.33	-0.87	-0.22	1.09
	Flood period	2.31	2.67	1.15	0.58	-0.58
	Drought period	1.53	2.33	1.09	-0.22	- 0.87
	Variation in monthly rainfall	15.00	139.51	1.03	-0.97	-0.06

by wealth / financial capital like livestock ownership, income from crop cultivation, income from non-farm sources, size of the farm holding and cropping intensity, growing of tolerant varieties availability of institutional support, livelihood strategy, potential for irrigation and literacy rate.

Cropping intensity, adoption of tolerant varieties and access to credit was higher in cyclone region, whereas the other sub components except farm holding size were found to be higher in Vedaranyam block.The overall adaptive capacity score was positive in cyclone region (0.047) and in drought region (0.323) block and negative in flood region (-0.270) block and (Table 5.18). ,

Though the overall score of adaptive capacity found to be positive in cyclone region, individual sub-component values like livestock ownership and non-farm income sources which have a dominant role next to agriculture are found to be low In general, improving the adaptive capacity has indirect effect on improving the sensitivity of the coastal farmers. Creating opportunities for non-farm income in all the three blocks reduces the dependence of farming community on agriculture, thereby reducing their sensitivity to natural events. In the present study normalized value of non-farm income was high in drought region (1.11) which shows that the opportunity to seek non-farm employment in this block is high than other regions.

Sensitivity: Sensitivity is basically the biophysical effect of climate change and it can be altered by socio-economic changes. In agricultural sector sensitivity to climate induced disaster variability were measured by food and water scarcity. Table 5.15 shows that number of crops cultivated was higher in cyclone region and drought region .Also, in all the three blocks all the farm households reported using a rain water source. Apart from this the share of cultivable waste (8 ha)and the household that donot stock the produce was found to be higher in cyclone region (22 per cent).The overall sensitivity score for all the three regions were found to be negative accounting -0.035 in cyclone region, 0.098 in flood region and -0.277 in drought region (Table 5.18).

This implies that cyclone region and flood regions are more sensitive to natural disasters. Natural resource based income like agriculture, livestock management will also increase the sensitivity of the households as they are highly dependent on climatic condition while the non-farm income sources may reduce the sensitivity as the return from non-farm activities are higher than on - farm activities during the disaster period.

Exposure:

Exposure is defined as a degree of climate stress upon a particular unit of analysis; it may be represented based on the average reported number of cyclone, floods and drought events over the past five years and mean and standard deviation of monthly average rainfall. Cyclone region is highly vulnerable because the region is located in the coastal area whereas flood region is highly vulnerable because the farm land was located in low lying area. The overall exposure score for cyclone region is (0.603), flood region is (-0.383) and drought region is (1.340) block (Table 5.18).

Vulnerability Index

In order to quantitatively assess the overall vulnerability index, Principal Component Analysis (PCA) was run using statistical software (STATA) for the 18 indicators listed in Table.16 Eighteen components were extracted in the first stage of the PCA but only the first six were significant based on the Eigen value criterion being greater than 1(The Eigen value is measure of standardized variance, with a mean of 0 and standard deviation of 1).The first principal component explained a larger variation (20.34 per cent), second principal component explained 12.40 per cent, third and fourth component explained 0.08 per cent each, fifth and sixth component explained 0.07 and 0.06 per cent of variation. Hence the first component factor score was used to construct the vulnerability index, as it explained the majority of the variation. The weights (or scores) assigned to the indicators on first component were -0.081, along with their associated statistics.

It could be observed from the table 5.17 that the factor scores, the scoring factor of the first principal component was positively and negatively associated with the indicators .Thus, for the construction of the vulnerability indices, indicators of adaptive capacity which were positively associated with the scoring factor of the first principal component and all the indicators of sensitivity and exposure which were negatively associated with scoring factor of the first principal component were taken. Higher values of the vulnerability index would show less vulnerability and vice versa. This is because, adaptive capacity was considered to be positively contributing to the reduction of vulnerability, while exposure and sensitivity were negatively contributing in vulnerability reduction.

Based on the formula for vulnerability index given in the methodology, the vulnerability index of each region was calculated based on the normalised value of each indicator as well the weights or scores assigned to the indicators as shown in table 5.16.

It is evident from table 5.18 that the net effect of adaptive capacity was positive in cyclone and drought regions. Sensitivity was negative in cyclone and drought region and Exposure was found to be positive in cyclone and flood region. Farmers in the cyclone and flood regions are highly vulnerable to natural disasters. The vulnerability of cyclone region was mainly associated with lack of livestock ownership (-1.06), non-farm income (-0.29), lower level of literacy rate (-0.32), farmers mainly dependent on agriculture as a source of income (-1.07), high frequency of cyclone (-0.87)

Similarly, the vulnerability of the flood region was attributed to lower farm (-0.97) and non-farm income source (-0.82), low cropping intensity (-0.39), low farm holding size (-1.14), less number of crops cultivated (-1.15), less amount of stock holding (-1.04) and increased incidence of flood occurrence (0.58).

Vulnerability of flood region was associated with Livestock ownership (0.93), increased non-farm income (1.11) stabilisation of farm income (1.03), agriculture as a main source of income (0.91) and higher number of crops cultivated (0.58).

It could be concluded from the table 5.18 that the farmers in the cyclone and flood regions were highly vulnerable to natural disasters and drought region farmers are less vulnerable comparatively with other two regions.

The way to reduce the vulnerability is to decrease sensitivity and to increase adaptive capacity. Creating other job opportunities would decrease sensitivity to disaster events. To increase adaptive capacity, adaptive strategies such as repairing and building reservoirs in cyclone and flood region, irrigation and water storage in drought region, implementing disaster-need agricultural practices like increasing crop diversification will reduce the vulnerability of the farming community.

Table 5.17 Factor scores from principal component analysis and associated statistics

Indicator	Components	Eigen value	Proportion	Cumulative	Scoring Factor:PCA1
Adaptive Capacity	Livestock ownership	3.2538	0.2034	0.2034	-0.081
	Non-farm income	1.9845	0.1240	0.3274	-0.153
	Farm income	1.3862	0.0866	0.4140	-0.129
	Farm holding size	1.3236	0.0827	0.4967	-0.074
	Cropping intensity	1.1693	0.0731	0.5698	-0.043
	Adoption of Tolerant variety	1.0505	0.0657	0.6355	-0.094
	Access to credit	0.9908	0.0619	0.6974	0.004
	Illiterate sample respondents	0.9269	0.0579	0.7553	0.004
	Dependence solely on agriculture as a source of income	0.8857	0.0554	0.8107	0.09
	Percentage of households with well irrigation	0.00	0.00	0.00	0.00
	Percentage of households buying well water	0.00	0.00	0.00	0.00
Sensitivity	No.of crops cultivated by respondents	0.8631	0.0539	0.8646	-0.20
	Share of cultivable waste to the total land area	0.7712	0.0482	0.9128	0.16
	Percentage of households that do not stock crop produce	0.6918	0.0432	0.9561	0.172
	Percentage of households that utilize a natural water source	0.00	0.00	0.00	-0.073
Exposure	Cyclone period	0.6234	0.0390	0.9950	-0.528
	Flood period	0.0794	0.0050	1.0000	0.462
	Drought period	-0.0000	-0.0000	1.0000	0.533
	Variation in monthly rainfall	-0.0000	-0.0000	1.0000	0.306

Table 5.18 Index of major components and overall vulnerability index

S.No	Indicator	Cyclone region	Flood region	Drought region
1	Adaptive Capacity	0.047	-0.270	0.323
2	Sensitivity	-0.035	0.098	-0.277
3	Exposure	-0.603	0.029	-0.75
	Vulnerability Index	**-0.591**	**-0.397**	**1.35**

Effects of the disaster events in the study area

The ultimate impact of a natural disaster on a household depends on the household's vulnerability to its effects. Disasters result in significant economic damage. In addition to their immediate effects on health and mortality, disasters can have indirect, long-term health effects through various mechanisms, including income shocks to households and restricted access to health care. Effects of natural disaster in the study area were analysed and discussed below.

Identification of socio-economic effects of the disasters in the study area

In view with above discussion various socioeconomic effects of the natural events on coastal farmers were enquired individually. These effects includes,

1. **Physical effects** (casualties / deaths / injuries / property damage)

   Physical effects sometimes may also have indirect effect like illness from contaminated water during disaster period. Moreover not only the human loss, losses of livestock, damage of building structures includes the physical effects.

2. **Psychosocial effects** (emotional signs such as anxiety / depression /grief)

   Psychosocial effects relates with mental health during the disaster period and needs support from friends, relatives and neighbours.

3. **Behavioural effects** (sleep and appetite changes)
4. **Socio-demographic effects** (the destruction of households' dwellings)

These effects mostly experienced by the low income family households where older or less stringent households were affected during flood and cyclonic period. Experience related with these socio-economic effects was enquired and numbers of affected farmers are presented in Table 5.19. The results in the table reveals that after the occurrence of natural disasters, there is a high frequency of physical effect in cyclone prone and flood prone region (31.67 and 28.33 per cent) and psychosocial effect in flood prone region was high with 33.33 per cent. Other socioeconomic effects include the behavioural and socio-demographic effect. The percentage of behavioural effect was 28.33, 18.33 and 33.33 respectively in cyclone, flood and drought. It is clear that it was high in drought prone region. The socio-demographic effect was high in flood region (20 per cent).

Table 5.19 Socio-economic effects of disasters on the coastal farmers in the study regions

Socio economic effect	**Cyclone Region**		**Flood Region**		**Drought Region**	
	Responses	Per cent	Responses	Per cent	Responses	Per cent
Physical	19	31.67	17	28.33	15	25.00
Psychosocial	13	21.67	20	33.33	14	23.33
Behavioural	17	28.33	11	18.33	20	33.33
Socio-demographic	11	18.33	12	20.00	11	18.33
Total	60	100.00	60	100.00	60	100.00

This implies that apart from the loss of income on the coastal farmers due to disaster there may also be other side effects like these socio economic characteristics .These are the loss not only to the agriculture but also had negative effect on survival and property.

Factors that increases the effects of natural disasters in Nagapattinam district

There are so many factors in an ecosystem that increases the effect of natural disasters. Some of the factors that accelerate the effect of these disasters were land degradation, topography of farm land, climatic factor, diversification in agricultural activities, standard of living of farmers, flexibility of farmers and adoption of new technologies.

Response of farmers to these factors are presented in the below Table 5.20

Land degradation

Land degradation leads to a significant reduction of the productive capacity of the land. Land degradation occurs mostly due to climate induced forms like water and wind erosion, sand dunes formation, drought and desertification, salt accumulation. The low lying nature of the study districts coastline makes it prone to coastal erosion and flooding very often. It is evident from the table that 15 per cent of the farmers in cyclone and drought region felt that the land degradation leads to natural disaster.

