# COMMUNITY RESILIENCE AGAINST NATURAL HAZARDS IN RICE FARMING SYSTEMS: A SOCIAL NETWORK ANALYSIS

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**(2021-11-109)**

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**KERALA, INDIA**

**2023**

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## THESIS

***Submitted in partial fulfillment of the requirement for the degree of***

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**Faculty of Agriculture**

**Kerala Agricultural University**

**DEPARTMENT OF AGRICULTURAL EXTENSION**

**COLLEGE OF AGRICULTURE**

**VELLANIKKARA, THRISSUR - 680656**

**KERALA, INDIA**

**2023**

# DECLARATION

I, **Suddamalla Manoj Kumar Reddy (2021-11-109)** hereby declare that the thesis entitled **"Community resilience against natural hazards in rice farming systems: A social network analysis"** is a bonafide record of research done by me during the course of research and that it has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Place: Vellanikkara

Date:

**SUDDAMALLA MANOJ KUMAR REDDY**

(2021-11-109)

# CERTIFICATE

Certified that this thesis entitled **"Community resilience against natural hazards in rice farming systems: A social network analysis"** is a bonafide record of research work done independently by **Mr. Suddamalla Manoj Kumar Reddy (2021-11-109)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Place: Vellanikkara
Date: 14.11.2023

**Dr. Binoo P Bonny**
(Major Advisor, Advisory committee)
Professor and Head
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# CERTIFICATE

We, the undersigned members of the advisory committee of **Mr. Suddamalla Manoj Kumar Reddy (2021-11-109),** a candidate for the degree of **Master of Science in Agriculture** with major field in **Agricultural Extension,** agree that this thesis entitled **"Community resilience against natural hazards in rice farming systems: A social network analysis"** may be submitted by **Mr. Suddamalla Manoj Kumar Reddy (2021-11-109)**, in partial fulfillment of the requirement for the degree.

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*SUDDAMALLA MANOJ KUMAR REDDY*

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# *Introduction*

# CHAPTER 1

# INTRODUCTION

## 1.1. Problems and Threats to Indian agriculture

The 2023 August is reported as the driest August since 1901 by the Indian Meteorological Department with a deficit of 36% from the average rainfall. Such a deficit is said to have far-reaching effects on the standing crops, especially in the regions where rain-fed agriculture is practised. But, over the past few years, such climate-related vagaries are not new to the farmers. A heat wave over the northern parts of India in 2022, has reportedly reduced wheat production by 8 per cent, threatening the food stocks of India. During 2017-2019, India suffered a crop loss on 18 million hectares of land due to incessant rainfall, leading to floods (Shagun, 2021). In the recently released Global Food Security Index, 2022 by The Economist Group, India was ranked 68$^{th}$ out of 113 major countries in terms of food security. It is also identified as one of the most vulnerable countries from the food security point of view, with increasing uncertainties in weather, crop production and farmers' income.

Indian agriculture already suffers from many structural problems, such as small and scattered landholdings, lack of storage facilities, low mechanisation, nonavailability of credit, lack of irrigation facilities, price volatility, etc. Around 86 per cent of India's agricultural landholdings are small and marginal, with an average of 1.08 ha per person. These small land holdings restrict farmers from investing in machinery and irrigation facilities as they cannot achieve economies of scale. As of 2020, out of 139.9 million hectares of net sown area in India, the net irrigated area is only 75.46 million hectares, leaving many farmers vulnerable to climate vagaries. Indian farmers also do not have sufficient storage facilities to store their produce scientifically after the harvest, leading to higher post-harvest losses. The total storage facilities available in India as of 2022 are around 145 million tonnes, while the total agricultural production in the country is 311 million tonnes (Haq, 2023). Such inadequate storage facilities, in tandem with the low credit availability of the farmers, are leading them towards distress sales at low prices. With agriculture being the only source of income for many small and marginal farmers in India, such distress sales affect their livelihoods and create price fluctuations in the market. Even though the income earned through agriculture is tax-free in India, many farmers struggle to meet their livelihood requirements. In addition to these issues, farmers in India are now facing a new challenge in the name of climate change. As the consequences of climate change, climate vagaries such as erratic rainfall, floods, droughts, and severe incidences of pests and diseases are recurring frequently.

Emphasising the importance of the climate change effect on agriculture, the United Nations has included the dimension of climate change in its sustainable development goals (SDG) agenda to be achieved by 2030. Among the SDG, goal 13 features climate action, the fight against climate change. The goal consists of specific targets such as strengthening the resilience and adaptive capacity to natural and climate-related hazards, integrating climate change measures into national policies, building human and institutional capacity for dealing with climate change, etc. In addition, another goal, numbered 2, is Zero Hunger. This goal mainly targets ending hunger by ensuring access to food for all people, ending malnutrition, doubling farmers' agricultural productivity and incomes, increasing resilient farming practices, etc.

The presence of these two goals in the SDGs showcases the importance and urgency of these issues across the globe. Climate change is reported to increase the frequency and intensity with which natural hazards occur over the coming years. Agriculture, which depends on climate and weather parameters, is highly prone to such dangers, which may lead to loss of crops and income for farmers. Such crop losses will have a significant impact on the food security of the nations.

Building resilience in the farming communities against the natural hazards is the way to ensure that the livelihoods of farmers are safeguarded and the food security of the nations is sustained (Singh *et al*., 2022).

### 1.2. Resilience

The word resilience has been derived from the Latin word "resilio", which means "bounce back". Resilience is defined as “the ability of people, households, communities, countries, and systems to mitigate, adapt to, and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth" (USAID, 2012). The United Nations 2030 goals feature the improvement of resilience in six out of its seventeen goals, thereby meaning its importance in the present situation. With climate change leading to unpredictability in weather conditions, farmers are at an insecure situation. Resilience is a concept which helps in addressing this unpredictability by enabling the adaptive capacity and transformability of the systems (Shaw and Maythrone, 2013).

Resilience is generally understood in terms of exposure, sensitivity and adaptive capacity.

Exposure: This includes identifying and analysing natural hazards in the given context and how the people and their livelihoods will get adversely affected, thereby leading to losses and damage.

Sensitivity: It includes understanding the vulnerability of the regions to natural hazards and the internal characteristics of the areas, such as types of assets available, production, etc.

Adaptive capacity: It involves assessing the ability of households that are responsible for dealing with and responding to any shocks. Insurance coverage, natural buffers, and income diversity are specific examples that improve adaptive capacity.

Farmers in India are significant communities concerning crop production systems. Therefore, farming communities must be able to withstand, handle and recover from the losses caused by natural hazards (Jayadas and Ambujam, 2021). Among the different farming systems, rice production systems assume high significance regarding food security and ecological stability.

### 1.3. Rice farming scenario in India

With over 464 lakh hectares cultivated during 2021-22, Rice is India's single largest grown crop, followed by wheat with 305 lakh hectares. The details of rice area and production for 2021-22 can be seen in Figure 1.1.

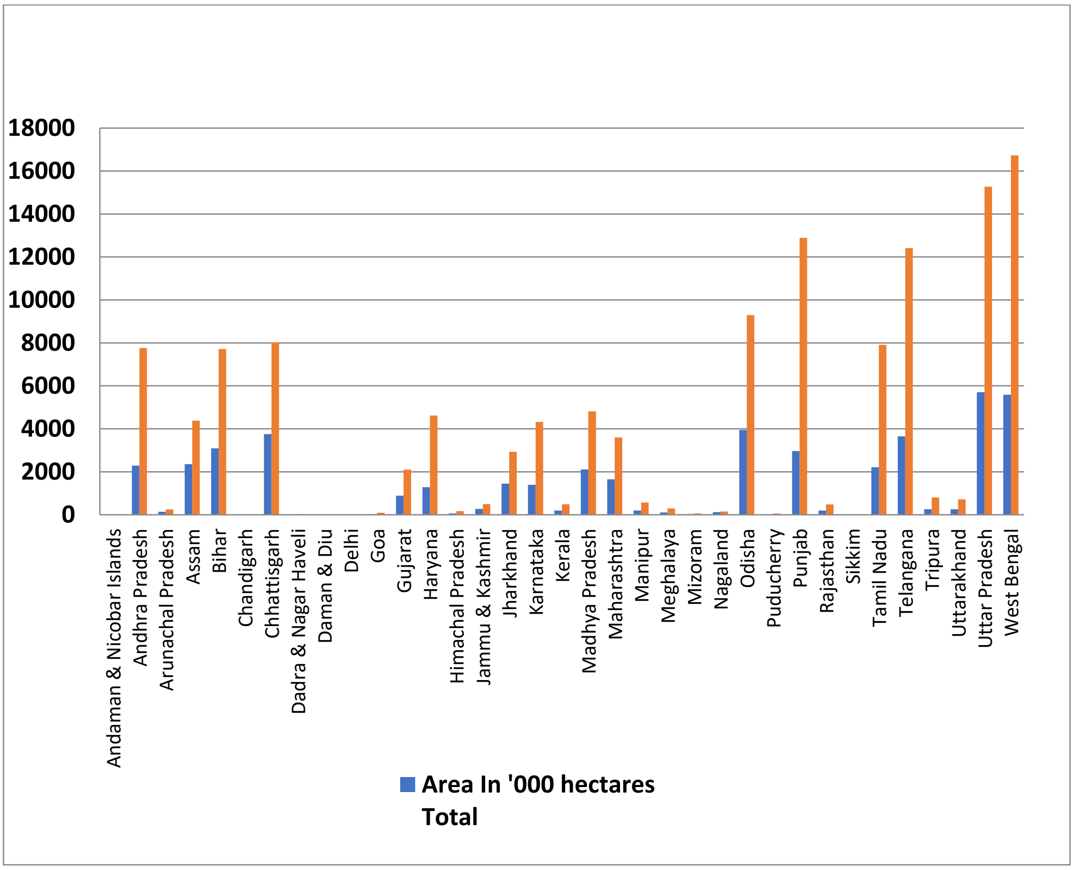



**Figure 1.1. State-wise area and production of rice in India (2021-22)**
(Source: GOI, 2023a)

It can be comprehended that rice production is not limited to any particular state or union territory and is widely distributed among many states. Rice is India's primary source in meeting the calorie requirement of the nation, especially for the low-income population. The Public distribution system annually provides grains free and at subsidised prices to the almost 800 million population of the country. Along with its importance in meeting the nutritional needs of the nation's population, India is also the major rice exporter to many countries. India alone accounts for around 40 per cent of the global rice exports. It can be observed from Figure 1.2 that the non-basmati rice exports from India are sent mostly to low-income countries. Thereby, India also plays a significant role in meeting the calorie requirements of many low-income countries. However, with climate change destroying crops, the government may further restrict itself from rice export to other nations.

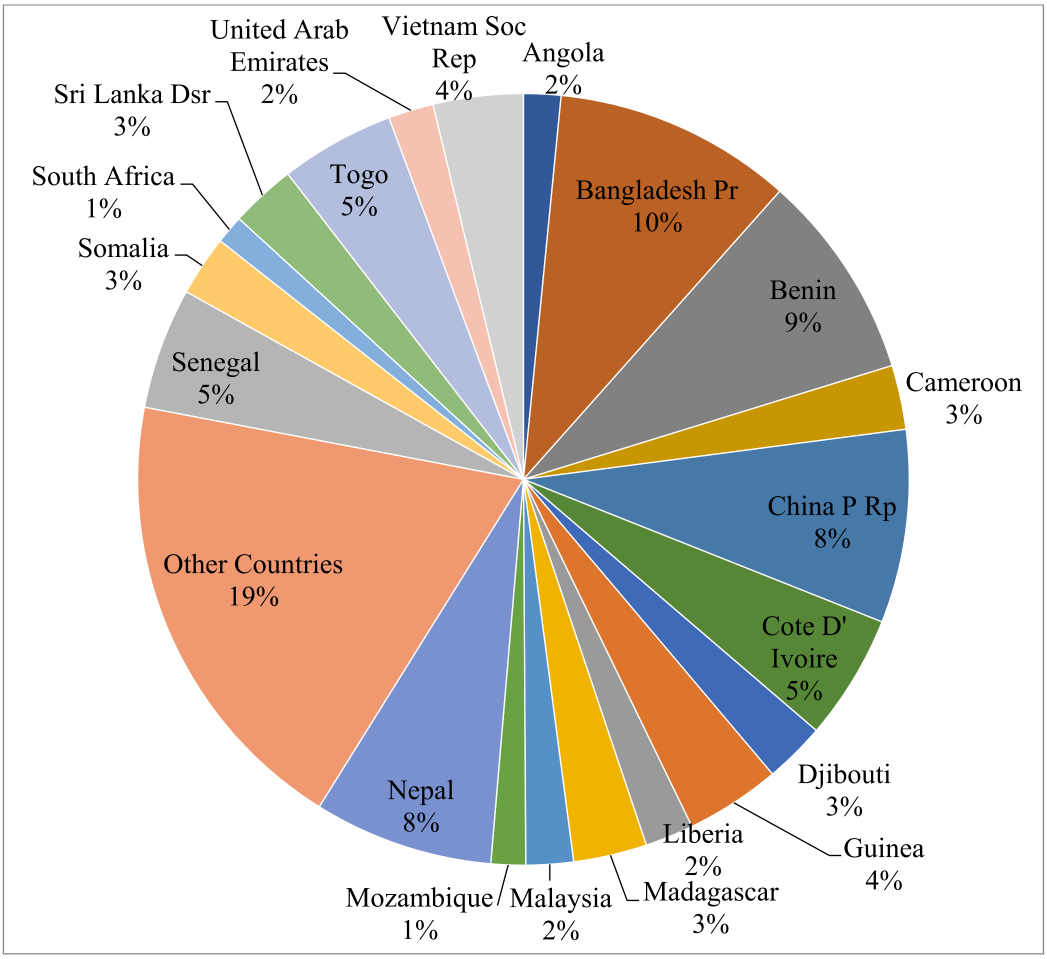



**Figure 1.2. Country-wise non-basmati rice exports from India (2019-22)**
(Source: APEDA, 2023)

In July 2023, India also banned non-basmati white rice exports, fearing cereal inflation that may arise from the El Nino situation. The government justified the ban, citing the recent trend in cereal inflation and the increasing retail prices over the year (GOI, 2023b). In September 2022, too, India restricted non-Basmati white rice exports by imposing 20 per cent export duties on it, citing the reason for production losses in the Kharif 2022 season. Such export bans will help safeguard the nation's requirements, but these measures lead to further price rises worldwide, especially in low-income countries.

### 1.4. Vulnerabilities of rice farming systems in India

Rice farming in India is mainly done under flooded irrigation where assured irrigation facilities are available, and in some regions, it is done using direct seeding methods. Most of the rice farming systems remain highly vulnerable to natural hazards, mainly droughts, floods, erratic rains, pests, and diseases.

### 1.4.1. Droughts

Since the Green Revolution, India has been affected by 13 significant droughts. Most of these droughts coincide with the El-Nino Southern Oscillation years, reducing rains in the Indian sub-continent. These reduced rains will affect the planting dates of the crop and the standing crops. Low rainfall affects both rainfed farming and surface irrigated areas. With low rainfall in the catchment areas, the water level in the dams will be affected. Thereby, the irrigated regions will also be under threat. The relationship between drought and rice yield is inverse, with a correlation coefficient of -0.27 at a 1 per cent statistical significance level (Birthal *et al*., 2015).