Topography of farm land

According to (ISDR 2002), the topography of a place may aid in accelerating the effects of natural disasters. If the farmers cultivate the crops in flood plain, there will be an occurrence of flood disaster due to the accumulation of water in the plains or if it is a sloppy area after a heavy flood all the nutrient soils will be washed away affecting the crops simultaneously leads to the loss of income of the farmers. Most of the farm lands in the study area were found to plains and some of the area with slight undulation especially in flood prone region. It has the least effect on natural disaster. The percentage of farmers expressed that it has effect on natural disaster was 11.67 per cent, 8.33 per cent and 5 per cent in cyclone, flood and drought regions.

Climatic factor

Agriculture is potentially the most vulnerable of all human economic activities to the effects of climatic change (Trevor Johnson, 2001). As agricultural production is highly dependent on weather, climate and water availability, weather and climate related disasters such as floods and droughts could lead to crop failures, famine, loss of property and life. These climatic change results in climate induced natural disasters such as cyclone, flood and drought are more frequent in the study area. It is obvious from the table that climate change is the predominant factor in all the regions. About 30 per cent of the sample farmers in flood and drought region and 25 per cent of the farmers in cyclone region told that the most frequent factor that increases the effect of natural disasters is change in climate.

Standard of living of farmers

Coastal farmers are the most affected during the disaster period and they mostly experience reduction in safe drinking water and food security. Standard of living of most of the small and marginal farmers in the study area was observed to be poor. It is evident form the table that the factor standard of living increases the effect of disasters by 11.67 per cent in cyclone region, 13.33 per cent in flood region and 15 per cent in drought region.

Diversification in agricultural activities

It is the involvement of farmers on one or more enterprises at the same time. Palanisamy et al (2009) have examined the vulnerabilities of the costal districts of Tamil Nadu to climatic change. They have concluded that Ramanathapuram and Nagapattinam districts are most vulnerable to climatic change. The crop diversification indices of the two districts for the year 2005-06 are respectively 0.403 and 0.413 which means that only about 40 per cent of the agricultural area are occupied by diverse crops. It was found in the study area that the diversification of crops is limited due to this climate induced natural disaster. The percentage of farmers expressed that the effect of natural disasters by diversification of farmers was 15 per cent in cyclone region, 11.67 per cent in flood region and 10 per cent in drought region.

Flexibility of the farmers

Flexibility means planning in such a way as to be able to shift interest when favourable opportunities arise. If the farmer is not flexible he might be in trouble during unfavourable conditions, which will lead to a loss in income. The large farmers in the study area are able to adjust the disaster situation than the small and marginal farmers due to poor standard of living of the households. It is evident form the table that 11.67 per cent in cyclone region, 13.33 per cent in flood region and 10 per cent in drought region.

Adoption of new technologies

Technology has a dominant role to play during disaster period. If new technologies were not adopted like using resistant crop varieties and new land management practices there is a chance of losing the farm which will lead to a loss in income. It was observed that farmers with large farm size in the study area adopts new technology and invested high on farm machineries to cope up with the disasters situation. 10 per cent of the farmers in the cyclone region, 8.33 per cent of the farmers in the flood region and 15 per cent of the farmers in the drought region felt that adoption of new technology as the effect of natural disasters.

. **Table 5.20 Factors that increase the effects of natural disasters in Nagapattinam district**

(in per cent)

Factors	Cyclone Region		Flood Region		Drought Region	
	Responses	Per cent	Responses	Per cent	Responses	Per cent
Land degradation	9	15.00	8	13.33	9	15.00
Topography of farm land	7	11.67	5	8.33	3	5.00
Change in climate	15	25.00	19	31.67	18	30.00
Diversification in agricultural activities	9	15.00	7	11.67	6	10.00
Standard of living	7	11.67	8	13.33	9	15.00
Flexibility of farmers	7	11.67	8	13.33	6	10.00
Adoption of new technology	6	10.00	5	8.33	9	15.00
Total	60	100.00	60	100.00	60	100.00

From Table 5.20 the most frequent factor that increases the effects of natural disasters were identified and that was found to be the change in climate in all the three disaster prone region with 25 per cent, 31.67 per cent and 30 per cent respectively and the less dominant factor that increases the effects of natural disasters in cyclone region are adoption of technology. The other factors included are standard of living of the rural, topography of the farm and diversification of agricultural activities which was found to be 11.67 per cent each and land degradation which was found to be 15 per cent. Similarly in the flood region, the less dominant factor that increases the effect of natural events was topography of the farm land adoption of technologies with a percentage rate of 8.33 per cent each.

It could also be seen from the Table 5.20 that in drought region the factor topography of the land shows less impact and the other factors includes diversification of agricultural activities and flexibility of farmers with a percentage rate of 10 per cent each, whereas the other factors involved are environmental degradation, standard of living of the coastal farmers and adoption of new technologies with a percentage rate of 15 per cent each.

It is a fact that natural disasters hit farmers who are vulnerable, and these factors make the coastal farmers vulnerable to natural disasters. It is evident from the results that the climate change is one of the major factors that increase the natural disaster affecting the farming community engaged in farming.

Factors influencing the income of coastal farmers affected by natural disasters

Table 5.21 to 5.23 below show the impact of the independent variables on the income of the coastal area farmers. As discussed in methodology, the variables included in the regression model are land degradation, climatic factor, crop diversification, standard of living, adoption of technologies.

The analyses were carried out using four models. The significancy was tested using four statistical and econometric criteria – t-ratios, magnitude of the Coefficient of Multiple Determination (R^2), the F-Statistic and the sign of coefficient or parameter estimate. Exponential and double log functional form were chosen as the lead equation of the models, because it has the highest R^2 and F-value.

Table 5.21 Factors influencing the income of coastal farmers in cyclone region

Variables	Linear	Semi log	Double log	Exponential
	Co-efficient	Co-efficient	Co-efficient	Co-efficient
Land Degradation (X_1)	75.22 (1.00)	149.62 (0.94)	2.15 (1.58)	0.61 (2.05)
Climatic factor (X_2)	-69.37** (-3.66)	-79.33* (-5.99)	-0.57* (-5.06)	-0.39* (-5.18)
Crop diversification (X_3)	16.79** (1.84)	48.43** (2.04)	0.78* (3.85)	0.15** (2.11)
Standard of living (X_4)	3.89 (0.14)	28.54 (0.98)	0.50 (1.03)	0.09 (0.83)
Adoption of technologies(X_5)	0.39 (2.45)	0.23** (2.15)	1.09** (2.10)	0.22** (1.89)
Constant R^2 F Value	11.57 0.57 14.20	56.79 0.55 13.36	10.47 0.86 64.10	11.55 0.86 67.47

Figures in parentheses under the independent variables are the respective t-values
* 1 % Significance level
** 5% Significance level

Table 5.22 Factors influencing the income of coastal farmers in flood region

Variables	Linear	Semi log	Double log	Exponential
	Co-efficient	Co-efficient	Co-efficient	Co-efficient
Land Degradation (X_1)	-44.89* (-5.69)	-167.17* (-6.35)	-6.50* (-10.83)	-1.86* (-10.77)
Climatic factor (X_2)	-13.35** (-1.90)	-51.05** (-2.08)	-2.63* (-4.73)	-0.76* (-4.83)
Crop diversification (X_3)	-9.25 (-1.78)	-22.34 (-1.47)	-0.07 (-0.01)	-0.01 (-0.12)
Standard of living (X_4)	10.46 (1.98)	23.68 (1.64)	0.29 (0.89)	0.10 (0.91)
Adoption of technologies(X_5)	0.85 (0.31)	9.39 (0.57)	0.08 (0.23)	0.02 (0.18)
Constant R^2 F Value	231.82 0.58 14.92	321.83 0.57 14.82	21.05 0.76 34.19	18.97 0.75 34.21

Figures in parentheses under the independent variables are the respective t-values
* 1 % Significance level
** 5% Significance level

Table 5.23 Factors influencing the income of coastal farmers in drought region

Variables	Linear	Semi log	Double log	Exponential
	Co-efficient	Co-efficient	Co-efficient	Co-efficient
Land Degradation (X_1)	-90.09* (-6.69)	-320.183* (-6.75)	-4.46* (-8.21)	-1.28* (-8.29)
Climatic factor (X_2)	-5.03* (-2.24)	-2.87* (-2.04)	-5.90* (-7.34)	-1.61* (-6.75)
Crop diversification (X_3)	17.99** (2.01)	37.98** (1.88)	0.34** (1.58)	0.18** (1.79)
Standard of living (X_4)	5.54 (0.69)	8.41 (0.45)	0.32 (1.49)	0.13 (1.47)
Adoption of technologies(X_5)	15.66* (5.28)	29.12* (4.64)	0.61* (4.43)	0.32* (4.81)
Constant R^2 F Value	344.14 0.59 15.57	28.77 0.58 15.30	13.24 0.83 53.92	10.96 0.81 54.08

Figures in parentheses under the independent variables are the respective t-values

* 1 % Significance level

It could be observed from the tables 5.21 to 5.23 that there exist a negative co-efficient of the variable X_2 (Climatic factor) significant at 1 per cent in all the three disaster regions which indicates a negative relationship with the dependent variable.

For climatic factor that affect income, the current analysis focussed on rainfall and temperature which are related with climate induced natural disasters such as floods, drought and cyclone as these are the most common weather related constraints in the study area. These variables were estimated against farm income of the farmers. Results shows that the association between the farm income and climatic factor was statistically significant at one per cent level and the coefficient for this variable had a negative sign in all the three regions which implies that cyclone, flood and drought incidence negatively affected the farm income.

Elasticity for the climatic factor indicates that a percentage change in the rainfall will increase the incidence of cyclone lead to the reduction in the income level of the farmer at 0.57 per cent in cyclone region .Similarly, in flood region a percentage change in the rainfall increases the incidence of flood and reduces the income level of the farmer at 2.6 per cent (Table 5.22).

Likewise in drought region (Table 5.23) one percentage increase in temperature will increase dryness and reduces the income level of the farmer at 5.90 per cent. This implies that there is a great need for agroforestry and green belt development in cyclone and erosion prone areas in order to prevent the farmlands in future.

From the tables 5.21 to 5.23 it could be observed that the variable X_1 (land degradation) shows a negative relationship with the dependent variable Y and showed significancy at one per cent level in flood and drought region. As land degradation is the major problem in these regions a percentage increase in the degradation of the land due to erosion in flood region will decrease the income level of the farmer by 6.50 per cent and a percentage increase in land degradation due to water scarcity will decrease the income level of the farmer by 4.46 per cent in drought region.

It could also be observed from the table 5.21 and 5.23 the variable X_3(crop diversification) had a positive coefficient which is significant at five per cent in cyclone region and drought region indicates that for a unit increase in the practice of crop diversification will increase the income of the farmers by 0.78 per cent in cyclone region and 0.34 per cent in drought region. Farmers in this area naturally preferred cultivating rice. If farmers diversify their agricultural activities there will be an increase in the income.

Similarly the variable X_5 (adoption of new technology) in cyclone and drought region shows a positive co-efficient which is significant at five per cent level in cyclone region and one per cent in drought region which implies that for every unit increase in the usage of technology will increase the income of the farmers by 0.65 per cent in cyclone region and 0.61 per cent in drought region. As paddy is the main crop cultivated in the study area farmers will be benefitted if new technologies like SRI paddy cultivation, adaptation of flood tolerant varieties and usage of agricultural machineries etc. to reduce the cost of cultivation.

Income of the coastal farmers before and after the occurrence of natural disasters

Wilcoxon matched pairs signed rank test is the non-parametric test which is used to find whether there is any difference between two sets of paired observations. This nonparametric test makes use of the sign and the magnitude of the rank of the differences (original paired differences minus the hypothesis value). As mentioned in the methodology, difference in the income earned by the farmers before and after the effects of disasters in the study area were analysed through this test and the results are presented in Table 5.24

Table 5.24 Test scores of Wilcoxon matched pairs signed rank test in disaster regions

Income before disaster – Income after disaster	**Cyclone region**	**Flood region**	**Drought region**
(N) Negative ranks Positive ranks Ties Total	 50.0[a] 10.0[b] 0[c] 60	 57.0[a] 3.0[b] 0[c] 60	 46.0[a] 14.0[b] 0[c] 60
Mean rank	31.80 24.00	31.72 7.33	30.41 30.79
Sum rank (for total sample)	1590.00 240.00	1808.00 22.00	1399.00 439.00
Test statistics Z – value Asymptotic significant(2-tailed)	 -4.90[a] 0.000	 -6.574[a] 0.000	 -3.563[a] 0.000

a - post < pre, b - post > pre, c - post = pre

The test produced Z-values of -4.90, -6.574, and -3.563 in all the three affected region which were significant when compared with the critical Z-value at 0.05 of 1.64. The result shows that there was a significant difference between the income earned by the farmers before and after the occurrence of natural disasters in all disasters affected regions.

Agricultural failure and further reduction in the income level during the disaster period tends to engage with several income opportunities through non-farm income source. Though the non-farm income source supports financially, severity of heavy rain, flood or cyclonic event during that period reduces the days of employment, simultaneously reduces the level of income.

Income management of farm households against disasters

Income management is the coping mechanism which are influenced by the farmers previous experience. It is the remedial action taken by the farmers whose survival and livelihood are threatened by the natural events. There are nine income management strategies that were posed the respondents to choose as many as they would expect to employ during a disaster situation. Table 5.25 shows the results of the income management of the rural household at the time of crop failure.

Table 5.25 Income management of farm households against disasters

S.No.	Source	Cyclone region	Flood region	Drought region	Total N=180
1	Savings in Bank	14 (23.33)	6 (10.00)	11 (18.33)	31 (17.22)
2	Sale of stored produce	9 (15.00)	11 (18.33)	16 (26.67)	36 (20.00)
3	Sale of fixed assets	-	5 (8.33)	6 (10.00)	11 (6.11)
4	Borrowing from friends and relatives	12 (20.00)	17 (28.33)	14 (23.33)	43 (23.89)
5	Borrowing from money lenders2	17 (28.33)	22 (36.67)	17 (28.33)	56 (31.11)
6	Hypothecation of assets or jewellery	6 (10.00)	18 (30.00)	15 (25.00)	39 (21.67)
7	Bank loan	19 (31.67)	25 (41.67)	28 (46.67)	72 (40.00)
8	Agricultural labour & non - farm income	29 (48.33)	30 (50.00)	38 (63.33)	97 (53.89)
9	Government relief & Insurance	58 (96.67)	55 (91.67)	51 (85.00)	164 (91.11)

(Figures in parentheses are percentage to respective total)

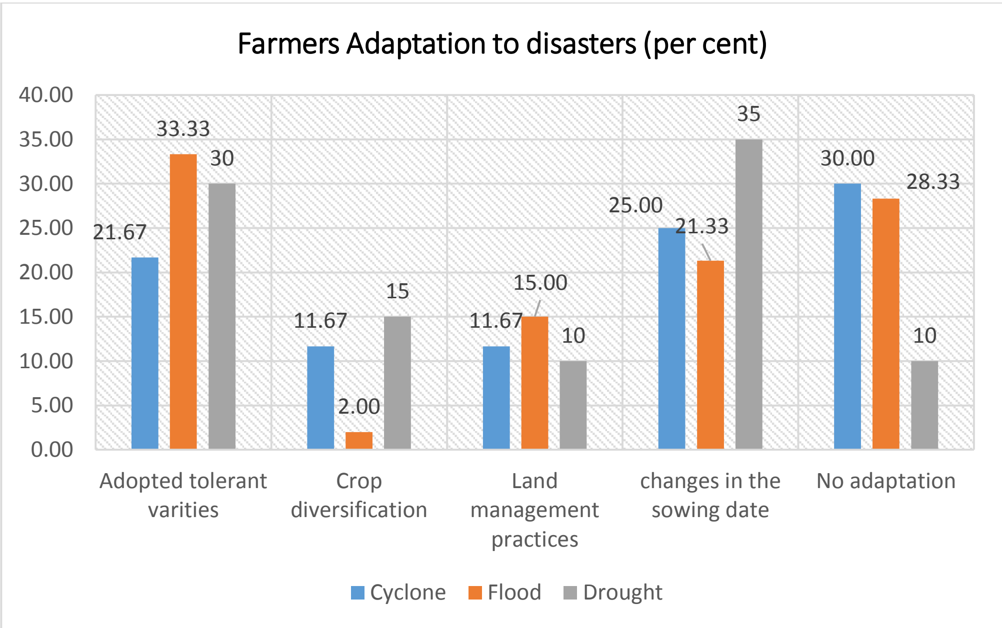
The foremost alternative for the farmers in all the disaster prone region was government relief fund and insurance. The other main income management measures followed by the farmers were agricultural income and non-farm income, availing bank loan, borrowing from money lender, borrowing money from friends and relatives, hypothecation of assets and jewellery (Table 5.25).

Agricultural labour and non-farm income in drought region was found to be high due to the fact that they were highly engaged with other occupation like small scale industries, engaged as a labour in prawn culture etc.,

Farmer's choice of adaptation at farm level during the disaster event

The adaptation methods for this study are based on asking farmers about their perceptions of disaster events and the actions they take to counteract the negative impacts of disaster events (Figure 5.3.)

Figure 5.3 Farmers adaptation to disaster events



As indicated in Figure 5.3 Adaptation of tolerant varieties of paddy like BPT 5142, ADT-45, Co-43 is most commonly used adaptation in all the three regions, whereas crop diversification with pulses, groundnut is practiced less. Similarly adaptation of land management techniques like conservation tillage, were also found to be less in all the three regions.

It could also be seen that most of the farmers adopt the technique of changing their sowing date with a percentage of 35 per cent in drought region, 25 per cent in cyclone region and 21.33 per cent in flood region.

Moreover, 30 per cent in cyclone region, 28.33 per cent of farmers in flood region and 10 per cent in drought region farmers reported that they have not taken any adaptation method for a number of reasons.

Analysis of the determinants of farmers' choice of adaptation methods

Independent variable

Different household and farm characteristics, infrastructure and institutional factors influence the use of adaptation methods by farmers. The most commonly cited household characteristics include age, education, farming experience, marital status, gender of the head of household, and wealth. Farm characteristics include farm size, fertility, and slope; institutional factors include access to extension and credit; and infrastructure includes distance to input and output markets.

The dependent variables used for the present study are number of farmers who practiced adoption of tolerant varieties, crop diversification, started using new land management practices, changes in the sowing date, and no adaptation. For ease of study, all the dependent variables were taken together for the analysis. The independent variables includes education of the household head, experience in farming, age of the household head, size of the household, farm income, non-farm income, farm size, livestock ownership, extension on crops and livestock, credit, temperature and rainfall.

Table.5.26 gives the descriptive statistics of the independent variables hypothesized to affect adaptation measures in this study.

Multinomial logit model (MNL) was used to analyse the determinants of farmer's choice of adaptation of different techniques during the period of disaster such as cyclone, flood and drought. The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable. The marginal effects from the MNL measures the expected change in probability of a particular choice being made with respect to a unit change in an independent variable.

Table 5.26 Description of model variables for the multinomial logit model

Explanatory variable	Mean	Standard deviation
Education of the household head (years)	6.99	3.01
Experience in farming(years)	27.17	10.87
Age of the household head (years)	50.75	11.87
Size of the household(numbers)	4.64	1.08
Farm income(Rs/ha)	24331	12219
Non-farm income(Rs/ha)	39152	13732
Farm size(ha)	1.61	1.14
Livestock ownership(dummy:1 if livestock owned and 0 otherwise)	0.72	0.45
Extension on crop and livestock production(dummy:1 if extension service is accessed and otherwise)	0.55	0.50
Credit(dummy:1 if there is access and 0 otherwise)	0.76	0.43
Temperature (^{0}C	33.97	3.63
Rainfall (mm)	94.24	6.61

The estimated coefficients of the multinomial logit model, along with their levels of significance are presented in the Table 5.27. In all cases the estimated coefficients should be compared with the base category of no adaptation. Table 5.28 presents the marginal effects along with the levels of statistical significance at five per cent level.

It could be observed from table 5.28, that age of the household does not have significant influence on adoption of new technologies which implies that age is not a matter for adopting new technique during the occurrence of disaster event. Years of education of the farmer significantly helped him to adopt new land management practices during disaster situations. This implies that farmers with higher level of education are more likely to adopt better to disaster events.

Nonfarm income, significantly increases the likelihood of adopting tolerant varieties, crop diversification, using new land management practices and adoption to early sowing or late sowing. A unit increase in nonfarm income increases the probability of adopting tolerant varieties, crop diversification, using new land management practices and adoption to early sowing or late sowing by 1.7 per cent, 2.2 per cent, 7.3 per cent and

6.2 per cent respectively. When the farmer's non-farm income increases, there is a chance of investing in agriculture during disaster events to cope up the situation.

It was evident from the results that ownership of livestock is negatively related to adoption of crop diversification and early and late sowing by 8.1 per cent and 8.5 per cent respectively. The co-efficient of crops and livestock extension have a significant and positive relationship of choosing measures such as adopting new land management practices (7.7 per cent) and early or late sowing of seeds (3.9 per cent) .This implies that farmers who have access to extension services are more likely to be aware of disaster events as well as the knowledge of various management practices they could employ to adopt to disaster conditions.

Access to credit has a negative and significant impact on the likelihood of using tolerant varieties, adopting new land management practices and early or late sowing by 4.2 per cent, 4.7 per cent and 4.7 per cent respectively and positive and significant impact on crop diversification by 8.7 per cent. This implies that farmers accessing credit are likely to be already engaged in different income generating activities which improve their adaptive capacity and thereby reducing need for adoption of new technique.

The results also reveal that higher annual mean temperature over the survey period in drought regions tend to induce adoption of tolerant varieties which influence positively new adopting technologies during the period of disaster. A rise in temperature by one degree higher than the mean increases the probability of using tolerant varieties by 8.2 per cent and adoption of late sowing or early sowing by 3.5 per cent. These imply that, when the temperature is high, farmers will conserve soil to preserve the moisture content and use drought tolerant varieties to cope with increased temperature. Moreover, farmers will vary planting dates so that critical crop growth stages do not coincide with peak temperature periods.