### 1.4.2 Floods

In Southeast Asia, around 22 million hectares of lowland rice areas are affected by floods, which cover 6.2 million hectares of India (Azarin *et al*., 2017, Dar *et al*., 2017). Though rice plants are grown in sub-merged conditions worldwide, the crop cannot withstand complete submergence. Submergence during the early days of the harvest will lead to total crop failure, and the odds of survival are very low. In the later stages, complete submergence of the crop results in lower availability of $CO_2$, impacting photosynthesis and reduced yields. Also, as rice is cultivated in the lowlands, excess water from the watershed areas will flow to the lowlands, resulting in complete inundation of crops in many instances. This inundation during the harvesting season will result in a total harvest loss to farmers.

### 1.4.3. Erratic rains

Erratic rains during the harvesting season result in the lodging of the plants and, in some cases, completely damaging the crop. This leads to the germination of the grains in the panicle, increased moisture content, and making it difficult to harvest. Lodging in rice crops during the harvesting stage is reported to cause a 5-80 per cent decrease in production, significantly affecting the quality of the produce and reducing the harvesting efficiency (Shah *et al*., 2017)

### 1.4.4. Pests and diseases

Rice crop is prone to severe attacks of many pests and diseases such as stem borer, brown plant hopper, rice blast, brown spot, bacterial leaf blight, etc. With the changing climate scenario and the practice of rice mono-cropping, many pests and diseases are occurring in high intensity, causing huge losses to farmers. For instance, Min *et al*. (2014) reported that the brown plant hopper (*Nilaparvata lugens*), the most devastating pest of rice, accounts for about 20 to 80 per cent of yield reduction, accounting for economic losses of around $300 million in Asia annually. According to Asibi *et al*. (2019), rice blast (*Pyricularia oryzae*) is one of the most serious diseases in rice, affecting upland and low-land rice production, leading to yield losses of around 10 to 50 per cent annually.

### 1.4.5. Schemes to promote farmer resilience

However, the Indian government is assisting its farmers through various schemes to improve the resilience of farmers to natural hazards. Crop insurance, one of the critical feature influencing resilience, is being adopted by many farmers. Pradhan Mantri Fasal Bima Yojana (PMFBY), the central government's flagship scheme, provides crop insurance to protect the farmers from natural hazards from pre-sowing to post-harvest stages. The scheme operates at low premium rates collected from farmers. Regarding food and oilseed crops, 2.0 per cent of the premium rate for Kharif crops and 1.5 per cent for Rabi crops is collected and 5 per cent of the premium rate for annual commercial and horticultural crops is charged from the farmers. Rest of the premium is shared by the central and state governments on 50:50 basis and in the north eastern states on 90:10 basis.. In addition to the lower premium rates followed in the scheme, many state governments are further reducing the burden on the farmers by paying the premium amounts from the state’s fund. Along with this, input subsidy is also provided to the farmers from the National Disaster Response Fund if the farmer has suffered crop loss of more than 33 per cent. An amount of Rs. 6800/- per ha in rainfed areas and Rs. 13,500/- per ha in irrigated areas is being given as input subsidy to farmers to compensate for the losses.

National Innovations in Climate Resilient Agriculture (NICRA), the flagship project under the Government of India, is also continuously working on studying the impacts of climate change on Indian agriculture and promoting resilient technologies. A vulnerability assessment of all the Indian districts was also done under NICRA. From 2014-23, the Indian Council of Agriculture released 1888 new varieties of different field crops which are climate resilient (ICAR, 2023). Traits such as drought tolerance, submergence tolerance, and disease resistance were imparted into the unique features of the released varieties. District contingency plans, which will be vital in case of extreme weather events, have been developed for 650 districts all over India.

### 1.5. Social networks and resilience

A social network represents a specific type of social advancement that relies on interconnected relationships among individuals with similar interests. These connections facilitate the exchange of information, resources, services, or collaborative efforts centred around a shared objective (Poudel *et al*., 2015). This is especially advantageous in less developed regions with inadequate educational, outreach, and agricultural information services in rural areas. Indian farmers are always embedded in social networking for gathering information and resources sharing with other farmers and organisations. Formal and informal knowledge networks help access diverse information, which is crucial for the resilience of agricultural systems (Sumane *et al*., 2018).

Analysing these social networks will help understand the relationships and interactions between individuals, groups, organisations, or other social entities. It also reveals how information, resources, and influence flow within and between these entities. It aims to uncover social networks' underlying structure and dynamics, identifying key actors, subgroups, and centralisation or decentralisation tendencies. These underlying relationships help us understand the factors contributing to the community's resilience. Much evidence from the literature shows that social networks are critical in improving disaster resilience. Social networks among people have many functions that promote resilience, such as sharing resources, cooperation in shared activities, knowledge exchange, and collective action (Chapman *et al*., 2018; Esparcia, 2014; Henry and Vollan, 2014).

### 1.6. Objectives

Though many studies report on the determinants of farm resilience, the dynamics of community resilience built on social relationships are not fully explored. When applied to communities, resilience is defined as the capacity of the system to maintain stability and health amidst challenges from socio-economic and natural disasters (Buikstra *et al*., 2010; Kulig *et al*., 2013). It is in this context that the study focuses on the community resilience of rice, the principal food crop of India addressing the following specific objectives.

1. Spatial and temporal analysis of natural hazards in rice farming systems

2. Delineating the socio-economic and agro-ecological determinants of community resilience

3. Mapping the structural and functional influence of social networks on community resilience in rice farming systems

4. Developing local adaptation plans to build community resilience against natural hazards

### 1.7. Scope of the study

Studying the resilience of farming systems has broad implications for agriculture, food security, sustainable development and the livelihood of farmers. With climate change posing more threats to farming systems, it is essential to study the underlying factors that make the systems vulnerable to natural hazards and the factors that promote adaptive capacity mitigation against them. In India, rice is the most consumed item in the food basket, and with the highest area under cultivation among all the crops, rice farmers must be made resilient to continue the crop's cultivation. Further, as farming involves lots of networking for sourcing information and resources, analysing the social networks of the rice farming communities will result in understanding the main actors involved and the importance of formal and informal networks.

Further, the results can be used to identify interventions and plan hazard management strategies to promote community resilience. Thus, an estimate of community resilience holds the potential of being a defining concept that takes cognisance of system properties related to marginality, power, and associated social and institutional structures that are important to explain differential susceptibility to natural hazards (Tanner et al. 2015). It will help the policymakers and farmers to understand the factors that are promoting as well as the factors that are negatively impacting the resilience of the rice farmers.

### 1.8. Limitations of the study

As the study was conducted by a single student investigator, it had the following limitations.

1. This study was conducted only in a total of 4 districts, 2 in Andhra Pradesh and 2 in Kerala, thereby limiting the scope of generalisation of the results.

2. As the study is conducted as part of the M.Sc. programme, time constraints have limited the study to only 220 respondents.

3. The farmers were not maintaining any field records hence this study relied on the memory recall and the perspectives of the respondents. This may have caused bias in the study. However, triangulation of data is done to limit the bias.

4. Though there is abundant literature available on the aspects of resilience to disasters, there was very scarce published literature in the field of farm resilience which made it difficult to compile the literature review.

### 1.9. Organization of the thesis

The thesis is structured into distinct chapters, each serving a crucial role in presenting the research comprehensively. The introduction lays the foundation by defining the research question, objectives, scope and limitations of the study. Following this, the review of literature chapter synthesizes existing research and theories, establishing a contextual framework for the study. The methodology chapter then outlines the research design, data collection methods, and analytical tools employed, ensuring transparency and replicability. The results and discussion chapters present and analyze the research findings, respectively, offering insights and interpretations. Finally, the summary and conclusion chapter encapsulates the key discoveries, emphasizes their significance, and often suggests future research directions. Additionally, the thesis includes an appendix section for supplementary material, a comprehensive list of references to acknowledge sources, and an abstract summarizing the entire study.

# Review of literature

# CHAPTER 2

# REVIEW OF LITERATURE

The review of literature chapter serves as a critical foundation for any research study, providing a comprehensive examination of existing scholarship relevant to the research topic. This chapter comprises of key theories, concepts, and empirical studies that have shaped the field. By delving into this body of knowledge, we aim to contextualise our research within the broader academic discourse and identify gaps or areas where this study can contribute new insights. Based on the objectives of the study, the review was arranged under the following sub-headings

2.1 Natural hazards in agriculture

2.2 Concept and measurement of resilience

2.3 Variables affecting resilience

2.4 Farmer social networks

## 2.1 Natural hazards in agriculture

Astafyeva (2019) defined natural hazards as the naturally occurring phenomena of geological, hydrological, or meteorological origin that might have a negative impact on humans or on the environment.

According to UNISDR (2004), hazard is a "process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation". They classified natural hazards broadly into 8 groups: meteorological and hydrological hazards, extraterrestrial hazards, geohazards, environmental hazards, chemical hazards, biological hazards, technological hazards, and societal hazards

UNISDR (2009) defined hazard as "a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage."

Burton and Kates (1963) defined natural hazards as the elements in the physical environment that are harmful to humans and are caused by forces that are extraneous to them, including geophysical and biological causal agents.

### 2.1.2 Studies on natural hazards in agriculture

Singh *et al*. (2022) in their work reported that maximum temperature, minimum temperature, and rainfall as the major natural hazards that had an inverse relation with agricultural production. However, when farmers applied different climate resilient strategies such as climate tolerant crops and varieties, changed planting dates, and improved irrigation facilities, the relation of production was found positive with the above-mentioned variables. Further, they suggested that credit availability should be enhanced to small and marginal farmers, which helps them to adopt new technologies and climate-resilient training should be given to the farmers.

Gummadi *et al.* (2021) researched the relationship between farmers' suicides and climate change vulnerability in Indian states. They revealed that the primary reasons for farmers' suicides in India are debts (39%) and natural disaster-caused crop failures (19%). They have also found a statistically significant relation between climate change vulnerability and the suicide of farmers. Further, they pointed out that it is essential to delineate the factors that are responsible for the resilience of farmers and use them to reduce farmer distress.

According to Food and Agricultural Organisation (2021), droughts and floods were the major natural hazards affecting agriculture. It was observed that droughts caused an estimated loss of USD 37 billion between 2008-2018, followed by floods with USD 21 billion.

Cariappa *et al.* (2021) in their work on crop losses, reported that the primary cause of crop loss was scarce rainfall leading to drought (53.90%), followed by pest, disease and animal attacks (14.24%) and together by floods, cyclones, lightning, storm (14.24%).

Ponnurangam *et al.* (2019), in their study on crop damages in rice, found that flood inundation in the Srikakulam district duncof Andhra Pradesh during the

Titli cyclone resulted in total production losses of 23 per cent, which translated to 189160 tonnes.

Guntukula (2020) analysed the impact of climatic variables on rice productivity in India from 1961 to 2017 and found that climate variables explained 87 per cent of the variation in rice crop yield. A statistical significance was also found between the yield losses caused by the natural hazards related to increase in temperature and rainfall.

Aditya *et al.* (2018) reported that 23.2 per cent of rice farmers suffered crop loss, and the average crop loss in rice was Rs. 19938/ha.

Arora and Birwal (2017), in their study on crop losses in Odisha, observed that hazards related to droughts and floods recurred every alternate year. The average value of crop loss due to floods was Rs. 11,253 and Rs. 3588 for droughts. Small and marginal farmers were more severely affected than large farmers. This was primarily because of the differences in the coping strategies that small and marginal farmers used in mitigation in contrast to large farmers. Small and marginal farmers indulged in low-income generating activities to diversify their income, whereas large farmers utilised institutional measures and technological options such as crop insurance schemes and use of short-duration varieties respectively.

Duncan *et al.* (2017) in their study on rice farmers' resilience, stated that most of the sample farmers had experienced crop losses more significant than 50 per cent due to floods and cyclones during 2008 and 2013, respectively. Also, 8.33 per cent and 19.33 per cent of the farmers responded that they could carry on as usual and did not need to cope with the losses that occurred during the hazards, respectively.

According to FAO (2017), extreme events such as floods and droughts would become more frequent and with more intensity due to climate change. This posed a severe threat to both food producers and consumers.

Rosenzweig *et al.* (2014) reported that yield losses due to climate change would be as high as 60 per cent by the end of the century, depending on the crop, location and future climate scenario.

## 2.2 Studies related to community resilience

### 2.2.1 Definition of resilience and community resilience

Taarup-Esbensen (2022) defined community resilience as the community's ability to absorb disturbances and retain its critical activities and structure after a disaster.

Healy (2006) defined community resilience as the capacity of the community to absorb disturbance and reorganise while undergoing change so as to retain key elements of structure and identity that presence its distinctness.

Chopitany *et al*. (2017) explained resilience as the ability of a system to recover, reorganise and evolve following external stresses and disturbances.

Folke *et al.* (2010) referred to community resilience as the general capacity of a community to absorb change, seize the opportunity to improve living standards and to transform livelihood systems while sustaining the natural resource base.

USAID (2012) defined resilience as the ability of people, households, communities, countries, and systems to mitigate, adapt to, and recover from shocks and stresses to reduce chronic vulnerability and facilitate inclusive growth.

Folke (2006) defined resilience as the ability of a system to absorb shocks or stresses while maintaining existing structure and function.

According to Holling (1973), resilience is a measure of a systems' persistence and ability to absorb change and disturbance while maintaining the same relationships between populations or state variables.

### 2.2.2. Studies on resilience measurement

Sun *et al*. (2023) measured farmers' livelihood resilience using an index focusing on three dimensions: buffer capacity, self-organisation capacity and learning capacity. Each dimension had indicators and sub-indicators which were used for measuring resilience.

Zawalinska *et al.* (2022) developed a framework for measuring farming resilience in which resilience is conceptualised as potential resilience and revealed resilience. Potential resilience is calculated using the dimensions of robustness, adaptability, and transformability. Revealed resilience is studied in terms of the total factor productivity of the system.

Meuwissen *et al*. (2019) have developed and used a framework for assessing the resilience of farming systems. The framework consisted of a mixed method approach that included quantitative methods such as econometrics modelling and qualitative methods such as participatory approaches, access to experiential knowledge, and interviews. The framework analysed the robustness, adaptability and transformability of the farming system, which are considered as promoting factors of resilience. The major constraint of this method is that it is primarily developed with a focus on the European Union's agricultural policies, thereby providing less flexibility for use in other countries.

Hernández Lagana *et al.* (2017) developed a Self-evaluation and holistic assessment of the climate resilience of farmers and pastoralists (SHARP+) tool for measuring the resilience of farmers. The SHARP+ tool assessed the socio-economic, environmental and agronomic aspects of farming and the household. The framework is operationalised in the field through a questionnaire including quantitative and qualitative answers, which are transformed into scores. The score reflects the level of resilience of the households.

Cutter *et al*. (2014) developed a disaster resilience assessment tool termed Baseline resilience indicators for communities to quantify the resilience of the community as a score. It involved assessing multiple dimensions relevant to disaster resilience using secondary data.

Plodinec (2012) developed an indicator-based framework for measuring resilience with community as the unit of analysis. The framework consisted of a total of 241 indicators with a focus on infrastructure, economics, natural systems, and social systems.