Like rising of temperature, higher levels of rainfall in flood and cyclone regions tend to induce adoption of new technologies to reduce crop loss. It is a fact that increases in rainfall relaxes the condition made due to high temperature on soil and crop growth. The results of this analysis also showed that the increase in rainfall significantly increases the adoption of adjusting the sowing date and adoption of new technologies.

Table 5.27 Parameter estimates of the multinomial logit model for adaptation disaster event

Explanatory Variables	Adoption of tolerant varieties		Crop diversification		Land management practices		Early sowing or late sowing	
	Co-eff	P value	Co-eff	P value	Co-eff	P value	Co-eff	P value
Age	0.046	0.362	-0.012	0.859	0.027	0.589	0.019	0.689
Education	-0.106**	0.087	0.155	0.408	0.287**	0.041	0.281	0.100
Size of the household	0.265	0.610	0.015	0.978	-0.033	0.574	-0.030	0.942
Experience in farming	-0.035	0.535	-0.110**	0.075	-0.033	0.401	-0.022	0.599
Farm income	0.000*	0.016	0.000	0.535	-0.003	0.567	-0.806	0.901
Non-farm income	0.000**	0.043	0.000**	0.036	0.000**	0.099	0.000**	0.093
Farm size(ha)	-0.545	0.192	-0.110	0.741	0.000	0.797	0.000	0.101
Livestock ownership	-1.395	0.238	-1.236**	0.039	-0.034	0.983	-1.227**	0.042
Extension on crop and livestock production	2.973**	0.059	-1.080**	0.024	-1.080**	0.094	2.562**	0.032
Credit	-1.773**	0.016	1.994	0.177	-2.555	0.000	-1.773**	0.016
Temperature	-2.367	0.737	8.935	0.217	3.327	0.647	0.147**	0.06
Rainfall	3.326	0.164	0.491	0.815	-2.229	0.316	0.080**	0.05
Constant	49.79	0.704	-57.058	0.558	56.91	0.540	22.20**	0.039
Number of observation	180							
Prob>chi square	64.14							
Log likelihood	-59.33							
Pseudo R-Square	0.3509							

* 1% significant level

** 5% significant level

Table 5.28 Marginal effects from the multinomial logit disaster event adoption model

Explanatory Variable	Adoption to tolerant varieties		Crop diversification		Started using new land management practices		Early sowing or late sowing	
	Co-eff	P vale	Co-eff	P vale	Co-eff	P vale	Co-eff	P vale
Age	-0.001	0.655	0.002	0.694	0.002	0.694	0.001	0.865
Education	0.010	0.473	0.001	0.945	-0.015**	0.077	0.051	0.159
Size of the household	0.015	0.594	0.001	0.984	-0.005	0.798	-0.014	0.876
Experience in farming	-0.001	0.645	-0.001	0.645	-0.004	0.424	0.001	0.850
Farm income	0.000	0.138	0.000	0.807	0.000	0.767	0.000	0.277
Non-farm income	0.000**	0.017	0.000**	0.022	0.000**	0.073	0.000**	0.062
Farm size(ha)	-0.011	0.620	0.033	0.432	-0.030	0.254	-0.171	0.114
Livestock ownership	-0.130	0.340	-0.098**	0.081	0.030	0.457	-0.097**	0.085
Extension on crop and livestock production	-0.200**	0.015	0.225	0.724	0.076**	0.077	0.387**	0.039
Credit	-0.122**	0.042	0.198**	0.087	-0.347**	0.047	-0.254**	0.020
Temperature	3.200**	0.082	0.755	0.322	-0.343	0.450	-2.849**	0.035
Rainfall	0.158	0.325	-0.016	0.946	1.801**	0.068	-1.375**	0.039

** 5 % significant level

Analysis of farmers' perceptions and adoption to disaster events

Description of model variables for the Heckman Probit selection model

Heckman Probit Model was used to study the factors that determine adaptation to disaster events in all the three study regions. Descriptive statistics of independent variables included in the selection model and outcome of the model are presented in Table.5.30 and Table.5.31 respectively. The results show that out of the total sample size of 180 farmers 60 per cent of the farmers were aware of disaster events and the remaining 40 per cent were not aware about the occurrence of disaster events.

It is also revealed from the table that out of the total sample size of 180 farmers 66.11 per cent of the farmers adopted some of the techniques like adoption of tolerant varieties, starting new land management practices, early or late sowing of the seeds, crop diversification practices etc., to overcome the disaster events and rest of 33.88 per cent of the farmers were not adopting any of the techniques.

Table 5.29 Description of variables of the selection equation used in Heckman Probit Model

Farmers perception on disaster events	Farmers who perceived changes (per cent)	Farmers who did not perceived changes(per cent)
Independent Variables	60	40
Description		
	Mean	Standard deviation
Education of the household head in years (continuous)	6.99	3.01
Age of the household	50.75	11.87
Farm income from crop cultivation in Rs.(continuous)	24331	12219
Non-farm income (Rs)	39152	13732
Information on disaster events	0.60	0.49

Probit model was run and tested for its appropriateness over the standard probit model and the results indicated the presence of a sample selection problem (dependence of the error terms from the outcome and selection models), justifying the use of the Heckman probit model with *rho* significantly different from zero with the likelihood

Table 5.30 Description of variables of the outcome used in Heckman probit model

Dependent Variables	Adopted farmers(Per cent)	Non adopted farmers (per cent)
Adoption to disaster events (dummy: takes the value of 1 if adopted and 0 otherwise)	66.11	33.88
Independent variables		
Description		
Adoption to disaster events	Mean	Standard Deviation
Education of the household head in years (years)	6.99	3.01
Experience in farming (years)	27.17	10.87
Non-farm income(Rs)	39152	13732
Size of the household(numbers)	4.64	1.08
Farm size(ha)	1.61	1.14
Livestock ownership(dummy:1 if livestock owned and 0 otherwise)	0.72	0.45
Extension on crop and livestock ((dummy:1 if extension service is accessed and otherwise)	0.55	0.50
Credit (dummy:1 if there is access and 0 otherwise)	0.76	0.43
Temperature	33.97	3.63
Rainfall	94.24	6.61

Table 5.31 Results of Heckman probit selection model

Explanatory Variables	Adoption Model		Selection Model	
	Regression Coefficients	Marginal Values Coefficients	Regression Coefficients	Marginal Values Coefficients
Education	0.001 (0.884)	0.002 (0.867)	0.341* (0.000)	0.115* (0.000)
Experience	-0.002 (0.479)	-0.001 (0.637)	-	-
Age of the household	-	-	0.034** (0.0019)	0.011** (0.012)
Farm income	4.85E-06 (0.137)	2.50E-06 (0.111)	0.000 (0.384)	0.0001 (0.387)
Non-farm income	-	-	0.00001* (0.000)	0.00002* (0.000)
Size of the household	0.103** (0.002)	0.101** (0.002)	-	-
Farm size(ha)	0.087* (0.024)	0.026* (0.014)	-	-
Livestock ownership	-0.20134* (0.027)	-0.20408* (0.026)	-	-
Credit	0.145* (0.09)	0.150* (0.02)	-	-
Temperature	-0.253 (0.407)	-0.162 (0.599)	-	-
Rainfall	-0.027* (0.000)	-0.0165* (0.000)	-	-
Constant	-5.108* (0.000)		-4.36* (0.000)	
Total observations	180			
Censored	72			
Uncensored	108			
Wald Chi square (Zero slopes)	68.10 P<0.000			

*1 % significant level
** 5 % significant level

function of the Heckman probit model significant with Wald χ^2= 68.10, and p < 0.0000 showing the strong explanatory power of the variables.

Adaptation to disaster events is a two- step process which requires that farmers perceive disaster event in the first step and respond to changes in the second step through adoption. It could be evident from the results that the variables positively and significantly influence adoption to disaster events includes size of the household, farm size, livestock ownership, extension on credit and livestock ,access to credit and rainfall.

The family size is significant and has a positive coefficient implies that larger families tend to adopt more to disaster events than smaller farmers. It shows that increasing the size of the household by one person increases the probability of adaptation to disaster event by 10.10 per cent by engaging additional human power during the disaster period. This implies that large family size is normally associated with a higher labour endowment, which would enable a household to accomplish various agricultural tasks, especially during peak seasons. Likewise, increasing farm size increases the probability of adoption by two per cent. The co-efficient of farm size is positively and significantly correlated implies that large scale farmers are more likely to adopt because there will be more capital and resources, so that it is possible for them to invest in new technologies which demand high cost. Access to credit has a strong influence on farmer's decisions to adopt during disaster events. The result shows that credit accessibility is positively and significantly related his shows that if farmer has access to credit his probability of adoption of technology to disaster events increases by 15 per cent. More financial resources allows the farmers to change the farming practices in response to changes during disaster events. Other variables like livestock ownership, extension on crop and livestock, and increasing rainfall have negative probability of adoption.

It could also be revealed from the table 5.31 that perceiving to disaster events is positively related to education, age of the households, non-farm income and information on disaster events. It shows that higher the age of the household head by one year increases the probability of perceiving a change in climate by 1.1 per cent, Likewise, factors that are believed to create awareness about disaster events, such as access to information on change, increase in non-farm income and increase in the education level increases the likelihood of adoption by 31.2 per cent, 0.01 per cent and 11.5 per cent respectively.

Constraints to farmers farm level adoption strategies

Farmers practice different adoption methods to cope up with disasters. In this process they face various constraint at field level.

Access to information is highly desired by the farmers to achieve the optimal farm yield and it can be made available through extension workers, government agencies, rural radio and televisions. If information is not disseminated properly farmers may unable to cope-up the situation.

Credit is the major source of investment in agriculture especially during the disaster event to adopt the techniques. Lack of credit limits the ability of the farmers to get the necessary resources and technologies they might want in order to adjust during condition.

Cyclone, flood and drought disasters affect coastal farmers in larger extent, affecting agriculture. Severity of this event sometimes leads to the failure of adoption techniques and leads to complete loss of crops. This situation is found to be a major constraint in adopting the technology like improved crop varieties, crop diversification, during the disaster event. Low input usage by farmers due to market constraints reduces the profitability of input use which is one of the main constraints during the time of adoption of technique. The perceived constraints to use various farm level adoption techniques during disaster event and are presented in table.32.

Table 5.32 Farmers constraints to adaptation method

S.No.	Particulars	Cyclone Region	Flood Region	Drought Region
1	Lack of information	10 (16.67)	5 (8.33)	27 (45.00)
2	Lack of credit accessibility	25 (41.67)	30 (50.00)	14 (23.33)
3	Magnitude of the event	12 (20.00)	15 (25.00)	8 (13.33)
4	lack of necessary farm inputs	13 (21.67)	10 (16.67)	11 (18.33)
	Total	60 (100.00)	60 (100.00)	60 (100.00)

(Figures in parentheses are percentages to respective total)

The results from the household survey indicated that lack of credit accessibility is the main constraint to adopt technology during disaster event and that was found to be higher in flood region (50 per cent). Lack of information reported to be the highest constraint found in drought region (45 per cent) and severity of the event was found to be high in flood region (20 per cent) and lack of necessary farm input was found to be high in cyclone region (21.67 per cent).

Crop loss insurance

Many of the adaptation strategies were followed by the farmers to avoid crop loss during the disaster period which was discussed earlier. Crop loss results during the incidence of disaster events. Government of India has framed guidelines for providing relief from National Disaster Response Fund (NDRF) and State Disaster Response Fund (SDRF) in the event of natural calamities such as cyclone, cloud burst, drought, floods, earthquakes, landslides, pest attack, Tsunami, cold wave etc. Assistance is given for entire holding of small and marginal farmers who have suffered crop loss of 50 per cent or more due to natural calamities like cyclone, drought and floods. The farmers in the study area avail their compensation through National Agricultural Insurance Scheme which is one of the largest insurance plans for the farmers in the world. The objective of the scheme is to provide insurance coverage and financial support to the farmers in the event of failure of any of the notified crops as a result of natural calamities, pests and diseases to encourage the farmers to adopt progressive farming practices, high value inputs and higher technology in agriculture and to help stabilize farm incomes, particularly in disaster years. According to the Disaster report, Nagapattinam, during the occurrence of “Thane” cyclone, the total paddy crop lost was 53,630 hectares in Nagapattinam and the compensation of Rs.10, 000 per hectare was allotted to the affected farmers.

Likewise, during the occurrence of drought during the year 2013, crop loss in Nagapattinam was 1.81 lakh hectares and the compensation given was Rs.15000 per acre provided through insurance company.

Previously, during the flood period 2005, relief fund was given through National Calamity relief fund to small and marginal farmers at the rate of Rs.2500 per hectare and large farmers were allotted Rs.1000 per hectare.

Assessment of crop loss due to disaster events at farm level and financial support by the government

Compensation was given to the farmers during the year 2012 for cyclone and flood region and the year 2013 for drought region. Relief funds were calculated based on the crop cutting experiment at field level done by the Government (Directorate of Economics and Statistics in association with Department of Agriculture).

The extent of crop loss faced by the paddy growing farmers in all the three disaster prone regions and the financial support provided through NAIS are given in table 5.33.

Table 5.33 Extent of crop loss (Paddy) and financial support from the government

Particulars	Cyclone region	Flood region	Drought region
Normal yield(Kg/ha)	4752	4955	4397
Actual Yield (kg/ha)	1229.75	1729.75	2753.70
Crop loss (per cent)	74.12	65.09	37.37
Indemnity(Rs/ac)	13313.33	13637.5	8506.05

Note: Normal yield: Average yield in kg/ha as recorded by JDA, Nagapattinam District.

Actual yield: Actual yield in kg/ha realized by the sample farmers

Since the region is prone to natural calamities most of the farmers insured their crops to get the financial support from the government. It could be seen from the table 5.33 that crop loss due to cyclone was about 75 per cent in cyclone region, 65.09 per cent and due to flood in flood region and was 37.37 per cent due to drought in drought region. The amount of financial support availed by the affected farmers was Rs.11313.33 /ha in cyclone region, Rs 13637.5 /ha in flood region and Rs.8506.05 /ha in drought region.

Crop loss restoration

Crop loss restoration is calculated on the basis of indemnity received by the farmers. As paddy is the predominant crop in the study area indemnity is paid only to paddy crop through the scheme NAIS. The scheme is operated on the basis of "Area Approach". Whenever crop loss occurs the compensation amount will be calculated by the Agricultural Insurance Company of India Limited, and the same will be credited to the insured farmer's accounts by the concerned banks. Based on the crop loss and indemnity received by the farmer, crop loss restoration is calculated.

The actual loss incurred by the farmers and the percentage of loss restored are presented in Table.5.34

Table 5.34 Loss restored by sample farmers

Particulars	Cyclone region	Flood region	Drought region
Crop Loss in (Rs/ac)	32553.75	41553.75	36131.25
Indemnity received to crop loss by the farmer (Rs/ac)	11313.33	13637.50	8506.05
Crop loss restored (in per cent)	40.89	32.81	34.61

The result from the Table 5.34 shows that among the three disaster affected region crop loss restoration was high in cyclone region which accounted for 40.89 per cent. In the flood region crop loss restored was 32.81 per cent and in drought region it was 34.61 per cent.

Though the crop insurance scheme aimed to restore the crop loss, there existed a variation in restoration due to many factor like farm size, farmers financial condition, sum insured etc.

Insured and Premium paid by the sample respondents

In the study area, the farmers avail the crop insurance through primary agricultural co-operative society and they make a frequent visits to avail the fund every year. In general the relief fund allotted to the study area is Rs.15000 per acre in drought region Rs.10000 per acre in cyclone and flood region and the amount released is based on the crop cutting experiment conducted at the field level.

The details about the premium received, sum insured and sum paid by the farmers were analysed and presented in table 5.35. It could be observed that premium paid to sum insured by the farmers in the cyclone region was 20.54 per cent, in flood region was 15.15 per cent and drought region was 10.95 per cent. The amount received in the flood prone region was found to be high based on the severity of the disaster incidence at the farm level.

Table 5.35 Sum insured and premium paid by the sample respondents during the period

S.No	Particulars	Cyclone region	Flood region	Drought region
1	Sum Insured to paddy crop (Rs/ac)	15000	15000	10000
2	Premium paid (Rs/ac)	2918	2884	1670
3	Premium paid to sum insured (per cent)	20.54	15.15	10.95
4	Amount received for the crop lost (Rs/ac)	11313.33	13637.5	8506.05
5	Time of settlement of amount (days after harvest/loss)	90	90	90-120

Farmer's perception about the agricultural insurance scheme

Agricultural insurance is an effective mechanism for reducing the losses where the farmers suffer due to natural calamities. It had formed a great support to resource poor farmers who had no alternatives other than borrowing under adverse situations. Though the benefits of the scheme were well known, it still have not achieved the expected coverage from the point of view of the beneficiary farmers. Opinions regarding the crop insurance scheme were elicited from the farmers and the results are presented in Table.5.36.

It could also be observed that all the farmers in the cyclone region (100 per cent) were aware about the crop insurance programme, whereas 81.67 per cent of the farmers in the flood region and only 56.67 per cent of the farmers in the drought regions were aware of the insurance programme. As the farmland is very near to coast, damage to the farm lands were found to be high in cyclone regions. Therefore, extension officials make frequent visit to coastal farm households. Moreover, healthy relationship between the extension officials and famers enables the farmers to know about the insurance program in detail whenever they reached for.

About 93.33 per cent of the farmers in cyclone region, 73.33 per cent in the flood regions and 48.33 per cent in drought regions were interested in continuing the programme. They reported that it reduces the financial burden during the period of crop loss and hence farmers are interested in continuing the programme.

The percentage of farmers satisfied with existing programme were 58.33, 48.33 and 38.33 in the order of cyclone, flood and drought regions and rest of the farmers mostly small and marginal farmers felt that the compensation paid was low.

Also the result shows that 78.33 per cent in the cyclone prone region, 70.00 per cent in the flood prone region and 56.67 per cent of the drought prone region farmers felt that crop insurance was the better way of reducing loses and the remaining 15 per cent, 20 per cent and 31.67 per cent of the farmers from cyclone, flood drought regions respectively felt that mixed and diversified farming was a better way of reducing losses.

Awareness regarding premium and indemnity

It was observed from the table 5.39 that about 86.67 per cent, 70 per cent and 48.33 per cent of the farmers from cyclone, flood and drought region respectively regions were aware about the premium charged for the paddy crop. Similarly, 85 per cent, 56.67 per cent and 35 per cent of the insured farmers from the region of cyclone, flood and drought were aware about the way of collection of premium.

It could also be revealed that out of the total sample respondents 76.67 per cent of the farmers from the cyclone region, 65 per cent of the farmers in flood region and only 30.00 per cent of drought region farmers opined that the premium rate charged was reasonable and most of the farmers from all the regions felt that that financial help was necessary through compensation especially during crop losses.

Majority of the farmers i.e., 86.67 per cent, 70 per cent and 48.33 per cent from cyclone, flood and drought region farmers were willing to pay premium to insuring agency in order to insure their crops.

From the survey it was observed that the compensation fund was received within three months of the period from crop loss. Only 36.67 per cent, 31.67 per cent and 21.67 per cent of the farmers from cyclone, flood and drought regions felt that the compensation paid was adequate. Most of the farmers suggested to increase the compensation amount.

Farmer's awareness about the basis for fixing the compensation amount was very less. It was only 20 per cent in cyclone region, 11.67 per cent in flood region and 18.33 per cent in drought region.

Awareness regarding yield calculation

It could be seen from the table 5.40 that only 30 per cent of the farmers from cyclone region, 23.33 per cent from flood region and 20 per cent of the farmers from drought region were aware about method of calculating threshold yield and 21.67 per cent, 21.67 per cent and 15 per cent of the farmers in the order of above mentioned region opined that the method of calculating threshold yield was appropriate. According to NAIS threshold yield is the average yield of crop in the insurance unit based on past yield data of three years for paddy and five years data for other crops and multiplied by certain percentage (level of indemnity) fixed by the insurance agency.

And only 23.33 per cent of farmers in cyclone regions, 20 per cent in flood regions and 18.33 per cent in drought regions suggested that threshold yield should be taken for calculating compensation.

The percentage rate of farmers aware about the method used in conducting crop cutting experiments was very less and out of the total responses which 25 per cent, 18.33 per cent, 20 per cent of the farmers in the order of cyclone, flood and drought regions, said that present method of calculating crop cutting experiment was an ideal method.

Opinion regarding impact of crop insurance

Regarding the impact of crop insurance scheme in the three disaster affected blocks the farmers opinion about the tie up of crop insurance with crop loan was enquired and 53.33 per cent of the farmers in cyclone region, 41.67 per cent in flood region and 63.33 per cent of the farmers in drought region suggested to avail crop insurance compensation along with crop loan. Several farmers expressed their satisfaction with coverage of crops under the scheme.

Few of the farmers felt that the crop insurance scheme has prompted them to go in for riskier high yielding varieties in paddy (Table 5.39). Majority of sample farmers i.e., 53.30 per cent in cyclone region, 40.00 per cent in flood region and 56.67 per cent in drought region felt that crop insurance was a good measure against risk and uncertainty.