Mayunga (2007) proposed a theoretical framework for assessing community disaster resilience using a capital-based method. The components, namely social, economic, human, physical and natural capital, with focus on indicators needed for the development and maintenance of a sustainable community were used. The limitations of this framework are the data availability of each capital and the difficulty in establishing weights for each indicator.

### 2.3 Review of variables influencing resilience

#### 2.3.1 Annual Income

Nagadevi (2021) in their work on farmers in Palakkad district of Kerala found that 65 per cent of farmers in the sample had medium level of annual income (1 lakh – 2 lakh) followed by 20 per cent with low level of income (<1 lakh) and 15 per cent with high level of annual income (>2 lakh).

Anirudh, K.C. (2019) studied paddy farmers in Palakkad district of Kerala and found that majority of the farmers (80%) had annual income of less than 2 lakh, while 20 per cent of the farmers had more than 2 lakh annual income.

Xavier (2020) in his study on rice farmers, found that 77 per cent of the farmers belonged to the medium-income category while 14 per cent of them had a high level and 9 per cent of them had a low level of income.

Thangjam and Jha (2019), in their study, stated that 32.5 per cent of the farmers had annual income between Rs.40000-80000, followed by 27.5 per cent with above Rs.160000, 22.5 per cent with Rs.80000-120000, and 17.5 per cent with Rs.120000-160000.

Karangami *et al.* (2019) in their work reported that 96 per cent of the farmers had a medium level of income, followed by 16 per cent with a low and 8 per cent with a high level of income.

Saikia and Barman (2013), in their work on rice farmers in Assam, reported that most farmers (75%) had income below Rs.75000, followed by 25 per cent of the farmers with income above Rs.75000.

#### 2.3.2 Crop insurance

Kumar *et al*. (2023) in their work on determinants of crop insurance, reported that landholding size, farming experience, and access to institutional credit significantly affect the adoption of crop insurance. They also reported that out of 8055 farm households, only 46.02 per cent have insured their crop.

Hema *et al*. (2022) concluded in their study that crop insurance played a vital role in resilience by providing the required financial resources to the farmers to deal with economic loss caused by crop failures. Such liquidity would help the farmers continue cropping in the following seasons.

Paulraj and Easwaran (2020), in their study on the evaluation of Pradhan Mantri Fasam Bima Yojana in Tamil Nadu, reported that 63.79 per cent of the farmers belonging to age between 40-60 years had insurance on their crops, followed by 20.69 per cent of the <40 years age and 15.52 per cent of the >60 years age had insured their crops.

Cariappa *et al.* (2021) in their work on crop losses, stated that only 4.80 per cent of the farmers in their study have availed of crop insurance, out of which 4.07 per cent of the farmers are loanee and 0.73 per cent of non-loanee farmers. Further, the paper also reported that 87.01 per cent of the farmers have responded that they have not received the claim amount, followed by 7.09 per cent received but not in time.

Tiwari *et al.* (2020), in their study on crop insurance in India, observed that Kerala had 72 per cent of beneficiaries which are highest among all the southern states, followed by Karnataka with 49 per cent, Andhra Pradesh with 40 per cent and Tamil Nadu with 40 per cent.

Anirudh (2019) in their work on adoption of crop insurance in Palakkad district of Kerala reported that delay in the payment of claims is the major constraint faced by them followed by inadequate claim amount, dissatisfaction with area approach

Suresh (2019) reported that the significant constraints as perceived by the extension officials in the working of crop insurance schemes included delay in payment of insurance claims, inadequate publicity of schemes, lacunae in the assessment of crop loss and reporting.

Elum *et al*. (2018) studied crop insurance and revealed that crop insurance served as an adaptation measure against climate change. It helped in reducing the risks involved in the production. The study's results proved that possession of crop insurance significantly affected the farmers' net income.

Aditya *et al*. (2018) in their work on the adoption of crop insurance, have found that among rice farmers, the coverage of insurance is 3.9 per cent.

In their work on crop insurance, Uvaneswaran and Mohanapriya (2014) observed that 82 per cent of the farmers had insured their crops, and 18 per cent had not. They further reported that paddy was the crop which had maximum insurance coverage with 38 per cent of rice farmers adopting it. This could be attributed to the high vulnerability of the crop to natural hazards like cyclones, droughts and floods.

Rathore *et al*. (2011) assessed the performance of crop insurance in the Udaipur district of Rajasthan. They reported that the use of inputs such as labour, seeds, manure, fertilisers and pesticides was significantly higher among the farmers availing crop insurance than the uninsured farmers. The study also reported that insured farmers had higher agricultural income than uninsured farmers.

### 2.3.3 Compensation received

Duncan *et al*. (2017) in their study on the resilience of rice farmers, reported that 46.33 per cent of the rice farmers had received government relief for the crop losses that occurred due to 2008 floods.

Uvaneshwaran and Mohanpriya (2014) observed that there was a delay in the claim settlement to the farmers, which resulted in the farmers resorting to borrowing loans from informal sources to bear the risk.

Gireesh (2021) in their work on flood affected farmers in Thrissur district of Kerala reported that all the farmers in the study (n=160) have received monetary compensation for the crop losses incurred by them during the 2018 floods. They further reported that the farmers have not received the compensation amount on time and that they have not received full compensation amounts.

### 2.3.4 Kisan Credit Card (KCC)

Kumar *et al.* (2023) in their paper on the impact of lending through KCC, found that access to KCC increases farmers' use of agricultural inputs and also the income from farms, especially for the small and marginal farmers.

Malik and Malik (2022) in their study on the progress of KCC scheme in India, reported that during 1999-2019, the compound growth rate of total number of KCCs issued was 4.01 per cent, and compound growth rate of sanctioned credit was 13.58 per cent per annum.

GOI (2023) reported that as of December 2022, a total of 3.89 crore farmers in India have KCC whereas the total operational holdings as per the 2015-16 agricultural census is 14.6 crore.

Sarkar and Barman (2014) in their study on the low progress of KCC in Assam, stated that small land holdings, complex paperwork, less literacy among farmers, inadequate loan amounts and uncooperative behaviour of the bank employees as the major factors that hindered its progress.

### 2.3.5 Source of credit

Baghel (2021) revealed that all the respondents had acquired credit from co-operative societies, followed by 35.84 per cent availing credit from nationalised banks and 20.75 per cent availing credit from informal sources such as friends/relatives.

Cariappa *et al.* (2021) in their work reported that 33 per cent of the farmers borrowed from the banks, followed by 20.7 per cent from professional money lenders and 17.3 per cent from cooperative societies.

Duncan *et al.* (2017) found that 42 per cent of the rice farming households availed loans from co-operatives, followed by 37 per cent from money lenders, 26 per cent from family and kin, 8 per cent from self-help groups and 6 per cent from banks.

Vasavi (2017) in her work, analysed the agricultural credit preference in Kasaragod district of Kerala. She found that the majority of the farmers (36.67%)

were availing loans from cooperatives followed by 26.67 per cent from regional rural banks and 1.11 per cent from informal sources.

### 2.3.6 Diversity of income

Athira (2019) mentioned in their work on rice farmers that the majority of the rice farmers had agriculture as their only source of income, followed by 17.50 per cent having small-scale business, and 5 per cent of them were working as farm labourers.

Duncan *et al.* (2017) in their study on the resilience of rice farmers, stated that 74 per cent of the sample farmers were undertaking daily wage labour or diversified strategies to compensate for the losses they have incurred due to natural hazards.

Samarpitha *et al*. (2016) in their study, reported that only 90 per cent of the farmers had agriculture as their only source of income, and only 10 per cent of the farmers had secondary sources of income.

Maheriya (2013) in their study revealed that 58.33 per cent of the rice farmers relied on farming and animal husbandry as their source of income, followed by 25.00 per cent of them depending on farming and farm labour and 16.67 per cent of them depending on farming alone.

Smitha (2011) in their study on rice farmers in Palakkad district, observed that most of the farmers had rice cultivation as their sole source of income, and only a negligible percentage had other sources besides farming.

Armah *et al*. (2010) found that diversification of income is the main factor that helps reduce the risk of livelihood failure. The farmers used income from different sources to protect themselves from the fluctuations in crop yield seasonal variability. This also reduced the farmers' vulnerability and generated financial resources for farmers.

### 2.3.7 Availability of savings

Singh *et al*. (2021) studied the saving pattern of farm households in India and found that marginal farmers had no savings because of the inadequacy of their income. They reported that the total income used for consumption purposes decreased with the increase in farm size.

Wieliczko *et al*. (2020) stated that more than half of the small farmers had savings, but the level of savings was very low. The sustainability of the farm was under threat with this level of savings as the chance of meeting unexpected expenses was low. They also revealed that middle-aged farmers with higher education levels had higher savings than other farmers.

Hamsa and Umesh (2020) revealed that in progressive areas, the average propensity to save was higher than in the less progressive regions. Irrigated farms (88.54%) had a higher proportion of savings than the less irrigated farms. They also found that female-headed households had more savings when compared with male-headed households.

**2.3.8 Education**

Hema *et al.* (2022), in their study on the resilience of farmers concluded that farmers with higher education levels had higher levels of resilience by around four times compared to those with lower levels of education.

Anirudh, K.C. (2019) in their work on palakkad paddy farmers found that majority of the farmers in the region had education up to high school and higher secondary level (41.11%) followed by 21.67 per cent up to upper primary, 18.89 per cent primary level, 16.11 per cent up to degree and post graduation level.

Nagadevi (2021) in their work on farmers in Palakkad region of Kerala reported that majority of the farmers (42.50%) had an education at secondary level followed by 26.66 per cent with higher secondary education, 22 per cent with primary education and 8.33 per cent with graduation and above level of education.

Gireesh (2021) in their study found that majority of the farmers in the Thrissur district of Kerala (62.50%) had education up to high school followed by 24.37 per cent with higher secondary education, 6.88 per cent with college and above educational level and 6.23 per cent with primary education. She further reported that there were no illiterates in the sample.

Govindharaj *et al.* (2021) reported that most rice farmers (79.58%) had primary school education, followed by 20.42 per cent having high school education.

In their study, Paulraj and Easwaran (2020) found that 37.93 per cent of the farmers who insured their crops had college level education. .

Thangjam and Jha (2019) in their study reported that the majority of the farmers (26.65%) had middle school education, followed by 23.75 per cent illiterate, 15 per cent with secondary level, 12.5 per cent with primary level, 11.25 per cent with higher secondary, 7 per cent graduates and 2.5 per cent above graduates.

Arya (2018) identified that the majority of the farmers (31.67%) had completed middle school education, while 30 per cent of farmers had completed primary level education, 20 per cent of them were illiterate and 18.33 per cent of them had completed high school and above education.

Samarpitha *et al.* (2016) in their study reported that the majority of the rice farmers in Andhra Pradesh had an education level of SSC to Intermediate (43.33%), followed by 33.33 per cent below SSC, 12.5 per cent illiterate and 10.83 per cent graduate and above level.

Rohila *et al*. (2016) in their study stated that 21.67 per cent of the farmers had a middle level of education, followed by 20.83 per cent with metric education, 15.83 per cent of higher secondary, 14.17 per cent in graduate education, 13.33 per cent in illiterate category and 0.83 per cent of post-graduate category.

### 2.3.9 Farming experience

Thangjam and Jha (2020), in their study on sustainable rice production in Manipur, found that 43.12 per cent of the rice farmers had 11-20 years of experience in rice farming, followed by 33.75 per cent up to 10 years, 13.75 per cent between 21-30 years and 9.38 per cent above 30 years of experience.

Manasa (2021) in her study on paddy farmers in the Mandya district of Karnataka mentioned that the majority of the farmers (66.67%) had up to 20 years of experience, followed by 23.33 per cent with 21-30 years and 10 per cent with experience above 31 years.

Karangami *et al.* (2019) in their work reported that 62 per cent of rice farmers had a medium level of experience, followed by 34 per cent with high experience and 24 per cent with high experience in rice cultivation.

Samarpitha *et al.* (2016) reported that the majority of the rice farmers, 46.67 of the rice farmers had the experience of 21-30 years, followed by 30.83 per cent with 11-20 years, 12.50 per cent with up to 10 years and 10 per cent with more than 30 years of experience.

### 2.3.10 Community action

Ma *et al.* (2022) in their work on farmer's community participation noted that community participation in disaster prone areas helped in improving their ability to resist and cope with the disasters.

Baruah *et al.* (2022) in their work on collective action among women farmers in Odisha state concluded that collective action among the farmer community improved their knowledge on agriculture practices and technology, improved their social networks.

Fayayi and Lizarralde (2018) in their work concluded that community participation during the times of disasters helps in mitigation of the risks as it increases the collaboration among the stakeholders.

### 2.3.11 Social participation

Khuvung *et al*. (2022) in their study reported that 49 per cent of the sample rice farmers did not have any membership in any organisation, followed by 30.3 per cent with participation in one organisation, 13.7 per cent with participation in more than one organisation and 6.7 per cent in office bearer of an organisation.

Nagadevi (2019) found that majority of the farmers (58%) in the Palakkad region of Kerala had medium level of social participation followed by 25 per cent with high level and 17 per cent with low level of social participation.

Gireesh (2021) found that majority of the farmers in Thrissur district (61.25%) had medium level of social participation followed by low (21.25%) and high level of social participation (17.50%).

Baghel (2021) found that 73.75 per cent of the rice farmers had membership in at least one organisation, followed by 15.00 per cent of them with membership in more than one organisation, 6.25 per cent holding a position in the organisation and 5.00 per cent having no membership.

In their study, Thangjam and Jha (2019) reported that 51.25 per cent of the farmers had a medium level of social participation, followed by 27.5 per cent with low and 21.25 per cent with high social participation.

Samarpitha *et al.* (2016), in their work on rice farmers in Andhra Pradesh, reported that 64.17 per cent of the farmers were members of a cooperative society, followed by 60.28 per cent with membership in Rythu Mitra groups.

Shankaraiah and Narayana Swamy (2012) in their work on rice farmers in Andhra Pradesh, stated that 40 per cent of the farmers had a medium level of social participation, followed by 35 per cent high and 20.83 per cent low levels of participation.

**2.3.12 Farm size**

Balla and Goswami (2022) revealed that the majority of the rice farmers (68.40%) are marginal farmers, followed by 26.60 per cent small farmers and 5 per cent medium farmers in Andhra Pradesh

Khan *et al*. (2022) in their study on the impact of farmers' adaptation to climate change on rice yields, stated that the mean landholding size of rice farmers was 8.7 with a standard deviation of 6.8.

Gireesh (2021) in their work on flood affected farmers in Thrissur district of Kerala found that majority of the farmers in the area (39.38%) were small farmers followed by 38.12 per cent marginal, 20.62 per cent semi-medium and 1.88 per cent medium farmers. They also reported that there were no large farmers in the sample.

Govindharaj *et al.* (2021) in their study reported that 45.52 per cent of the farmers had land holding of 2.6 to 5 acres, followed by 45.42 per cent having 1.1-2.5 acre, 18.96 per cent having up to one acre, 3.96 per cent having 5.1-10 acre and 0.42 per cent having more than 10 acres.

Thangjam and Jha (2019), in their study, reported that the majority of the farmers (30%) belong to the small farmer category, followed by 80 per cent marginal farmers, 1.25 per cent semi medium and 1.25 per cent medium farmers.

Karangami *et. al* (2019) in their work noted that 59 per cent of the farmers had medium landholding (2.01 to 4ha), followed by 47 per cent with high (2 to 4 ha) and 14 per cent with low landholding (up to 1 ha).

**2.3.13 Source of irrigation**

Baghel (2021) found that all the sample farmers had tube wells as their source of irrigation, with 7.50 per cent having canals along with tube wells as their source.

Athota *et al.* (2018) in their work reported that 65 per cent of the sample farmers had a canal as their source of irrigation, followed by 20.83 per cent with both canal and bore well, 14.17 per cent with bore well as the only source of irrigation.

Samarpitha *et al.* (2016) in their study reported that 71.11 per cent of the farmers had irrigation canals as their source of irrigation, followed by 12.22 per cent with canal and bore wells, 11.94 per cent with bore wells and 2.78 per cent with dug wells and 1.94 per cent with tanks as their source of irrigation.

**2.3.14 Tenurial status**

Nagamani *et al*. (2023) studied the adoption behaviour of tenant and owner farmers towards usage of short-duration varieties and found that there is a significant difference between both the types of farmers in the adoption levels at a 1 per cent significance level. Tenant and mixed tenant farmers have adopted the short-duration varieties more than the owner farmers.

Nagadevi (2021) reported that majority of the farmers in the Palakkad district of Kerala were cultivating on their owned land (55%) followed by 28 per cent cultivating on owned land along with leased in land and 17 per cent of the farmers cultivating on fully leased in land.

Das *et al.* (2019) in their study on the socio–economic background of rice farmers, reported that 68.66 per cent of the farmers cultivate the crop only on their owned lands, followed by 19.66 per cent cultivating on wholly leased in farms and 10.66 per cent cultivating on partly owned and partly leased in farms.

Samarpitha et al. (2016), in their work on rice farmers in the Kurnool district of Andhra Pradesh, reported that 64.17 per cent of the farmers were own land farmers, followed by 29.17 per cent cultivating on partly owned and partly leased in farms. 6.67 per cent of farmers cultivating on completely leased in farms.

Revathi (2014) reported that 75 per cent of the tenant farmers in the East Godavari district of Andhra Pradesh were pure tenant farmers who do not own any land. Twenty-five per cent of the farmers in the region were mixed tenant farmers. In the case of the Kurnool district, 67.5 per cent of the farmers were pure tenant farmers, and 32.5 per cent of them were mixed tenants.

Prasad *et al*. (2012), in their work on tenant farmers in Andhra Pradesh found that 70 per cent of the total land cultivated in the East Godavari district is under tenancy farming. They further reported that there is no formal agreement between the lessor and lessee, which deprives the tenant farmer from availing of government support provided to the cultivators.

### 2.3.15 Recovery period

Duncan *et al.* (2017) in their study on the resilience of rice farmers, stated that 56 per cent of the farmers took two years or more to recover the crop losses incurred due to the 2008 floods that occurred in the Mahanadi delta region.

### 2.3.16 Perception of farmers on various weather parameters

A study by Singh *et al*. (2021) in Rajasthan revealed that the majority of the farmers in the study area perceived a change in the rainfall distribution (83%)

followed by an increase in the incidence of heat waves (63%), a temperature rise (55%) and increase in droughts (44%).

Paudel *et al.* (2020) reported that 99.22 per cent of the farmers said an increase in temperature, followed by 98.91 per cent reported a decrease in rainfall, and 96.63 per cent cited an increase in pest and disease incidence in crops.

Dhanya and Ramachandran (2016), in their work on farmers in Tamil Nadu, concluded that most of the farmers perceived a temperature rise (89%), followed by reduced rains (88%), delayed monsoon onset (74%) and a rise in intermittent dry spells (93%).

Kumar and Umesh (2015), in their work on perception analysis of farmers in Karnataka, observed that the majority of the farmers responded to a decrease in rainy days (95%), followed by 95 per cent responding to an increase in dry spells, 90 per cent responding a reduced rainfall amount, 72.50 per cent responding a change in the onset of rainfall.

**2.3.17 Crop diversification**

Baccar *et al.* (2023), in their work on strategies used by farmers to cope with unreliable water availability, concluded that increasing the farmer's capacity to cultivate multiple crops depending on the water requirements and availability was essential for improving the resilience of farming systems.

Kaushal and Jain (2023) studied crop diversification in Chhattisgarh, India and found that very low diversification was observed in all the crop groups.

Hema *et al.* (2022) have found that crop diversification has a statistically significant positive relation with resilience. They observed that the farmers who have adopted multiple cropping occupied higher levels in the resilience group than non-adopters.

Swami and Parthasarathy (2020) found that educated farmers were following multiple cropping to avoid the threats caused by climate variables. They also mentioned that crop failures in the previous reasons were the major reason influencing the farmers to diversify their cropping.

### 2.3.18 Knowledge and adoption of climate-resilient varieties

Swami and Parthasarathy (2020) studied that farmers' perception of climate change and their awareness of government schemes such as soil health cards plays a significant role in adopting short-duration crops. In the case of drought-resistant crops, schemes such as waiving off of loans and crop insurance schemes were negatively affecting the adoption. It reveals that plans that assure government financial support make farmers more reluctant to adopt the resilience crops.

Acevado *et al.* (2020) reviewed the adoption of climate-resilient crops in low and middle-income countries. They have concluded that extension outreach, the education level of farmers, access to improvised seeds and fertilisers and the socio-economic status of the farmers are the main determinants of the adoption of climate-resilient varieties.

Arora *et al.* (2019) studied the value given by farmers towards drought and flood-tolerant rice varieties in Odisha, India. They revealed that farmers in drought-prone and flood-prone areas are willing to pay a premium amount for tolerant cultivars.

### 2.3.19 Access to weather information

Sansa-otim *et al.* (2022) concluded that the majority of the respondents had access to weather information and that the forecasts were also almost correct. Further, the respondents felt that the information should be more location-specific and dissemination through SMS should be improved.

Sharma *et al.* (2021) found that 73 per cent of the respondent farmers received weather-related information. Overall, 42.1 per cent of the respondents mentioned that they were receiving information through mass media channels, 37.6 per cent responded that they received the information through ICT channels, and 26.3 per cent revealed that they got the info through face-to-face contact with other farmers and extension officials.

Jha and Gupta (2021) found a significant positive relation between access to information on climate variables and the use of adaptation strategies by farmers.

Nesheim (2017) reported that the dissemination of location-specific weather information allowed farmers to make informed decisions in performing different cultural operations such as sowing, irrigation, spraying, etc. It will also help the farmers in mitigating the risks caused due to droughts, pest attacks, strong winds, etc.

In their work, Camacho and Conover (2010) stated that information about weather contributed to reducing crop losses faced by farmers due to climate vagaries.

**2.3.20 Extension contact**

Khuvung *et al*. (2022) in their study reported that 23.66 per cent of the farmers had frequent contact with Agricultural Technology Management Agency, followed by Subject Matter Specialists (15.33%), agricultural officers (12.33%), field assistants (11%), agri clinics (4.33%).

Nagadevi (2019) in their work on farmers in Palakkad district of Kerala reported that majority of the farmers (52%) had medium level of extension contact followed by 28 per cent with high level and 20 per cent with lower level of extension contact.

Gireesh (2021) found that majority of the farmers in Thrissur district of Kerala (68.12%) had medium level of extension agency contact followed by low level (21.88%) and high level of contact (10%).

Baghel (2021) had mentioned that 47.50 per cent of the farmers had a medium level of extension contact, followed by 42.50 per cent with a low level of communication and 10.00 per cent with a high level.

Jha and Gupta (2021) concluded from their work that contacts with extension officials and utilising their services will enable the farmers to respond early and reduce the risks of natural hazards. They found a positive relation between agricultural extension services and the use of adaptation strategies by farm households against climate change.

Karangami *et al*. (2019) in their work reported that 93 per cent of the farmers had medium extension contact, followed by 22 per cent with high and 5 per cent with low extension contact.

Samarpitha *et al.* (2016) in their work on rice farmers in Andhra Pradesh, reported that 67.22 per cent of the farmers were maintaining contact with extension agents, and 32.78 per cent of the farmers were not maintaining any contact with the extension agents.

Narayana *et al.* (2012) in their work on rice farmers in Andhra Pradesh, stated that 70.00 per cent of the farmers had a medium level of extension contact followed by 17.50 per cent with low and 12.50 per cent of a high level of communication.

**2.3.21Training exposure**

Nagadevi (2021) stated that majority of the farmers in the Palakkad region of Kerala (89%) have received trainings related to good agricultural practices while 11 per cent of them never received any trainings.

Haneef *et al.* (2019) stated that only 35 per cent of the farmers have attended trainings related to agriculture, while the rest 65 per cent have never attended any form of training concerning agricultural practices. Farmers also have mentioned a severe lack of training institutions as a constraint which is hindering their interest in upgrading their knowledge of new practices.

Thangjam and Jha (2019) in their study found that 66.25 per cent of the rice farmers never attended any training, and 33.75 per cent of the farmers attended the training.

Saikia and Barman (2013), in their work on rice farmers in Assam, found that the majority of the farmers (74.16%) had never attended any training from institutions.

Narayana *et al.* (2012) in their work on rice farmers, reported that only 17.5 per cent of the farmers had undergone multiple trainings, and 35 per cent of the farmers received very low levels of training.

### 2.3.22 Access to roads

Egyir *et al.* (2015) mentioned in their study that the availability of roads near the farmlands is directly proportional to the capacities of farmers to mitigate and adapt to disasters.

Joerin *et al.* (2014) in their work on resilience, stated that the availability of roads is one of the critical characteristics of a well-functioning and resilient community.

### 2.3.23 Machinery possessed

Sarkar (2020) in his work on agricultural mechanisation in India, reported that there is a positive relationship between the land holding and machinery. He also found that farmers had more manually operated tools, followed by water lifting equipment, tractors and power tillers. The author also reported that there is relatively less inequality among different classes of landholders in water lifting equipment.

Panda (2017) in their study, mentioned that 41.11 per cent of the rice farmers had a medium level of machinery possession, followed by 32 per cent with low machinery possession and 23.33 per cent with high machinery possession.

NCAER (2023) report pointed out that as of 2018-19, only 4.4% of the total farmers in India had a tractor, followed by 2.5% farmers with power tiller.

### 2.3.24 Household assets

Jha and Gupta (2021) in their work on farm households in India, mentioned that the availability of household assets such as T.V., radio, and mobile phones improves the likelihood of using adaptation strategies such as soil and water conservation against climate vagaries.

Swami and Parthasarathy (2020) revealed that the farmers with assets such as T.V., mobile, and radio are adopting climate-resilient practices such as improved irrigation technologies than those not possessing such assets.

Anand *et al.* (2020) studied the availability of ICT tools with farmers in Bihar, India. They revealed that 87 per cent of the farmers had access to television, 80 per cent of them had internet access, and only seven per cent had personal computers/laptops.

Panda *et al.* (2019) found that all the farmers in the sample had televisions in their households, followed by 90 per cent having mobile phones, 37 per cent having radio and 27 per cent having computers.

Joerin *et al.* (2014) in their study on resilience, mentioned that the availability of household assets such as television, mobile phones, and motorised vehicles helped people to be informed about disasters. This information played a vital role in mitigating and adapting to the threats arising from the disaster.

**2.4. Studies on social networks of farmers**

Valujeva *et al.* (2023) reported that social network analysis of the farmers identified the key stakeholders and influential players in the networks. Network mapping helped in identifying the actors who act as the bridge between the policymakers, scientists and farmers. They further mentioned that horizontal strengthening within the farmer communities and policy departments and vertical strengthening between the farmers and policy departments are necessary for improving knowledge transfer.

Varshney *et al.* (2022) revealed that farmers were most likely to adopt new technologies when they learned about them through interactions with their own caste members. The results were found insignificant the other way. The study also showed that the likelihood of accepting information and advice is higher when SC/ST farmers interact with non–SC/ST farmers but not vice versa. They emphasised the importance of identifying the existing network among the farmers and focusing on them for better dissemination of information and technology adoption.

Negi *et al.* (2022) studied the effect of social networks on the diffusion of modern crop varieties in India. They stated that social networks will enhance the speed of information exchange, especially in developing countries where the public extension system is weak. They mention that the general channel for information dissemination is through the formal public extension officials to a few progressive farmers. However, village members vary in socioeconomic characteristics, such as caste and religion, which may cause social bias and hinder the process. Promoting homogenous groups such as self-help groups is emphasised to reduce social bias.

Konda *et al*. (2021) reported that social networks significantly contribute to successfully adopting new agricultural technologies, machinery and improved varieties. As a result, they also increase productivity and support resilience through coordinated efforts that provide a positive overall effect.

Bruce *et al*. (2021) worked on the effect of social networks on farming resilience. They have concluded that social networks among the Orkney farmers are increasing their resilience through higher collaboration, cooperation in activities, improved knowledge flow and resource sharing.

Jagriti *et al.* (2021) studied the of information acquisition networks of farmers in rain-fed areas in Telangana. They reported that friends form the main actors in the network of farmers for information acquisition with higher in degree scores followed by progressive farmers and scientists. They recommended a higher linkage between government institutions and the actors with higher degree centrality in the network for efficient information and resource dissemination.

Skaalsveen *et al*. (2020) stated that farmers interacted more with their peer farmers, who were more successful in their farming than with the agricultural experts. The main reason behind this is the importance given by the farmers to the practical experience of their peers. The network cohesiveness of the farmers also revealed the importance of intermediaries and their role as influencers and information providers.

Mittal *et al*. (2018) found that government institutions were playing a major role in the information networks of Bihar farmers with higher in degree followed by input dealers. They further mentioned that input dealers should be further made as nodal points for efficient information delivery to farmers. They also found that progressive farmers were highly networked with the government institutions compared to non-government institutions.

Magnan *et al*. (2015) in their study on social networks among Indian farmers concluded that policies promoting connections between farmers should be advocated. These connections will improve the information flow, leading to efficient dissemination of technologies.

Aldrich (2012) found that networks that link a community with formal institution officers played an essential role in economic development and resilience by providing resources and information.

Wetterberg (2004) observed that networks of a community with members outside the community, known as bridging networks, contributed directly to community resilience through the exchange of resources.

# Research methodology

# CHAPTER 3

# RESEARCH METHODOLOGY

Research methodology refers to the systematic framework and techniques employed in conducting a study or investigation to gather, analyse, and interpret data. It serves as a roadmap that guides researchers in formulating research questions, designing experiments, selecting appropriate data collection methods, and determining the most suitable data analysis techniques. A robust research methodology enhances the credibility and reliability of the study's findings by ensuring the research process is transparent, replicable, and logically sound. This chapter describes the selection of research design, location of the study, sampling procedure, data collection methods, methods used for measuring the objectives of the research and statistical analysis used to derive and interpret the results.

All the methods and techniques that are used in the present study on Community resilience against natural hazards in rice farming systems: A social network analysis have been detailed under the following subtitles.

3.1. Research design
3.2. Locale of the study
3.3. Sampling procedure
3.4. Spatial and temporal analysis of natural hazards
3.5. Measurement of Community Resilience
3.6. Mapping of social networks of the rice farming communities
3.7. Grey relational analysis
3.8. Methods for data collection
3.9. Statistical tools
3.10. Analytical tools

## 3.1. Research design

According to Kerlinger (1986), research design is the plan, structure, and investigation strategy conceived to obtain answers to research questions and control variance.