Table 5.36 Opinion of the farmers regarding crop insurance during the disaster events

S.No	Particulars	Cyclone Region		Flood Region		Drought Region	
		No. of Farmers	Percentage	No. of Farmers	Percentage	No. of Farmers	Percentage
1	Awareness about the crop insurance programme	60	100.00	49	81.67	34	56.67
2	The farmers being insured since the inception of the programme	52	86.67	43	71.67	27	45.00
3	The crop insurance programme is necessary	56	93.33	36	60.00	24	40.00
4	Farmers interested in continuing the insurance programme	56	93.33	44	73.33	29	48.33
5	Farmers who are satisfied with the existing programme	35	58.33	29	48.33	23	38.33
6	Crop insurance is the better way of reducing losses	47	78.33	42	70.00	34	56.67
7	Mixed and Diversified farming is a better way of reducing losses	9	15.00	12	20.00	19	31.67

Table 5.37 Awareness regarding premium and indemnity

S.No	Particulars	Cyclone Region		Flood Region		Drought Region	
		No.of Farmers	Percentage	No.of Farmers	Percentage	No.of Farmers	Percentage
1	Awareness of the premium rate	52	86.67	42	70.00	29	48.33
2	Awareness about the way of collection of premium	51	85.00	34	56.67	21	35.00
3	The premium rate charged is reasonable	46	76.67	39	65.00	18	30.00
4	Financial help is necessary through compensation especially during crop losses	52	86.67	42	70.00	29	60.00
5	Farmers willing to pay premium to insure their crops	52	86.67	42	70.00	29	48.33
6	Farmers who have received compensation at the right time	43	71.67	31	51.67	24	40.00
7	The compensation paid was adequate	22	36.67	19	31.67	13	21.67
8	Awareness about the way of payment of compensation	26	43.33	32	53.33	29	48.33
9	Farmers awareness about the basis for fixing the compensation amount	12	20.00	7	11.67	11	18.33

Table 5.38 Awareness regarding yield calculations

S.No.	Particulars	Cyclone Region		Flood Region		Drought Region	
		No. of Farmers	**Percentage**	**No. of Farmers**	**Percentage**	**No. of Farmers**	**Percentage**
1	Awareness about the method of calculating threshold yield	18	30.00	14	23.33	12	20.00
2	The method of calculating threshold is appropriate	13	21.67	13	21.67	9	15.00
3	Threshold yield should be considered	14	23.33	12	20.00	11	18.33
4	Awareness about the method used in conducting crop cutting experiment	15	25.00	11	18.33	12	20.00

Table 5.39 Opinion regarding impact of crop insurance

S.No	Particulars	Cyclone Region		Flood Region		Drought Region	
		No. of Farmers	**Percentage**	**No. of Farmers**	**Percentage**	**Percentage**	**No. of Farmers**
1	Crop insurance should be tied up with the crop loan	32	53.33	25	41.67	38	63.33
2	The existing coverage crops under crop insurance is sufficient	27	45.00	23	38.33	29	48.33
3	Farmers have taken loans due to the benefits of insurance scheme	15	25.00	12	20.00	19	31.67
4	There is a change in the area under paddy after insurance	6	10.00	11	18.33	9	15.00
5	Crop insurance has prompted the farmers to cultivate riskier high yielding varieties	9	15.00	7	11.67	11	18.33
6	Farmers feel that crop insurance is a good measure against risk and uncertainty	32	53.33	24	40.00	34	56.67

Cost and returns from paddy cultivation during calamity year and normal year

Paddy is the main crop cultivated in the entire district and there exist a wide variation in the yield during calamity year and normal year. Institutional claims like insurance and government relief funds supports the entire affected area to withstand the disaster situation to certain extent. The input use pattern and returns from paddy crop have been worked out for normal year (2006) and calamity year (2012 and 2013) and the results are presented in table 5.42. The results are so presented in such a way to know the comparative performance of paddy yield achieved by the farmers during normal year and calamity year in the study area.

Paddy production appears to show a decreasing pattern which is presumably due to the difficulties of rice cultivation under the unpredictability of disasters. The common problem of rice production in the villages studied were inadequate water supply in the dry season and cyclonic flood in the rainy season.

The result from the table 5.40 reveal that in cyclone and flood region the labour cost for cultivating paddy were found to be high during calamity year (23.31 per cent in cyclone region and 22.97 per cent in flood region). But in drought region labour cost were found to be low during calamity year (12.68 per cent). This is so because farmers normally go for broadcasting instead of transplanting during dry period which needs less manpower and hence reduces the labour cost. When compared with three regions labour cost were found to be high in flood region. This was mainly due to the fact that in flood region there was a need of high land management to avoid erosion and crop care practices like weeding which needs additional human labour thus increase in wage rate.

Fertilizer which is the major component next to wages was found to be higher in cyclone region which accounted for 19.09 per cent. The same in flood region was 17.30 per cent and in drought region was 16.07 per cent respectively. Being a vital input contributing to productivity, there is a tendency among farmers to go on increasing application of chemical fertilizer to adjust with soil salinity or runoff of fertilizer resulting in higher cost and lower profits during disaster period.

Application of pesticide and herbicide were found to be high in drought region (8.08 per cent) when compared to cyclone (7.39 per cent) and flood region (7.08 per cent).This was mainly due to the fact that most of the insect pests and weeds are naturally controlled by heavy rain or floods and needs low usage of these inputs in flood and cyclone region. But in drought region due to reduced rainfall, the population of sucking pests and weeds increased

Table 5.40 Region wise costs and returns of paddy in the study region

(Rs/ha)

Particulars	Cyclone Region		Flood Region		Drought Region	
	Normal Year	**Calamity Year**	**Normal Year**	**Calamity Year**	**Normal Year**	**Calamity Year**
A. Variable cost						
Seed	1000 (1.91)	1000 (1.91)	1200 (2.30)	1200 (2.05)	1500 (2.63)	1500 (2.56)
Human labour	12050 (22.99)	13100 (23.31)	12125 (23.24)	13475 (22.97)	9250 (16.22)	7425 (12.68)
Fertilizer	8825 (16.84)	10725 (19.09)	9375 (17.97)	10150 (17.30)	7800 (13.68)	9130 (16.07)
Pesticide / herbicide	4684 (8.94)	4150 (7.39)	3700 (7.09)	4125 (7.08)	4900 (8.59)	5150 (8.80)
Machinery	8583 (16.38)	10918 (19.43)	7800 (14.95)	10612 (19.00)	12582 (22.07)	10017 (17.92)
Irrigation	2777.625 (5.30)	1630 (2.90)	2400 (4.60)	2050 (5.10)	6250 (10.96)	8345 (14.93)
Interest on working capital	1810.87 (3.46)	1989.61 (3.56)	1713.25 (3.28)	2048.76 (3.67)	2312 (4.21)	2628 (4.70)
Subtotal(A)	**39730.495 (75.80)**	**43512.61 (77.43)**	**38313.25 (77.44)**	**44460.70 (79.61)**	**44594 (79.73)**	**45096 (79.06)**
B.Fixed cost						
Land cess	120 (0.23)	120 (0.21)	120 (0.23)	120 (0.21)	120 (0.21)	120 (0.21)
Interest on owned fixed capital (11 per cent)	1100.28 (2.10)	1100 (1.96)	1151.42 (2.33)	1174.53 (2.10)	1023.46 (1.86)	1070.88 (1.92)
Depreciation of implements and farm buildings	958.32 (1.83)	958.32 (1.71)	1342.42 (2.57)	1543.59 (2.76)	1532.2 (2.79)	2865.32 (5.13)
Rental value of land	10500 (20.03)	10500 (18.69)	8550 (16.39)	8550 (15.31)	7652 (13.93)	7652 (13.68)
Sub-total (B)	**12678.6 (24.19)**	**12678.32 (22.56)**	**11163.84 (26.57)**	**11388.06 (20.39)**	**10327.66 (18.80)**	**11706.2 (20.94)**
Total(A+B)	**52409.095 (100.0)**	**56190.93 (100.00)**	**49477.09 (100.00)**	**55848.82 (100.00)**	**54921.66 (100.00)**	**55907.2 (100.00)**
Yield(kg/ha)	5000	1229.75	4500	1729.75	5162.5	2729.75
Gross Income	**76750**	**30743.75**	**75500**	**25081.37**	**77875**	**38216.5**
Net income	**24340.905**	**-25447.18**	**26022.91**	**-19379.48**	**22953.34**	**-17684.8**

(Figures in parentheses are percentages to respective total) and thereby increases the usage of this inputs and hence expenditure on this inputs were found to be high.

The cost of irrigation was found to be higher in drought region than cyclone and flood region. It was about 14.93 per cent in drought region, 2.09 per cent in cyclone region and 5.10 per cent in flood region during disaster period. This was mainly due to frequent irrigation to the field from canals during the period of dry season which increases the irrigation cost. Likewise interest on working capital was also high in drought region accounts 4.70 per cent than other affected region.

In cyclone region total variable cost incurred by the paddy farmers in during normal year was 75.80 per cent and during calamity year was 77.43 per cent. Similarly, in flood prone region proportional spending on inputs were found to be 77.44 per cent during normal year and 79.61 per cent in disaster period. On an average total variable cost per hectare incurred by the farmers in the drought region was 79.72 per cent in normal year and 79.06 per cent in disaster period respectively.

Considering the fixed cost, land cess paid by the farmers in all the three regions was found to be same (Rs.120 per acre) which is common. Interest on owned fixed capital, depreciation of implements and farm buildings also found to be high in drought region during both the periods was mainly due to high investment on machineries used for pumping the water from canals, for land management practices etc.,

Total fixed cost in cyclone region accounted for 24.19 per cent in normal year and 22.56 per cent in disaster period. In the flood region it was 26.57 per cent and 20.39 per cent and in drought region it was 18.80 per cent and 20.94 per cent. Overall fixed cost were found to be high in cyclone region than other two region was mainly due to higher land value situated in the centre place of the district.

In general, average variable cost were found to be higher in disaster period. Overall net income realized in cyclone region accounted Rs.24340.90 in normal year whereas it is found to be negative in disaster period which accounted -25447.18. Similarly, in flood and drought region net income accounted Rs.26022.91 and Rs.22953.34 in normal year and Rs.-31073.45 and Rs -18585.8 respectively in disaster period.

From the above discussion in all the three regions, there exist a marked difference in proportional spending in the inputs during two periods. It implies that additional man power and additional input usage increases the expenditure during calamity period. Though necessary inputs were added due to the severity of the disasters, farmers in the affected region face the crop loss totally or partially.

It could be concluded that the expenditure during disaster period was high when compared with normal year. Net income realized by the farmers were also negative in all the three regions in disaster period. Though the farmers continue to adjust with some of the adaptation technique like cultivating tolerant varieties and increasing additional input usage, heavy loss occurs due to severity of the events and results in negative net income to the farmers. The effect of these cyclone, flood and drought disasters makes the coastal farmers more vulnerable which in turn leads to poor economic growth of the coastal households.

Impact of calamity events on coastal livelihood in the study area

The nature of the calamity events and their impact varies considerably. The frequency and severity of extreme weather events and natural disasters has increased in the past decades worldwide (Deffenbaugh et al.2005, Solomon et al.2007). The highest implication of the impact of calamity events were the reduction of agricultural productivity. Extreme weather events devastate farmlands and can lead to crop failure and simultaneously affects the socio-economic status of the coastal farmers.