For the conduct of this study, an ex-post facto research design has been used. This research design is selected because the events have already occurred, and the researcher has no direct control over the variables. Thereby, the study involves the study of the events that have occurred and finding the underlying variables that affected the event.

### 3.2. Location of the study

East Godavari and Kurnool districts of Andhra Pradesh and Palakkad and Thrissur districts of Kerala were selected as the study locations. The study areas were selected purposively based on their proneness to natural hazards, as reported by Rama Rao et al. (2019) in the "Risk and Vulnerability Assessment of Indian Agriculture to Climate Change". Along with proneness to natural hazards, the extent of area cultivated under rice was also considered for selecting the location. Based on the report, districts with high propensity to floods, i.e. East Godavari and Thrissur districts of respective states, were selected. Likewise, districts with high propensity to droughts, Kurnool and Palakkad districts were selected. The area under rice cultivation in these districts is also relatively high compared with other regions with similar natural hazard proneness levels. Fig. 3.1. shows the study area.

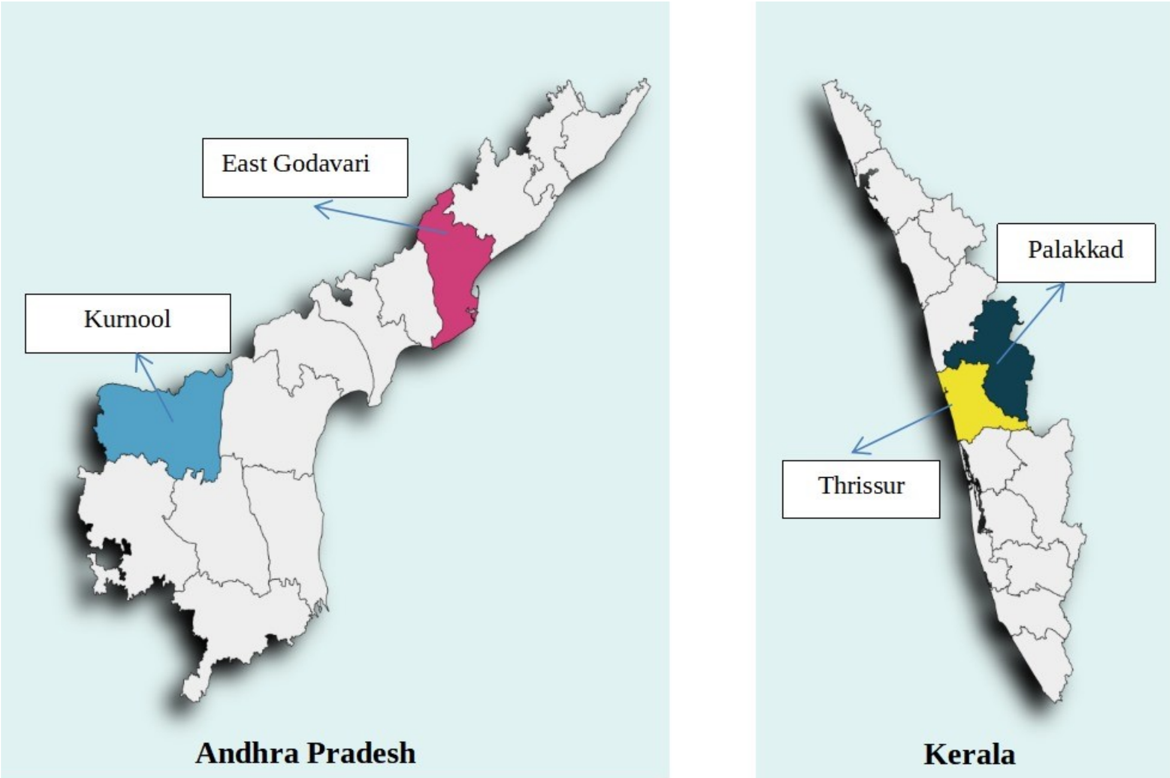



**Fig. 3.1. Outline maps of Andhra Pradesh and Kerala states showing the study area**

Depending on the area under paddy cultivation in these districts, proportionately, two villages from each district of Andhra Pradesh and one village from each district of Kerala have been selected.

### 3.3. Sampling procedure

Multi-stage sampling has been used in this study. In the first stage, the blocks/mandals were selected based on the crop losses that occurred in the respective districts. The data has been collected from the official sources and analysed to find the blocks/mandals that had reported higher crop losses in 2019-2023. Following that, the villages with higher rice cultivation areas in the block/mandal were selected for the study. For selecting the respondents, random sampling was used to study 30 rice farmers per village, thereby making the total sampling size 180 rice farmers. Along with the farmers, ten facilitators per district were also interviewed to understand the factors that promote resilience. The flow chart of the sampling procedure is given in Fig. 3.2.

### 3.4. Spatial and temporal analysis of natural hazards

The spatial and temporal trends of crop losses due to natural hazards were assessed using secondary data collected from the government sources of both Andhra Pradesh and Kerala states. The data related to crop losses due to natural calamities from 2019-2023 has been considered as data before 2019 was unavailable in some of the study locations. Based on the secondary data on crop losses in hectares, total production losses and total value losses have been calculated using following formulae.

**Total production loss = Total crop loss in ha. × Yield per ha.**

**Total value loss = Total production loss in tonnes × Price per tonne**

Total area under paddy cultivation, crop losses in paddy due to natural hazards and the minimum support prices for paddy during 2019-2023 collected from government reports were used in calculation.

### 3.5. Measurement of community resilience

Based on the objectives of the study, community resilience of the rice farming systems was selected as the dependent variable.

Community resilience of the systems was measured using the index developed by Jayadas and Ambujam (2021) with modifications suitable for this study. The index comprised four dimensions and sub-indicators under each dimension to understand the factors affecting resilience against natural hazards. The index consisted of four dimensions contributing to resilience viz. economic, social, technical, and physical. Under each dimension, relevant variables were included that determine the resilience of the farmers. Table 3.1. shows all the variables that are used in the calculation of the Community Resilience Index (CRI).

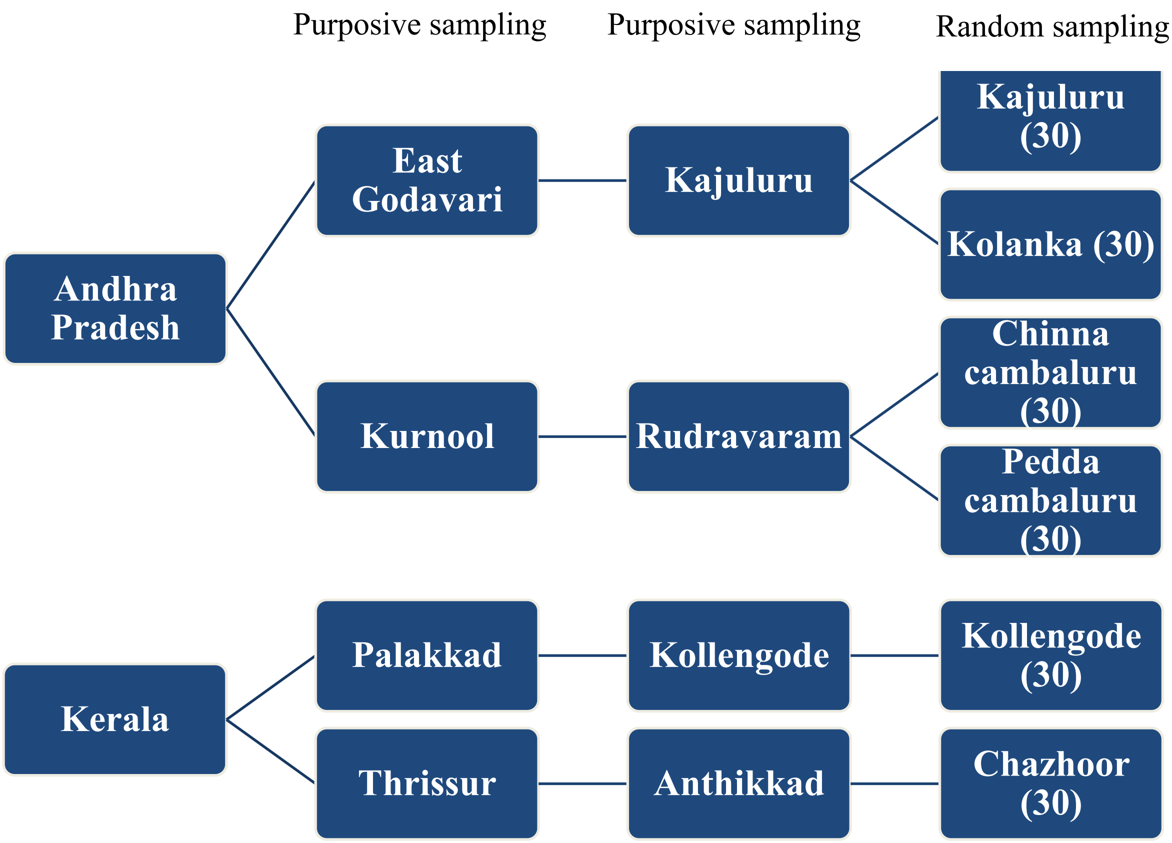



**Fig. 3.2. Flow diagram showing the selection of sample for the study**

**Table 3.1. List of dimensions and variables used in the community resilience index**

| Dimension | Variables |
|---|---|
| **Economic dimension** | |
| | 1. Annual income |
| | 2. Income loss due to natural hazards |
| | 3. Compensation received |
| | 4. Crop insurance |
| | 5. Availability of savings |
| | 6. Source of credit |
| | 7. KCC loans |
| **Social dimension** | |
| | 1. Community help |
| | 2. Social participation |
| | 3. Educational qualification |
| | 4. Extension agency contact |
| | 5. Community action |
| | 6. Access to climate related trainings |
| **Technical dimension** | |
| | 1. Knowledge on climate resilient varieties |
| | 2. Knowledge on crop diversification |
| | 3. Access to daily weather data |
| **Physical dimension** | |
| | 1. Farm size |
| | 2. Type of tenancy |
| | 3. Household assets |
| | 4. Farm machinery possession |
| | 5. Field drainage infrastructure |
| | 6. Access to roads |
| | 7. Irrigation sources |

### 3.5.1 Economic dimension

The economic dimension refers to the financial aspects of the farmer community, such as income, savings, access to credit, etc. Financial assets of the farmer community are essential for resilience as they provide means for investing in the inputs and technologies and help farmers during shocks caused by natural hazards by acting as a buffer.

#### 3.5.1. a. Annual income

Annual income has been defined as the total amount of money the farmers receive during a year after the deduction of the expenses. The scale Sivaprasad (1997) developed was used in categorising and scoring the variable with suitable modifications. Scoring of the variable was done as follows:

| Sl. No | Income (INR in Lakhs) | Score |
|---|---|---|
| 1 | <1.0 | 1 |
| 2 | 1.0 - < 2.0 | 2 |
| 3 | 2.0 - < 3.0 | 3 |
| 4 | 3.0 – 4.0 | 4 |
| 5 | >4.0 | 5 |

#### 3.5.1. b. Income loss due to natural hazards

The variable has been operationalised as the income that was lost by the farmer owing to the recently occurred natural hazard. It has been categorised and scored based on the procedure used in the Self-Evaluation and Holistic Assessment of Climate Resilience of Farmers and Pastoralists (SHARP+) developed by Hernández Lagana *et al.* (2022) as detailed below.

| Sl. No | Category of income loss | Score |
|---|---|---|
| 1 | Less than 10% | 4 |
| 2 | 10-30% | 3 |
| 3 | Around half | 2 |
| 4 | More than 60% | 1 |

### 3.5.1. c. Compensation received

The variable was operationalised as the financial payments received by the farmers as a form of reimbursement from the government when their crops were adversely affected due to natural hazards. This compensation helped the farmers to offset the economic losses that the farmers incurred. The variable has been categorised into two groups, Received and Not at all received and scored as follows:

| Sl. No | Compensation status | Score |
|---|---|---|
| 1 | Received | 1 |
| 2 | Not at all received | 0 |

### 3.5.1. d. Crop insurance

Crop insurance was operationalised as a mechanism that provided financial protection to farmers in the event of crop failures due to natural hazards. It served as a safety net for farmers during crop failures and helped stabilise their incomes. A schedule was developed for scoring the variable as follows.

| Sl. No | Crop insurance adoption | Score |
|---|---|---|
| 1 | Never | 1 |
| 2 | Often | 2 |
| 3 | Always | 3 |

### 3.5.1. e. Source of credit

The variable has been defined as the financial resources that a farmer has acquired through borrowing from a financial institution or any other sources. The variable has been scored as the following:

| Sl. No | Source of credit | Score |
|---|---|---|
| 1 | Formal sources | 3 |
| 2 | Both formal and informal sources | 2 |
| 3 | Informal source | 1 |

### 3.5.1. f. Availing KCC loans

The variable was defined as the loans taken by the farmers using their KCC with minimal interest rates of seven per cent from banks. A schedule has been developed and scored for measuring the variable. A score of 1 was given for the farmers availing KCC loan and 0 for those who are not availing.

### 3.5.1. g. Availability of savings

The variable has been defined as the accessible sources of funds that a farmer has set aside for future use or emergencies. The variable was measured by directly asking the farmer whether they have any savings to meet emergencies, and a score of 1 is given for Yes and 0 for No. In the case of yes, further classification of different forms of savings as detailed below was also recorded.

| Sl. No | Form of saving |
|---|---|
| 1 | Gold |
| 2 | Bank deposits |
| 3 | Self-help group savings |
| 4 | Other sources |

### 3.5.2. Social dimension

Social dimension deals with the social capital of the farmer community in terms of the effective functioning of the community. It encompasses the cooperation among community, trust, social participation, and other aspects that explain the social environment of the community. Social dimension of the farmers, thus formed a vital aspect of resilience as it enabled farmer's access to knowledge and support from other farmers, facilitating collective action during times of natural hazards.

#### 3.5.2. a. Community cooperation

It has been defined as the trust by the farmer that the community would help them in times of need. The variable was measured adopting the scale developed by Hernández Lagana et al. (2022) with suitable modifications. The scoring used was as follows.

| Sl. No | Community help | Score |
|---|---|---|
| 1 | Never | 0 |
| 2 | Sometimes | 1 |
| 3 | Always | 2 |

#### 3.5.2. b. Social participation

It has been defined as the degree of involvement of the farmers in formal and informal social organizations. As detailed below, the scale developed by Kamarudeen (1981) was used with slight modifications for measuring the variable.

| Sl. No | Membership in organisations | Score |
|---|---|---|
| 1 | No membership | 0 |
| 2 | Membership | 1 |
| 3 | Office bearer | 2 |

### 3.4.2. c. Educational qualification

The variable was operationalized for the study as the years of formal education attained by the respondent in terms of level of schooling. The respondents were categorized and scored based on the scale followed by Reshmi (2019) with slight modifications.

| Sl. No | Education level | Score |
|---|---|---|
| 1 | Illiterate | 0 |
| 2 | Primary (Upto 7$^{th}$ standard) | 1 |
| 3 | High school (8$^{th}$ to 10$^{th}$ standard) | 2 |
| 4 | Higher secondary (11$^{th}$ and 12$^{th}$) | 3 |
| 5 | Graduation and above | 4 |

### 3.4.2. d. Extension agency contact

It was defined as the extent of contact the farmers had with the agricultural extension officials. The scale used by Anoop (2013) was used with suitable modifications for measuring the variable. The scoring procedure is indicated in the following table.

| Sl. No | Category of personnel | Frequency of contact | | |
|---|---|---|---|---|
| | | Regularly (3) | Occasionally (2) | Never (1) |
| 1 | Agricultural officer | | | |
| 2 | KVK personnel | | | |
| 3 | University scientists | | | |
| 4 | NGO/ Extension functionaries | | | |

### 3.4.2. e. Exposure to trainings

Exposure to trainings was referred to the frequency of participation of the farmer in training sessions related to climate-resilient agriculture. It was measured using the scale Sasidharan (2015) used with suitable modifications and the scoring procedure is mentioned below.

| Sl. No | Number of trainings attended | Score |
|---|---|---|
| 1 | No training | 0 |
| 2 | Less than five trainings | 1 |
| 3 | Five or more than five trainings | 2 |

**3.4.2. f. Community action**

Community action referred to the collective efforts and activities undertaken by the community members to address agriculture-related issues and solve them within the local area. The scale and scoring procedure followed in the SHARP+ tool developed by Hernández Lagana *et al.* (2022) was slightly modified to measure the variable. The respondent was asked whether they had participated in any collective action to solve a pressing problem in recent years. Scoring was done as 1 for yes and 0 for no.

**3.4.3. Technical dimension**

The technical dimension of the farmers refers to the knowledge, skills and expertise with respect to climate-resilient agricultural practices of farmers. This dimension is crucial for community resilience, empowering farmers to make informed decisions and resilient farming practices.

**3.4.3. a. Knowledge of climate-resilient seed varieties**

It was operationally defined as the awareness of farmers on paddy varieties that are resilient under different climatic conditions. It was measured using the procedure followed by Jayadas and Ambujam (2021) with slight modifications. A score of 1 was given for the awareness on each type seed variety

| Sl. No | Seed variety | Aware |
|---|---|---|
| 1 | Lodging resistant / dwarf varieties | |
| 2 | Drought-resistant / upland cultivable varieties | |
| 3 | Early and late maturing varieties | |
| 4 | Pest and disease-resistant varieties | |
| 5 | Problematic soils tolerant varieties | |

#### 3.4.3. b. Knowledge on crop diversification

It was operationally defined as the information and understanding related to the practices of growing different crops simultaneously to reduce risks and improve overall productivity. The variable was measured using the scale followed by Jayadas and Ambujam (2021) with suitable modification. A score of 01 each was given for awareness about each strategy and 02 for aware and adopted category.

| Sl. No | Diversification strategies | Aware | Aware and adopted |
|---|---|---|---|
| 1 | Multiple cropping | | |
| 2 | Integrated farming system | | |
| 3 | Relay cropping | | |

#### 3.4.3. c. Access to daily weather data

Access to daily weather data refers to the availability and accessibility of up-to-date information about the weather conditions on a daily basis to the farmer. For measuring the access, a score of 1 is given if the respondent reported that they have access to daily weather data and 0 if the respondent reported that they have no access to the data.

### 3.4.4. Physical dimension

This dimension deals with the assets and infrastructure that are available to the rice farming communities that improve their resilience. The dimension encompasses land availability, irrigation sources, drainage availability, access to roads, machinery and household assets available to the farmers. The physical capital of the farmers acts as the foundation for resilience, a high level of physical capital contributes to a reduction in vulnerability to climatic shocks.

### 3.4.4.a. Farm size

Farm size was operationally defined as the total agricultural land holdings owned by the respondent during the study. The procedure used by Jaganathan (2004) was used for further classifying and scoring of the farmers based on their land holding size, as given below

| Sl. No | Farmer category | Score |
|---|---|---|
| 1 | Marginal farmers (< 1.00 ha) | 1 |
| 2 | Small farmers (1.00 – 2.00 ha) | 2 |
| 3 | Semi – medium farmers (2.00 – 4.00 ha) | 3 |
| 4 | Medium farmers (4.00 – 10.00 ha) | 4 |
| 5 | Large farmers (>10.00 ha) | 5 |

### 3.4.4.b. Type of farming

Type of farming refers to the kind of land that is available to the farmer at the time of interview for cultivation purposes. It is measured using the following procedure.

| Sl. No | Type of operational land holding | Score |
|---|---|---|
| 1 | Fully owned land | 3 |
| 2 | Partly owned and partly leased in | 2 |
| 3 | Fully leased in | 1 |

### 3.4.4. c. Household assets

Household assets refer to the physical assets available in the farmer's household. A score of 1 was given to each of the following available assets in the household.

| Sl. No | Asset |
|---|---|
| 1 | Radio |
| 2 | Television |
| 3 | Mobile with internet |
| 4 | Motor vehicle |

**3.4.4. d. Farm machinery available**

Farm machinery availability refers to the inventory of agricultural equipment and machinery a farmer owns. The machinery was categorised using the classification used by the National Council of Applied Economic Research (NCAER), 2023. A score of 1 was given for each type of the following machinery available to the farmer.

| Sl. No | Farm machinery |
|---|---|
| 1 | Tractor |
| 2 | Soil preparation machinery |
| 3 | Seeding and planting machinery |
| 4 | Harvesting and threshing machinery |

**3.4.4. e. Field drainage availability**

It was defined as the presence of a proper drainage system on the operational land holding of the respondent to remove the excess water from the field whenever necessary. A score of 1 was given for drainage availability and 0 if it was unavailable.

**3.4.4. f. Access to roads**

Access to roads refers to the availability of roads, either pucca roads or farm paved roads, within the reach of the operational land holding of the farmer. A schedule was developed to measure the variable, and the scoring procedure is given in the table below.

| Sl. No | Type of road | Score |
|---|---|---|
| 1 | *Pucca* road | 2 |
| 2 | Farm paved roads | 1 |
| 3 | No road | 0 |

### 3.4.4. g. Irrigation source

Irrigation source refers to the sources of water available for the purpose of artificially providing moisture to the soil. A score of 1 was given for each of the following sources available with the respondent.

| Sl. No | Source of irrigation |
|---|---|
| 1 | River |
| 2 | Irrigation canals |
| 3 | Bore well |
| 4 | Ponds/Tanks |

### 3.4.5. Calculation of Community Resilience Index (CRI)

Following data collection and scoring, in the next step of analysis, the scores of various variables have been normalized using the following formula

$$Zi = \frac{Xi - Xmin}{Xmax - Xmin}$$

Where, $Zi$ = standardised score, $Xi$ is the score of $n^{th}$ individual of $i^{th}$ variable, $Xmin$ is the minimum score obtained and $Xmax$ is the maximum score obtained.

Further, Principal Component Analysis (PCA) was used to arrive at the component loadings and eigenvalues, which was used as the weightage for the variables (Jayadas and Ambujam, 2021; Filmer and Pritchett 2001; McKenzie, 2005). Before running the PCA, the suitability of data for running PCA was checked using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. A value greater than 0.8 for the KMO measure is suitable for running PCA. After running the PCA, the component that explained the maximum variance with an Eigenvalue greater than one was selected. All the factor loadings of the variables in the component were taken as weights. After the weights were assigned for each variable, the score of the respondents was multiplied by the weightage to calculate the resilience index. The equation used for calculating the dimension-wise resilience index is given below:

$$\text{Dimension-wise resilience index}_i = \frac{\sum_{j=1}^{n}(Weightage * Variable\ score)j}{n}$$

Where i is the dimension, j is the number of variables under each dimension, and n is the total number of variables under each dimension. After calculating the dimension-wise resilience index i.e. Economic resilience, Social resilience, Technical resilience, and Physical resilience, respectively, overall community resilience was calculated using the following equation:

$$\text{Community resilience index} = \frac{\sum_{i=1}^{n}\frac{Dimension-wise\ resilience\ indexi}{Maximum\ resilience\ indexi}}{n}$$

where, *i* is the dimension and n is the total number of dimensions.

Finally, the calculated community resilience was categorised into low, medium, and high categories, following Jayadas and Anbujam (2021). The resilience category scores were as follows.

**Table 3.2. Classification of community resilience based on the CRI scores**

| CRI score | Resilience level |
|---|---|
| 0 - 0.3 | Low |
| 0.31 - 0.65 | Medium |
| 0.66 - 1.0 | High |

**3.6 Mapping of social networks of the rice farming communities**

For mapping the social networks, social network analysis (SNA) was used to map the actors and their linkages in the communities. Social network analysis will help in understanding the social capital of the communities, which has a vital role in the resilience of communities. According to Garrett and Frankenberger (1999), social capital is defined as the quantity and quality of social resources such as social networks, social relations, and access to broader institutions in the society upon which the community members depend in the pursuit of their livelihoods. It is informally described as the glue that helps bind the society's people together. At the community level, social capital significantly influences the attainment of resilience (Aldrich, 2012; Cutter *et al*., 2014). Social capital is conceptualised and measured in terms of three distinct means: bonding, bridging, and linking social capital, as given by Aldrich (2012).

### 3.6. a. Bonding social capital

Bonding social capital is the connections between individuals who are similar to each other and often live in close proximity, creating what can be described as "horizontal" ties (Putnam, 2000). Connections with family, friends, farmers in the community, etc., are considered under bonding capital. This type of social capital thrives on a high level of familiarity among individuals, a willingness to share aspects of their lives, and an implicit commitment to reciprocate support. Bonding social capital helps disseminate early warnings, community-based risk sharing, and resource sharing, which improve the absorptive capacity of a community. It also promotes the community's adaptive capacity by facilitating the adoption of new and resilient practices. However, this close-knit network characteristic can often cause redundancy in information spread.

### 3.6. b. Bridging social capital

Bridging social capital is the connection that links individuals or members of one community or group to other communities or groups, transcending factors like ethnicity, race, geographical boundaries, and language differences (Aldrich, 2012). This type of social capital enables community or group members to establish ties with external resources and to become part of broader social and economic networks. Connections with actors such as leaders and actors with political affiliations are considered bridging capital as they help link the community to outsiders. Bridging social capital directly enhances community resilience because individuals with social connections beyond their immediate community can rely on these connections when local resources are insufficient or unavailable (Wetterberg, 2004). This capital helps in knowledge transfer and technology sharing from different communities which may have already experienced the shock. This kind of capital facilitates the dissemination of proven good practices.

### 3.6. c. Linking social capital

Linking social capital refers to establishing trusted social networks that extend beyond individual and group boundaries and are characterised by explicit, formalised social connections. These networks are highly significant for economic development and resilience because they provide valuable resources and information that cannot be obtained through bonding or bridging social capital. Linking social capital is often seen as a vertical link between a network and some form of authority or influence in the social context (Aldrich, 2012). This form of social capital acts as a feedback loop between the farmers and the policymakers/government officials through which collaboration for information gathering and dissemination will occur. Strong vertical linkages are widely reported in improving the transformative capacity of the communities by improving the infrastructure, land reforms, and government accountability.

Communities with higher levels of bonding, bridging, and linking social capital tend to be more resilient than those with only one type of social capital or none at all. This observation is supported by research conducted by Aldrich (2012), Elliott *et al*. (2010), and Woolcock and Narayan (2000). It's important to emphasise that relying solely on one form of social capital is not a cure-all for addressing issues like food and livelihood insecurity.

To ensure that communities maintain resilience against various shocks and stresses over the long term, it is crucial to actively promote and sustain all three types of social capital simultaneously. Communities can take proactive measures to enhance their absorptive, adaptive, and transformative capacities, recognising that these different forms of social capital complement and reinforce each other in building resilience.

### 3.6.1. Data collection for social network analysis

In this study, for measuring the social capital of the rice farming communities, information networks and emotional support networks of the rice farmers have been mapped and used. The data was generated through the name generator technique, where each farmer can recall and list down the individuals they approached for accessing information and the persons from whom they seek emotional support (Burt, 1984; Hampton, 2011).

The schedule used for the data collection is included in Appendix - I. For analysis and mapping of the data collected, GEPHI software was used.

### 3.6.2 Quantitative analysis

In SNA, various network metrics are used to assess the characteristics of the networks. The metrics used in this study for evaluating social capital are in-degree centrality, betweenness centrality, closeness centrality, authority value, modularity, clusters and eigenvector centrality.

#### a. Degree centrality

The degree centrality of an actor in a network is the total number of all the inward and outwards ties linked to the actor from other actors in the network (Guzman *et al*. 2014). A higher degree of centrality value reflects the actor's importance in the particular network.

#### b. Closeness centrality

Closeness centrality is the measure of geodesic distance between an actor and all the other actors in a network. It indicates the closeness of an actor to all the other actors in the network (Golbeck, 2013). An actor with a high closeness centrality value reflects that the actor is centrally located in the network. Such actors can quickly interact with all the other actors in the network.

**c. Betweenness centrality**

Betweenness centrality measures how often an actor appears in the shortest path between two other actors in the network (Perez and Germon, 2016). An actor with a high betweenness centrality value has a critical role in connecting different actors in the networks. Such actors are considered the bridges in the networks. They can control the flow of information in the network.

**d. Modularity**

Modularity measures the strength of network division into different communities or modules (Ostroumova Prokhorenkova *et al.*, 2016). Each community will have dense connections within their own group and fewer connections with other community actors. A network with a higher modularity value reflects that the network is divided into clusters.

**e. Eigenvector centrality**

Eigenvector centrality is the measure of the total quality of connections. It measures not only an actor's connections but also its neighbours' centrality (Hansen *et al.*, 2020). Actors with high eigenvector centrality value are considered influential actors because of their higher connections with other influential actors.

For calculating the social capital, eigenvector centrality values of the actors that constitute bonding, bridging and bonding capital are used. The total eigenvector values of all the actors in the three capitals are finally arrived at and used to classify the networks based on their level of social capital.

### 3.7 Grey relation analysis (GRA)

GRA was proposed by Ju-long in the year 1982 as part of his grey system theory. GRA is applied in specific situations where the information cannot be classified as either completely white, i.e. perfect information is available, or completely black, where no information is available. The term grey in GRA represents the lack of complete information, as grey is the shade between white and black (Ju-Long, 1982). Community resilience is such a concept which cannot be considered as either complete white or complete black, i.e. 100 per cent resilient or zero per cent resilient. Along with community resilience, the information derived from social network analysis also lacks completeness. Under such circumstances in this study, GRA has been applied for decision-making to rank different regions' social networks and suggest adaptation plans accordingly. Eigenvector centrality values of the actors in the social networks were used as the criteria for performing GRA. The results reflect the ranking of different networks based on their eigenvector centrality values.

### 3.7.1. Steps involved in GRA

**a. Normalisation of data**

The starting point of GRA is the normalisation of data between the values 0 to 1 in order to make the data suitable for comparison. As the social networks considered for the GRA had positive relation with community resilience, the following formula is used for normalisation

$$x_i^*\ (k) = \frac{x_i^0(k) - \min x_i^0(k)}{\max x_i^0(k) - \min x_i^0(k)}$$

Where $x_i^*\ (k)$ is the normalised value, $x_i^0(k)$ is the original value, $\min x_i^0(k)$ is the minimum value in the data and $\max x_i^0\ (k)$is the maximum value.