Impact studies in Nagapattinam during normal years and disasters years allowed us to observe how floods, cyclone and droughts affected household welfare. Overall, the study revealed a decreases in income and household expenditure. Although farmers were able to cope up with expected seasonal cyclonic floods or droughts, the shock of a severe incidence disrupt livelihood considerably. Thus, the increase in intensity and frequency of disasters pose negative consequences on welfare of the farmers.

In the study region most of the small and marginal farmers are more vulnerable to disaster events of cyclone, flood and drought. table 5.42 revealed that all the variables such as performance of crop farming, expenditure per household and household's income during normal year and disaster period shows a negative deviation.

Average paddy yield observed during normal year accounted 4752 kg/ha in cyclone region, 4955 kg/ha in flood region and 4397 kg/ha in drought region and the same during calamity year accounted 1229 kg/ha in cyclone region, 1729.75 in flood region and 2150kg/ha in drought region respectively. Deviation of the yield from normal year were found to be -74.13 per cent in cyclone region, -65.09 per cent in flood region and -51.10 per cent in drought region.

As mentioned earlier in table 5.40, income from paddy production were found to be negative during calamity year in all the three regions when compared with the normal year. Table 5.43 also shows the deviation of income from normal year which accounted for -204.58 per cent in cyclone regions, -219.50 in flood regions and -181.49 per cent in drought regions.

Farmers attempted to reduce the loss in agricultural income during disaster years by seeking additional employment in the non-farm sector. Average non-farm income earned by the sample households in normal year was found to be Rs.30166 in cyclone region, Rs.32330 in flood region and Rs.54959 in drought region. The same were found to be low during calamity year which accounted for Rs.18053 in cyclone region, Rs.12708 in flood region and Rs.31968 in drought region. This implies that farmers in these regions seek employment mainly as wage labour. During rainy days employment opportunity get reduced normally in flood and cyclone regions and hence the additional earning from non-farm employment were also found to be low.

It is evident that household's expenditure were also found to be low during calamity year. Total household expenditure during normal year in cyclone region were found to be Rs. 16880, Rs. 22938 in flood region and Rs. 22090 in drought region and the same in calamity year were found to be Rs.12949 in cyclone region, Rs 17901 in flood region and Rs.17245 in drought region. Deviation in expenditure from normal year shows -23.28 per cent in cyclone year, -21.95 per cent in flood year and -21.83 per cent in drought region. This implies that when there is reduction in income level of the farmer during calamity year, household members adjust with the situation and tends to reduce their expenses.

This concludes that, impact of cyclone, floods and droughts was severe and significantly affects the economy of the livelihood in the study region.

Table 5.41 Impact of calamity events on coastal sample households in the study area

S.No	Particulars	Unit	Cyclone region			Flood region			Drought region		
			Normal year	Calamity year	Deviation from normal (%)	Normal year	Calamity year	Deviation from normal (%)	Normal year	Calamity year	Deviation from normal (%)
1	**Performance of crop farming**										
	Average paddy yield	Kg/ha	4752	1229	-74.13	4955	1729.75	-65.09	4397	2150	-51.10
2	**Income from households**										
	Non-farm income	Rs/yr	30166	18053	-51.10	32330	12708	-60.69	54959	31968	-41.83
	On-farm Income	Rs/yr	24340.95	-25447.18	-204.58	26022.91	-19379.39	-219.50	22953.34	-18705.7	-181.49
3	**Expenditure per household**										
	Food items	Rs/yr	11520	8040	-30.20	17880	14040	-21.47	17040	12480	-26.83
	Medical	Rs/yr	850	1284	51.05	744	1020	-27.05	400	325	-18.75
	Education	Rs/yr	2400	2150	-10.41	2714	2071	-23.69	2800	2700	-3.57
	Cloths and festivals	Rs/yr	2010	1475	-26.61	1600	770	-51.87	1850	1740	-5.94
	Total	Rs/yr	16880	12949	-23.28	22938	17901	-21.95	22090	17245	-21.93

CHAPTER VI

SUMMARY AND CONCLUSION

The present study was undertaken to analyse the impact and effect of disaster events on agriculture with a view to understand the scope for improving standard of living of the rural coastal farmers. The field survey was conducted in three blocks of Nagapattinam district.

Results of the study showed that the prevalent natural disasters that occur in Nagapattinam district were cyclone, flood and drought.

The objectives are

1. to identify the frequency and impacts of natural disasters that affect the coastal farmers
2. to evaluate and quantify the socio-economic effects of disasters on the coastal farmers and
3. to assess the vulnerability of coastal farmers to natural disasters and to identify policy options to strengthen their adaptive capacity

Sampling procedure

Nagapattinam, Talanayar and Vedaranyam blocks in Nagapattinam district were selected purposively. The selected area was divided into Cyclone region, flood region and drought region respectively. From each region 60 farmers were selected at random and the total sample size was 180.The primary data representing the agricultural year 2012 for cyclone and flood region and 2013 for drought region were collected from the selected respondents by personal interview using a pre-tested interview schedule. The secondary data about the study area were collected from the records of the State Department of Agriculture and Assistant Director of Statistics.

Findings

Natural disasters in Nagapattinam district

Nagapattinam is a multi-hazard prone district where the entire coast of the district is vulnerable to cyclone, flood and drought hazards with varying frequency and intensity. Every year these natural disasters in Nagapattinam district challenge agricultural production and crop area damage due to Thane, Nisha and Neelam cyclone were estimated to be 3170.2, 95152 and 17838 hectares.

Impact of natural disasters in the district due to cyclone, flood and drought on agriculture

The affected agricultural yield due to flood disaster was 1154 kg /ha in 2002-03, 1492 kg /ha in 2004-05, 1910 kg/ha in 2007-08, 2285 kg/ha in 2008-9 and 2976 kg/ha in 2010-11 respectively. Similarly due to drought disaster during 2013, Vedaranyam block was severely affected with crop area damage of 11523 hectares.

General characteristics of the farm

The farmers above 60 years was 16.67 per cent in cyclone region and 35 per cent in drought region. Similarly, in flood and drought region the percentage of farmers fall under the age group 31 to 40 years constitute 25 per cent in each region. Majority of the farmers in all the three regions were educated upto middle school and high school.

The average farm size was higher in cyclone regions (2.52 ha) than in flood regions (2.03 ha) and flood regions (2.43 ha). Moreover, small farmers were high in all the three regions which accounted cyclone region (53.56 ha), flood region (74.80 ha), drought region (79.60 ha) when compared to medium and large farmers. The total value of asset per farm in flood regions accounted Rs. 468974.70 which is higher than other two regions. In drought region it was Rs. 280081.70 and Rs. 240563.60 in cyclone regions.

Cropping pattern in all the three regions was dominated by paddy accounted for 85.75 in cyclone region, 100.00 in flood region and 80.50 percent in drought region. Cropping intensity were found to be high in drought region accounted 116.40 per cent and in cyclone and flood region it accounted for 117.71 per cent and 95 per cent respectively.

It is evident from the results that expenditure on food items and education was found to be higher in flood region which accounts 77.95 per cent and expenditure on education was found to be high in cyclone region which accounted for 14.21 per cent.

Farmer's perception about extreme events

The coastal farmers who lives with natural disasters expressed that not only the frequency but the intensity of the events also increased over the years.

Assessing the vulnerability of farm households to disaster variability

In the present study the vulnerability index was estimated with 18 sub components. The sub components were normalised by using their mean and standard errors and the normalized values. From the indexed sub component values, the major component values were worked out. From the major component values, household vulnerability index were estimated for all the three blocks selected. It was found that Nagapattinam (cyclone prone, -0.591) and Talanayar (flood prone, -0.391) blocks were highly vulnerable to disaster events and the block Vedaranyam (drought prone, 1.35) is less vulnerable comparatively with other two regions.

Effects of the disaster events in the study area

The ultimate impact of a natural disaster on a household depends on the household's vulnerability to its effects. Effects of natural disaster in the study area were enquired and found that physical effect was high in cyclone region and flood region accounted for 31.67 per cent and 28.33 per cent. Psychological effect was high in flood region (33.33 per cent) and behavioural effect was high drought region (33.33 per cent).

Factors that increase the effects of natural disasters in Nagapattinam district

Out of seven factor selected in the study the most frequent factor that increases the effects of natural disasters are climatic factor in all the three regions with a percentage rate of 25 per cent, 31.67 per cent and 30 per cent respectively and the less dominant factor that increases the effects of natural disasters in cyclone affected were found to be adoption of technology accounted 10 per cent. Similarly in flood region less dominant factor was topography of farm land and poor adoption of technologies accounted for 8.33 per cent each. Less dominant factor in drought prone region was topography of farm land accounted only five per cent.

Factors influencing the income of rural farmers by the natural disasters

Variables included in the regression model are land degradation, climatic factor, crop diversification, standard of living and adoption of technologies. Regression results shows that the association between the income and climatic factor (X_2) was statistically significant at one per cent level and the coefficient for this variable had a negative sign in all the three regions which implies that cyclone, flood and drought incidence negatively affected the farmer's income. Land degradation (X_1) shows a negative relationship with the dependent variable Y significant at one per cent level in flood and drought region with elasticity of 6.50 per cent in flood region and 0.34 per cent in drought region. Crop diversification shows a positive co-efficient at five per cent significant level with elasticity of 0.78 per cent in cyclone region and 0.34 per cent in drought region. In flood region adoption of technology shows a positive co-efficient in cyclone and drought region which is significant at five per cent l and one per cent level implies that for every unit increase in the usage of technology will increase the income of the farmers by 0.65 per cent in cyclone region and 0.61 per cent in drought region.

Income of the coastal farmers before and after the occurrence of natural events

Difference in the income earned by the farmers were analysed through non-parametric test called Wilcoxon Matched pairs Signed-Ranked test. The test produced a Z-value of -4.90 in cyclone prone region, -6.574 in flood prone region and -3.563 which was significant when compared with the critical Z-value of 0.05 1.64 and 1.96. There exist a difference in all the three disaster affected regions which indicates that there was a reduction in the income level of the coastal farmers after the effects of natural disasters.

Income Management of Farm Households against disaster variability

The foremost alternative for the coastal farmers in all the disaster prone region was government relief fund and insurance which accounted for 96.67 per cent in cyclone region, 91.67 per cent. In flood region and 85 per cent in drought region. The other main income management measures followed are availing bank loan, barrowing from money lender, barrowing money from friends and relatives, hypothecation of assets and jewelleries. Less dominant measures were savings in bank, sale of fixed asset and sale of stored produce.

Farmer's choice of adaptation at farm level during the disaster event

As reported by the farmers adoption of tolerant varieties of paddy like BPT 5142, ADT-45, Co-43 is most commonly used adaptation in all the three regions, whereas crop diversification with pulses, groundnut is practiced less. About 30 per cent in cyclone region, 28.33 per cent of farmers in flood region and 10 per cent in drought region farmers reported that they have not taken any adaptation method.