**b. Calculation of deviation sequence**

Deviation sequence was calculated using the following formula

$$Dev(k) = |x_i^0(k) - x_i^*\ (k)|$$

where, *Dev(k)* is the value after deviation

**c. Grey relation coefficients**

Grey relation coefficients are calculated using the following formula

$$GRC_i(k) = \frac{min\, Dev(k) + 0.5 * max\, Dev(k)}{Dev\ (k) + 0.5 * max\, Dev(k)}$$

**d. Grey relation grade**

It was calculated using the following formula

$$GRG_i = \frac{1}{n} \sum_{k=1}^{n} GRCi(k)$$

After arriving at the grades, the networks were ranked based on their grades. The ranks provide a deeper insight into the performance of a network relative to other networks. A network with the best rank is considered the best among all the networks. The type of actors and their ties in the said network were selected as the best and recommended for all the other regional networks.

**3.8. Methods of data collection**

For the study, a pre-structured interview schedule was prepared using literature review and expert consultation. A pilot study was conducted to check the reliability (Cronbach's alpha = 0.848) and validity of the schedule. Necessary modifications were made in the schedule after the pilot study for refining the schedule. The final schedule used in the study has been given in Appendix I.

**3.9. Statistical tools used in the analysis**

Based on the objectives of the study, level of data, relevant parametric and non-parametric tools were employed for the analysis. Basic statistical tools such as mean, frequency, percentage, and standard deviation were used to present the study results. Also, the Kruskal-Wallis test was used to test whether significant differences existed among the independent samples in the study. In the case of social network analysis, various centrality measures were used to derive inferences from the data. A brief description of the tools that were employed in the study is given below.

**a. Arithmetic mean**

Arithmetic mean is a measure of central tendency in statistics. It was calculated by summing a set of values and dividing the sum by the total number of values present in the set.

**b. Standard deviation**

Standard deviation is a measure to find the amount of variation or dispersion in a set of values from its mean. A lower standard deviation value means the value is closer to the mean of the dataset and vice versa.

**c. Frequency**

Frequency is the number of times a particular value appears in a dataset. It was used in analysis of the socio-economic variables of the respondents.

**d. Percentage**

Percentage was used to find out the proportion of farmers in each category of the variables. The data is used for comparing across the categories and its interpretation.

**e. Quartiles**

Quartiles were used in categorising the farmers based on their scores into low, medium and high categories. Farmers who scored below Q1 were considered into the low category, and those falling above Q3 were considered under the high category. The farmers who scored between Q1 and Q3 were in the medium category.

**f. Kruskal-Wallis test**

Kurskal-Wallis test is a non-parametric test which is used to find whether there are any significant differences between three or more independent samples. In this study, the independent samples are the four districts taken into study. The test was employed to find whether the differences in the Community

Resilience Index scores across the four districts are statistically significant. It also analysed whether the CRI scores significantly vary across farmers based on their land-holding categories. The test's null hypothesis is that there are no significant differences between the groups, and the alternate hypothesis is that there are significant differences between at least two groups. It is important to note that a significant difference between at least two groups will result in rejecting the null hypothesis. Further, to find the groups among which the differences exist, a post-hoc pairwise comparison test was used.

### 3.10. Analytical tools

For basic descriptive statistics, IBM SPSS Statistics V.21.0, MS Excel V.2211 64-Bit, and R-studio V. 2022.12.0+353 were used. For social network analysis and mapping of the networks, Gephi V.0.10.1 was used. IBM SPSS Statistics V.21.0 was used for the Kruskal-Wallis test and post-hoc tests.

### 3.11. Theoretical framework of the study

Based on the review of literature and methodology selected, a theoretic framework showing the conceptual model was worked out and is given in Fig. 3.3 below.

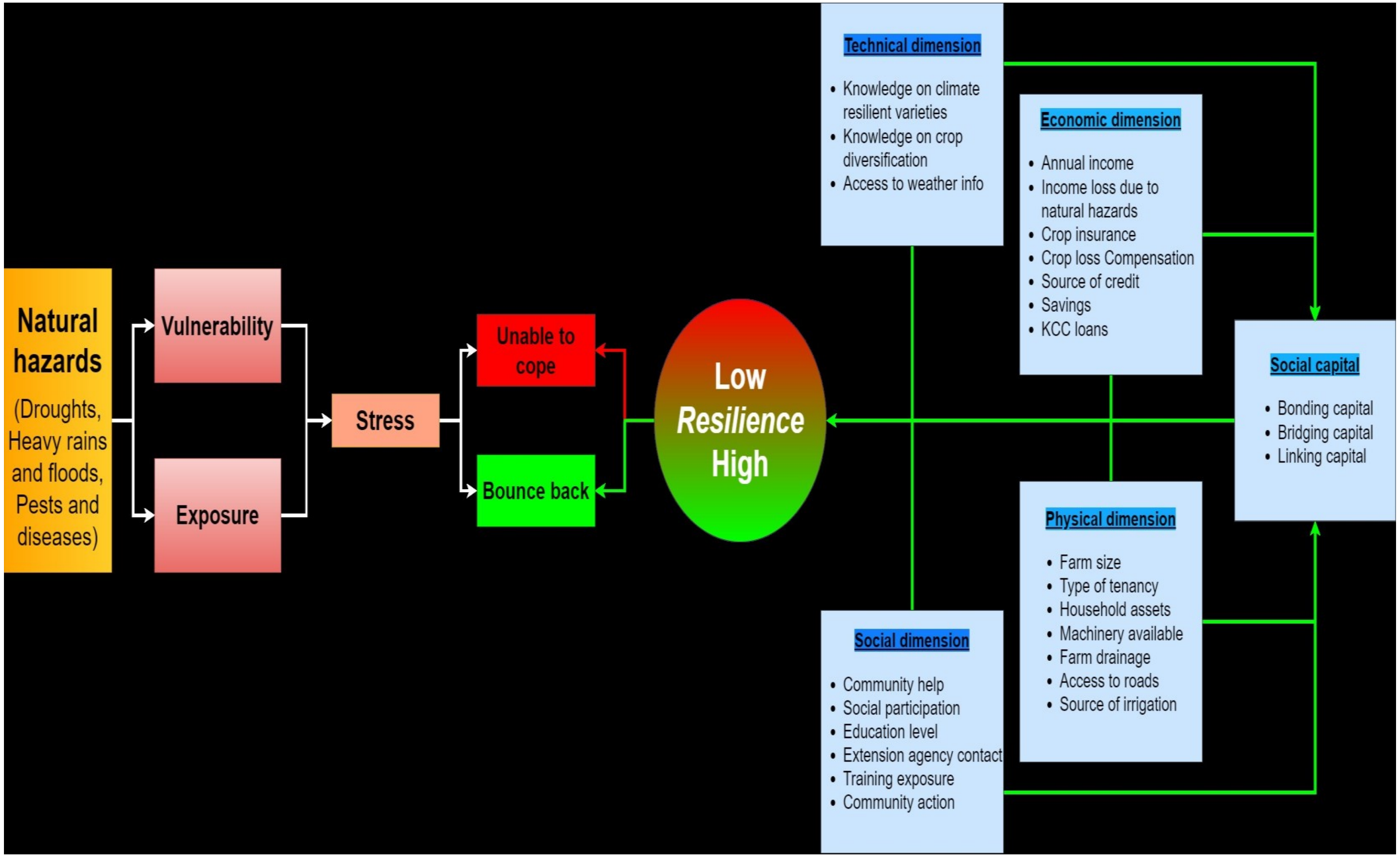



Figure 3.3. Theoretical framework of the study

# Results and discussion

# CHAPTER 4

# RESULTS AND DISCUSSION

The chapter presents the principal findings of the research obtained through proper analysis of data using appropriate statistical tools. Here we tried to contextualize these results within existing knowledge, to uncover their broader implications and add to the advancement of the research domain. The results along with the interpretations that aided in deriving new insights are presented in the following subheads.

4.1 Crop loss in paddy due to major natural hazards

4.2 Distribution of rice farmers across various resilience indicators

4.3 Measurement of community resilience

4.4 Social network analysis of paddy farmers

4.5 Local adaptation plans for building natural hazard resilience

## 4.1 Crop loss in paddy due to major natural hazards

The crop losses incurred by farmers due to natural hazards, mainly heavy rains and floods, pests and diseases and droughts, were collected from 2019-2023. The data has been analyzed and presented under the following subheads.

### 4.1.1 Trend of area under crop loss in Paddy

The following analysis examines the trends in area of paddy crop loss from 2019-2023 across four districts: East Godavari and Kurnool of Andhra Pradesh, Palakkad and Thrissur of Kerala. The data encompassed the area under crop loss in paddy reported annually by the respective State Departments of Agriculture. The results presented in Figure 4.1 and 4.2 respectively for the states of Andhra Pradesh (AP) and Kerala revealed that there were no clear trend in crop losses across the four districts during the period of study.

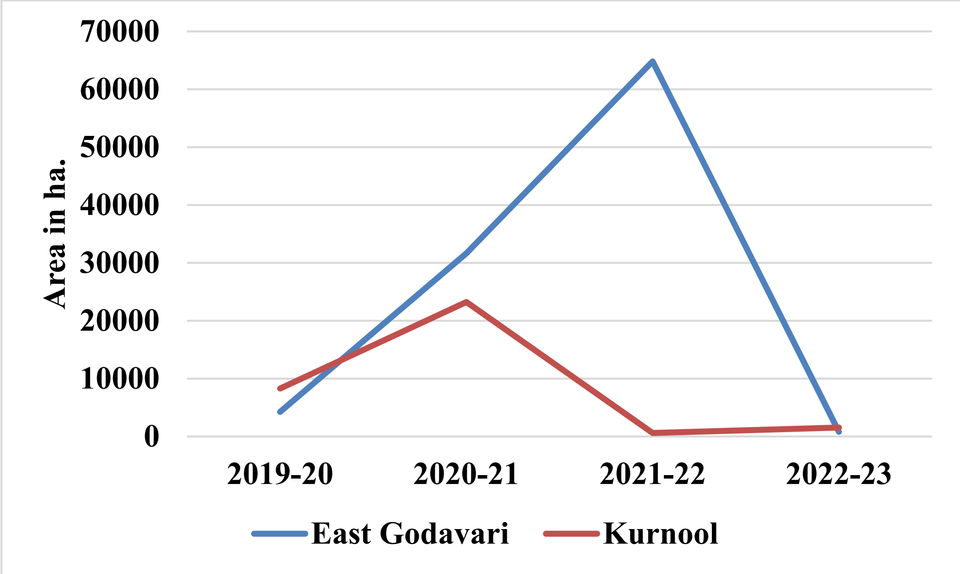



**Figure 4.1. Trend of paddy crop losses due to natural hazards in Andhra Pradesh districts**

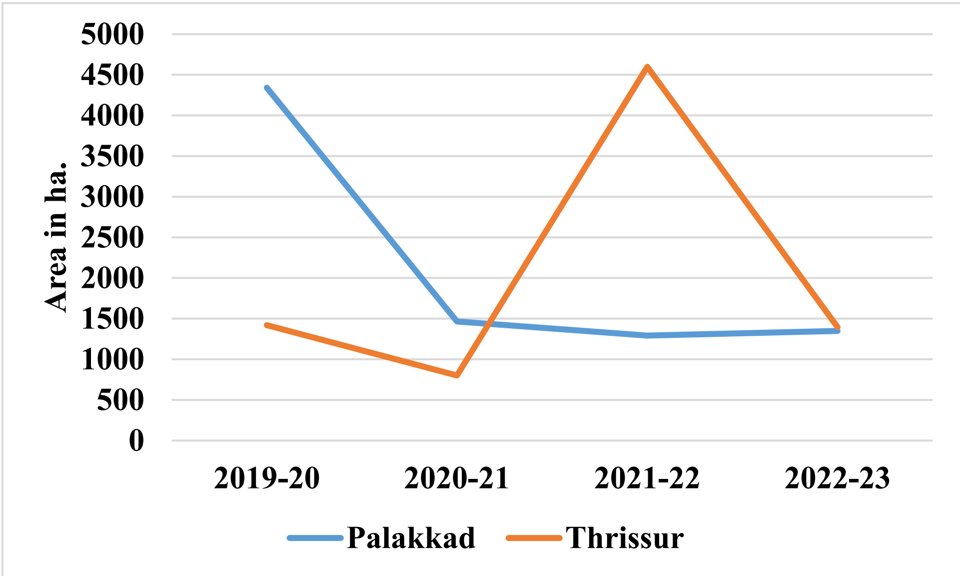



**Figure 4.2. Trend of paddy crop losses due to natural hazards in Kerala districts**

It could be observed from the results that across the four districts, paddy crop losses exhibited considerable spatial and temporal variability. In East Godavari district, the highest loss occurred during 2021-22 with a total damage of 64,823 ha and the least was seen during 2022-23 with damage of 796 ha. The primary reason for considerably higher losses during 2021-22 was due to the severe effect of cyclone Gulab, which occurred in the month of September (2021), that intensified the rains that extensively damaged the standing paddy crops. In Kurnool district, 2020-21 recorded a crop loss of 23,240 ha, the highest in the last four years. The primary reason behind this loss was a similar impact of cyclone Nivar, which occurred in November 2020. In the case of Palakkad district in Kerala, 2019-20 was the period with the highest crop loss that covered an area of 4341 ha. The main reason behind this loss had been the impact of heavy rains during the crop season. In Thrissur district of Kerala, the highest crop loss was seen in the year 2021-22 that affected an area of 4598 ha. This loss could be linked to the heavy rains coupled with an attack of pests and diseases during the same period. Notably, the highest losses incurred were not in the concurrent years across the four districts. This implied the spatial and temporal variations of natural hazard distribution across the study area. Further, it revealed the sporadic nature of extreme weather events that has become a regular feature under the present regime of climate change (Stocker *et al.,* 2013; Lu *et al.,* 2022).

### 4.1.2. Total production losses in paddy due to different natural hazards in Kerala

Heavy rains and floods were the only natural hazards that occurred during the period 2019-2022 in A.P. However, in Kerala, data was available for all the major natural hazards, namely heavy rains and floods, droughts, pests and diseases. Therefore, an analysis of the data was done to arrive at the percentage of loss caused by each hazard in different years of occurrence.

The results of the percentage of total loss caused by different natural hazards in Palakkad district of Kerala is shown in Fig. 4.3. It is evident from the figure that heavy rains and floods were the hazards that recurred in all the years during 2019-2022, with a contribution of more than 80 per cent to the total loss for the years 2019, 2020 and 2022. In the year 2022, pest and disease could be seen as the primary cause of crop loss, followed by heavy rains and floods. The scenario emerging from the results of crop losses showed a deviant picture of Palakkad district which has been reported as a drought-prone area in many studies (Rama

Rao et al., 2019). The losses due to droughts were very low compared to heavy rains and floods in the district.