Analysis of the determinants of farmers' choice of adaptation methods

Multinomial logit model was used to analyse the determinants of farmers 'choice of adaptation of different techniques during the period of disaster like cyclone, flood and drought. The independent variables used are education, experience, age, size of the household, farm income, non-farm income, farm size, livestock ownership, extension on crop and livestock, access to credit, temperature and rainfall and the dependent variables used are adaptation of tolerant varieties, crop diversification, starting new land management practices, early planting and no adaptation. The likelihood ratio statistics as indicated by χ^2 statistics

(64.14) are highly significant (P<0.0027), suggesting that the model has a strong explanatory power.

Results from the marginal effect indicates that the education significantly increases to adopt new land management practices during the disaster situation.

Non-farm income significantly increases the likelihood of adopting tolerant varieties, crop diversification, using land management practices and adaptation to early sowing or late sowing by 1.7 per cent, 2.2 per cent, 7.3 per cent and 6.2 per cent respectively.

Also, the ownership of livestock ownership of livestock is negatively related to adoption of crop diversification and early and late sowing by 8.1 per cent and 8.5 per cent. Access to crop and livestock extension has a positive and significant impact on adopting new land management practices by 7.7 percent and early or late sowing of seeds by 3.9 per cent but had a negative and significant impact on adaptation of tolerant varieties. Access to credit also has a negative and significant impact on using tolerant varieties, adopting land management practices and adopting early / late sowing technique.

The results also reveal that higher annual mean temperature over the survey period in drought regions tend to induce adoption of tolerant varieties which influence positively new adopting technologies during the period of disaster. Increase in rainfall also significantly increases the adoption of adjusting the sowing date and adoption of new technologies.

Analysis of Farmers' Perceptions and Adaptation to Disaster events

The Heckman probit selection model is employed to analyze the two-stage process of adaptation — perceiving changes due to disaster in the first stage and then adapting to perceived changes due to disaster in the second stage.

Out of the total size of 180 farmers 60 per cent of the farmers were aware of disaster events and the remaining 40 per cent were not aware about the occurrence of disaster events and out of the total sample size 66.11 per cent of the farmers were adopted some of the techniques to overcome the disaster events and rest of 33.88 per cent of the farmers were not adopting any of the techniques. The results indicated the presence of a sample selection problem (dependence of the error terms from the outcome and selection models), with the likelihood function of the Heckman probit model was significant Wald $_{\chi}{}^{2}$= 68.10, with p < 0.0000.

The regression analysis involves the explanatory variables as education, experience, farm income, size of the household, livestock ownership, extension on crop and livestock, access to credit, temperature and rainfall in the outcome model and education, age of the household, farm income, wage income and information on disaster events in the selection model and their marginal values were also found to be statistically significant.

It could be evident from the results that the variables positively and significantly influence adoption to disaster events includes size of the household, farm size, livestock ownership, extension on credit and livestock ,access to credit and rainfall.

It is observed that family size is significant and has a positive coefficient implies that larger families tend to adopt more to disaster events than smaller farmers. Also increasing farm size increases the probability of adoption by two per cent.

Credit accessibility is positively and significantly related which shows that if farmer has access to credit his probability of adoption of technology to disaster events increases by 15 percent.

Similarly, Perceiving to disaster events is positively related to education, age of the households, non-farm income and information on disaster events and factors that are believed to create awareness about disaster events, such as access to information on change, increase in non-farm income and increase in the education level increases the likelihood of adoption by 31.2 per cent, 0.01 per cent and 11.5 per cent respectively.

Farmers constraints to adaptation methods

As mentioned earlier farmers practice different adaptation methods to cope up with disasters. The results from the household survey indicated that lack of credit accessibility is the main constraint to adopt technology during disaster event and that was found to be higher in flood region (50 per cent). Lack of information reported to be the highest constraint found in drought region (45 per cent) and severity of the event was found to be high in flood region (20 per cent) and lack of necessary farm input was found to be high in cyclone region (21.67 per cent).

Assessment of crop loss due to disaster events at farm level and financial support by the government to paddy crop

Assistance is given for entire holding of small and marginal farmers who have suffered crop loss of 50 per cent or more due to natural calamities like cyclone, drought and floods. Compensation was given to the farmers during the year 2012 for cyclone and Flood region and the year 2013 for drought region. Relief funds were calculated based on the crop cutting experiment at field level done by the Government (Directorate of Economics and Statistics in association with Department of Agriculture).

Crop loss due to cyclone was 75 per cent in Nagapattinam block, 61.56 per cent and due to flood in Talanayar block and was 46.65 per cent due to drought in Vedaranyam block. The amount of financial support availed by the affected farmers was Rs.11313.33/ha in cyclone region, Rs 13637.5 /ha in flood region and Rs.8506.05 /ha in drought region.

Loss restorability

Crop loss restoration is calculated on the basis of indemnity received by the farmers. Among the three disaster affected region crop loss restoration was high in cyclone region which accounted for 40.89 per cent. In the flood region crop loss restored was 32.81 per cent and in drought region it was 34.61 per cent.

Insured and premium paid by the sample respondents

In general the relief fund allotted to the study area is Rs.15000 per acre and the amount released is based on the crop cutting experiment conducted at the field level. premium paid to sum insured by the farmers in the cyclone region was Rs 20.54 per cent, in flood region was 15.15 per cent and drought flood region was Rs.10.95 per cent.

Farmer's perception about the agricultural insurance scheme

Agricultural insurance had formed a great support to resource poor farmers who had no alternatives other than borrowing under adverse situations. All the farmers insured their farm land in order to reduce the crop loss during the disaster period and all the farmers in the cyclone region (100 per cent) were aware about the crop insurance programme, whereas 81.67 per cent of the farmer in the flood region and 56.67 per cent of the farmer in the drought region were aware about the insurance programme. Moreover, 58.33 per cent, 48.33 per cent and 38.33 per cent of the farmers in the order of cyclone, flood and drought regions were satisfied with existing programme

Awareness regarding premium and indemnity

About 86.67 per cent, 70 per cent and 48.33 per cent of the farmers from all the three regions were aware about the premium charged for the paddy crop and felt that financial help is necessary through compensation especially during crop losses.

Similarly, 85 per cent, 56.67 per cent and 35 per cent of the insured farmers from the region of cyclone, flood and drought were aware about the way of collection of premium and 76.67 per cent of farmers in cyclone region, 65 per cent in flood region and 30 per cent in drought region opined that the premium rate charged was reasonable.

Awareness regarding yield calculation

Only 30 per cent of the farmers from cyclone region, 23.33 per cent from flood region and 20 per cent of the farmers from drought region were aware about the method of calculating threshold yield and 21.67 per cent each in cyclone and flood region, and 15 per cent of the farmers in drought region opined that the method of calculating threshold yield was appropriate. The percentage rate of farmers aware about the method used in conducting crop cutting experiments was very less.

Opinion regarding impact of crop insurance

Regarding the impact of crop insurance scheme in the three disaster affected blocks the opinion about the tie up of crop insurance with crop loan was 53.33 per cent, 41.67 per cent and 63.33 per cent respectively. Majority of sample farmers i.e., 53.30 percent in cyclone region, 40.00 per cent in flood region and 56.67 per cent in drought region felt that crop insurance was a good measure against risk and uncertainty.

Cost and returns from paddy cultivation before and after the disaster period

Paddy the main crop cultivated in the entire district, there exist a wide variation in the yield during pre and post disaster period. The input –use pattern and returns from paddy crop have been worked out for pre (2006) and post disaster period (2012 and 2013).

As observed from the result expenditure on inputs during disaster period was high when compared with normal year in all the three regions. Net income realized by the farmers also negative in all the three regions in disaster period which accounted for Rs. -25447.18 in cyclone region, Rs.-19379.48 in flood region and Rs.-17684.80 in drought region respectively. Percentage deviation of the farm income from normal year were found to be -204.58 in cyclone region,-219.50 in flood region and -181.49 in drought region

Impact of calamity events on rural livelihood in the study area

Impact studies in Nagapattinam during normal year and disasters year allowed to observe how floods, cyclone and droughts affected household welfare. Overall, the study observed a decreases in income and decreased household expenditure. Average paddy yield during disaster year were found to be 1229 kg/ha in cyclone region, 1729.75 in flood region and 2150kg/ha in drought regions. Deviation of the yield from normal year were found to be -74.13 per cent in cyclone region,-65.09 per cent in flood region and -52.10 per cent respectively. Total household's expenditure were also found to be low during calamity year and the deviation from normal year were found to be -23.28 per cent in cyclone year, -21.95 per cent in flood year and -21.93 per cent in drought region. This shows nature of the calamity events and their impact varies considerably and the highest implication of the impact of calamity events is reduction of agricultural productivity. Thus, the increase in intensity and frequency of disasters pose negative consequences on welfare of the farmers.

Conclusions

Based on the results, of analysis discussed earlier and summarised above specific inferences were drawn with respect to each of the objective by empirically verifying the hypothesis.

First hypothesis was that in the coastal ecosystem there is a significant difference between the levels of income earned by the farmer's before and after the occurrence of natural disasters. Results of Wilcoxon matched pair signed rank test showed that after the occurrence of natural disasters there was a reduction in the farmer's income. Thus the null hypothesis was proved to be not true.

Second hypothesis was proved true by the result of adaptation of different technologies. Different households living in different agro ecological settings use different adaptation methods which influences coastal farmers perceptions on changes due to disaster events and their decisions to adapt.

Policy implications

Above summary and conclusions would suggest the following implications for policy.

- The results of the study revealed that the district is highly prone to cyclone and flood and hence there is a great of increasing adaptive strategies like repairing and building reservoirs in cyclone and flood region, irrigation and water storage in drought region, disaster- need agricultural practices like increasing crop diversification etc.,
- Since cyclones, flood and drought may have significant negative impacts on rice production, assistance for rice farmers in this region should be made more site-specific.

- There should be a proper distribution of information on disaster resistant crop varieties to the farmer.
- In the drought prone block of Vedaranyam, there exist an irregular rainfall and therefore extension officials should co-ordinate and facilitate the provision of necessary resources to overcome the drought situation.
- Farmers should be aided to adopt disaster management strategies in respect to agriculture so as to reduce financial losses when these disasters occur; so that the farmers should be educated on various disasters strategies.
- Though the crop cutting experiments were conducted at field level regularly after the occurrences of disaster in the study area ,the process of settlement of indemnity were found to be slow and hence it should be settled at the earliest possible, time.
- A large area in the coastal blocks suffers from problems such as salinity and water scarcity. Due to these problems, crop yields were affected considerably. Farmers must be trained on reclamation of problem soils and growing suitable crops and varieties like Green manures, vegetable crops(chilli, pumpkin),oilseed (sunflower),fruits-Water Melon
- Among the various components of adaptive capacity, the foremost policy emphasis should be placed to create opportunities for non-form income sources, which will not only improve the income of the community, but also reduce their dependence on agriculture.
- The research community, policymakers, practitioners and village people need to come up together with well-coordinated and planned actions to address vulnerability, loss and damage at block level.
- Those assisting affected households and areas in overcoming the ill-effects of natural disasters should consider not only in terms of consumption strategies, like provision of emergency food aid, but also non-consumption strategies, such as the provision of post-disaster emergency employment.

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