**Fig. 4.3. Crop loss in paddy (%) due to different natural hazards in Palakkad district of Kerala (2019-2022)**

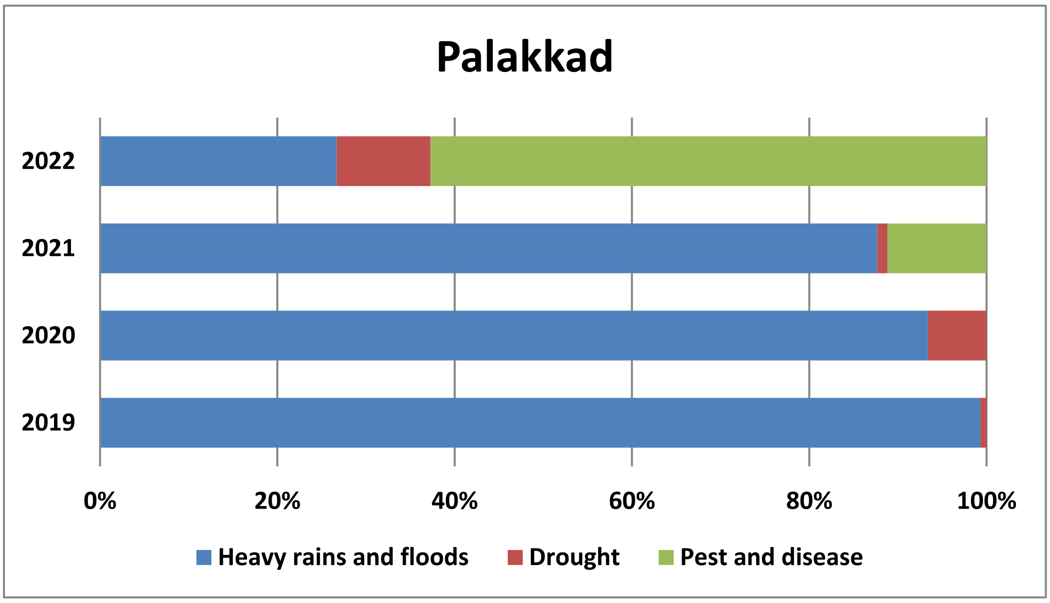
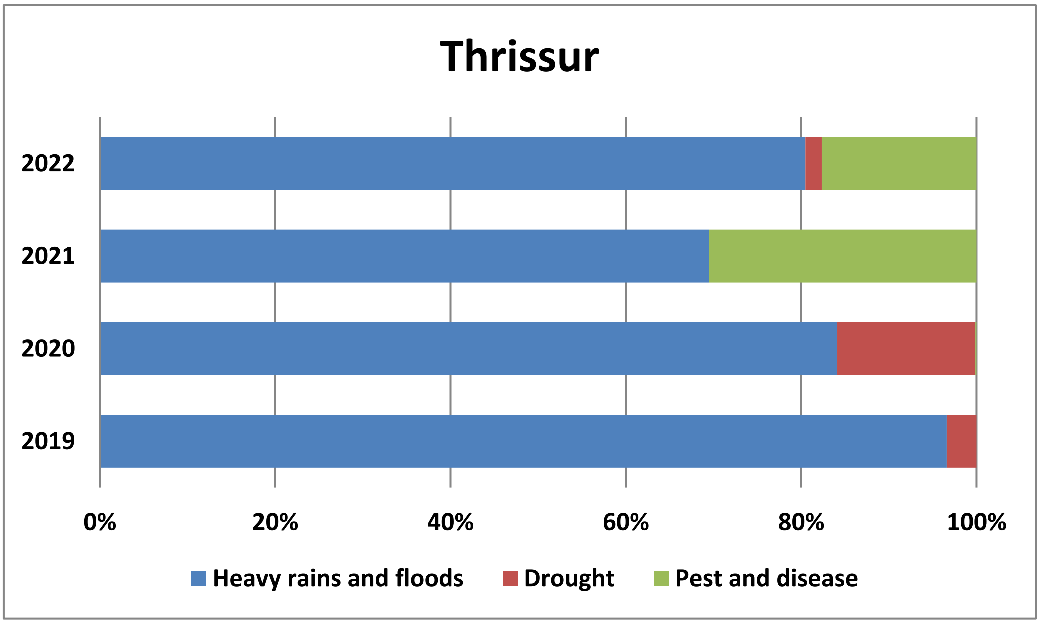



**Fig. 4.4. Crop loss in paddy (%) due to different natural hazards in Thrissur district of Kerala (2019-2022)**




The results were validated using the rainfall data of Palakkad during the same period (Appendix - II). The reported normal annual rainfall in Palakkad district has been 2142.5 mm. However, in the past four years of 2019-2022, only 2020 showed an observed negative deviation from the average rainfall of 1724.6 mm (IWRIS, 2023). In the years 2019, 2021, and 2022, the actual rainfall received was higher than the reported average normal rainfall (IWRIS, 2023). This implied that the occurrence of drought has been considerably less in the past four years which validated the results.

The results of paddy crop loss for the Thrissur region as shown in Fig. 4.4 also indicated that heavy rains and floods were frequent and recurring natural hazards in the district. During the period 2019-2022, heavy rains and floods contributed to more than 65 per cent of the total paddy crop loss in the region, followed by pests and diseases and drought. The results were validated using the rainfall data of Thrissur district during the same period (Appendix - II). During 2020, around 15 per cent of the total losses were caused by droughts as explained by the rainfall data. The data showed a negative deviation in actual rainfall (2520.76 mm) during 2020 compared to the normal rainfall (3077.3 mm) (IWRIS, 2023).

### 4.1.3. Total value of crop loss in paddy due to natural hazards

Total economic losses due to natural hazards in paddy incurred by the four districts were analysed and examined here. The results reported in Table 4.1 indicated that the total value loss was found to be the highest in all the districts corresponded to the years in which the district had the highest area of crop loss due to natural hazards.

**Table 4.1. Total value of crop loss in paddy due to natural hazards in the states of AP and Kerala (2019-2023)**

| State | District | Value of crop loss (INR in crores) | | | | |
|---|---|---|---|---|---|---|
| | | 2019-20 | 2020-21 | 2021-22 | 2022-23 | Total loss |
| AP | East Godavari | 39 | 298 | 634 | 08 | 979 |
| | Kurnool | 76 | 219 | 5.9 | 15.8 | 317 |
| Kerala | Palakkad | 34 | 11.5 | 10 | 10.9 | 66 |
| | Thrissur | 11 | 06 | 36 | 11 | 64 |

It is also evident from the results in the table that East Godavari had incurred the highest value loss of Rs. 979 crores during the period of 2019-22, while the lowest loss was seen in Thrissur district with a value loss of Rs. 64 crores. The difference in the losses could be attributed to the area loss that had occurred in the respective districts, as discussed earlier. Though the farmers primarily had to incur the loss, the government provided relief to farmers by giving crop loss compensation in the form of money. Under the National Disaster Relief Fund and State Disaster Relief Fund, the farmers who were affected with more than 33 per cent of area damage were eligible for compensation under the input subsidy scheme.

### 4.1.4 Total production loss in paddy due to natural hazards

This section focused on the total production loss in paddy incurred by the four districts due to natural hazards during 2019-2023. It is evident from Table 4.2 that Palakkad had the highest average production loss of 8.9 per cent, followed by Kurnool with 7.2 per cent, East Godavari with 5.9 per cent, and Thrissur with 2.7 per cent.

**Table 4.2. Total paddy production losses due to natural hazards in the states of AP and Kerala (2019-2023)**

| State | District | Production loss (%) | | | | |
|---|---|---|---|---|---|---|
| | | 2019-20 | 2020-21 | 2021-22 | 2022-23 | Average loss |
| AP | East Godavari | 1.0 | 7.3 | 15.0 | 0.2 | 5.9 |
| | Kurnool | 7.1 | 19.9 | 0.5 | 1.3 | 7.2 |
| Kerala | Palakkad | 18.3 | 6.2 | 5.5 | 5.7 | 8.9 |
| | Thrissur | 1.9 | 1.0 | 6.0 | 1.8 | 2.7 |

It could be observed from the table that the highest production loss was in Palakkad and was incurred during the 2019-20, where 18.3 per cent of the total production was lost owing to natural hazards. Palakkad has average production losses of above 5 per cent in all four years, which has influenced the overall results.

With Palakkad being the major rice-producing tract of Kerala state, the loss will have a significant impact on the food security, if not dealt with immediately. In the case of AP, Kurnool had an average production loss of 7.2 per cent, which was mostly influenced by the loss during 2020-21. The Nivar cyclone, which resulted in incessant rains during 2020, caused this significant production loss.

Heavy rains and floods, which are high speed onset hazards, are the common natural hazards across the four paddy farming systems. This implied mitigation as the best strategy to make farmers resilient. Heavy rains resulted in the complete lodging of the crop when it occurs with high intensity, which leads to production losses and reduced harvest efficiency. The use of varieties that are dwarf with high-yielding potential and market value have high relevance as mitigation strategy in all the four regions.

### 4.2. Distribution of four districts across the indicators of community resilience

Socioeconomic and personal indicators of community resilience selected for the study based on literature review and expert consultancy covered annual income, compensation received, source of credit, utilization of Kisan Credit Card (KCC), crop insurance, farm size, type of tenancy, education, involvement in community action, knowledge on climate resilient varieties, availability of road access to farms, access to weather information and training exposure. The distribution of farmers on these indicators estimated on tested and standardized scales are presented under the following subheads.

#### 4.2.1. Annual income

The annual income of paddy farmers across the four districts are given in Table 4.3. The results in the table indicated that 61.11 per cent of the total farmers had yearly income of less than 1 lakh, followed by 27.22 per cent in the annual income category of 01-02 lakhs. An evaluation of the district-wise distribution revealed that farmers in both the districts of AP, i.e. East Godavari and Kurnool, had lower incomes compared to the Kerala districts, with 88.33 per cent and 66.67 per cent of them having incomes less than 01 lakh, respectively. In the case of districts of Kerala, the majority of the farmers in Palakkad (36.67 %) and Thrissur (50 %) had annual income from rice farming between 1-2 lakhs. Also, the percentages of farmers who had relatively higher incomes of 3-4 lakh and more than 4 lakh were very low in districts of A.P. While in Kerala, 16.66 per cent of Palakkad and 10 per cent of Thrissur farmers had higher income of more than three lakhs. The findings align with the outcomes of work done by Thangjam and Jha (2019) and Reshmi (2019).

**Table 4.3. Distribution of annual income of paddy farmers of the states of AP and Kerala (N=180)**

| Sl. No. | Category of annual income (Rs in lakhs) | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | < 01 | 53 (88.33) | 40 (66.67) | 8 (26.67) | 9 (30) | 110 | 61.11 |
| 2 | 01 -02 | 6 (10) | 17 (28.33) | 11 (36.67) | 15 (50) | 49 | 27.22 |
| 3 | 02 - 03 | 1 (1.67) | 1 (1.67) | 6 (20) | 3 (10) | 11 | 6.11 |
| 4 | 03 - 04 | 0 | 2 (3.33) | 4 (13.33) | 0 | 6 | 3.33 |
| 5 | >04 | 0 | 0 (0) | 1 (3.33) | 3 (10) | 4 | 2.22 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

The average net annual income of an Indian citizen is reported as Rs. 1, 72, 000 (GOI, 2023c). The results of the study clearly indicated that most of the rice farmers in AP fell below the national per capita income levels, whereas the majority of Kerala rice farmers were in and above the cap of national average income. The lower levels of income among A.P. farmers compared to Kerala farmers reported in this study is also in line with results in the Situation Assessment of Agricultural Households and Land and Livestock Holdings of Households in Rural India (2019). Also, the natural hazard related loss incurred by farmers of AP was higher compared to Kerala farmers, which could also be considered as a measure of higher resilience of Kerala farmers derived from their higher income. Moreover, the low income hindered AP farmers from purchasing quality inputs such as seeds, fertilizers, and pesticides, which had negative influence on the farmers' resilience. Though the farmers in both districts of AP had diverse income sources, such as working as daily wage labour under the MGNREGA scheme and working as farm labour, which could not yield good income. So, the government should try to diversify the income sources of farmers by including more remunerative enterprises.

#### 4.2.2. Compensation received

The results in Table 4.4 provides a picture of the distribution of compensation amount received by paddy farmers for the crop loss incurred by them across four districts in the states of AP and Kerala. Compensation amount played a vital role in the resilience of farmers by supporting them economically to sustain their livelihood and to continue cultivation whenever affected by natural hazards. From the table, it could be observed that a total of 60.56 per cent of the farmers were receiving compensation amount for the loss they incurred due to natural hazards. In Kerala, more than 90 per cent of the farmers in both districts reported that they received compensation amounts for the crop loss. The entire process of reporting to evaluation of loss and payment of compensation was coordinated by the Krishibhavans, the local unit of the State Department of Agriculture. This single line authentication at local level ensured timely release of compensation amounts to the farmer involved. The results were in line with the findings of Revathi (2014).

At the district level, most of the farmers (66.67%) in East Godavari of AP had reported that they did not receive any compensation from the government. This could be explained by the fact that the majority of the farmers in the East Godavari region were lease land farmers. As per the prevailing government norms, lease land farmers could avail the compensation amount only if they entered into a legal agreement with the lessor. As per the legislation of AP lease land farmers need to avail the Crop Cultivator Rights Card (CCRC), which made them eligible to receive all the benefits of a farmer. CCRC is an agreement made between the cultivator and the landowner for a period of 11 months. This CCRC is required for the lease land farmers to avail benefits of any schemes that are provided to farmers in AP. However, the adoption of CCRC among the farmers has been significantly low, preventing the tenant farmers from availing the compensation amounts. This explained why majority of East Godavari farmers did not receive any compensation, as most of the farmers in the district were lease land farmers who were out of the purview of CCRC. Therefore, stringent policy interference to legalize CCRC, as an essential certificate for leasing out farm lands to cultivators need to be enforced through local extension offices to build better resilience against natural hazards.

**Table 4.4. Distribution rice farmers according to receipt of compensation for natural hazard loss in the states of AP and Kerala (N=180)**

| Sl. No. | Category of compensation receipt | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | Received | 20 (33.33) | 34 (56.67) | 27 (90) | 28 (93.33) | 109 | 60.56 |
| 2 | Not received | 40 (66.67) | 26 (43.33) | 3 (10) | 2 (6.67) | 71 | 39.44 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

### 4.2.3. Source of credit

Sources of credit formed another important indicator of community resilience against natural hazards. The results on the variable presented in Table 4.5 explained that a total of 42.22 per cent of the farmers were availing credit from formal sources such as banks. This was followed by 37.22 per cent of farmers who availed credit both from formal and informal sources and 16 per cent had availed credit from informal sources only. The distribution contradicted at district level with majority of farmers from East Godavari, (55%) availing credit only from informal sources such as money lenders, landlords, friends and family. This could be explained by the tenurial status of these farmers who cultivated on lease lands and lacked any possessions to provide as bank security which is needed for availing formal loans. In case of Kurnool district, majority (65%) of them availed credit both from formal and informal sources. However, in Kerala, farmers of both the districts availed their credit majorly from formal sources.

**Table 4.5. Distribution rice farmers based on their sources of credit in the states of AP and Kerala (N=180)**

| Sl. No. | Category of credit source | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | Informal | 33 (55) | 3 (5) | 0 | 1 (3.33) | 37 | 20.56 |
| 2 | Both informal and formal | 16 (26.67) | 39 (65) | 2 (6.67) | 10 (33.33) | 67 | 37.22 |
| 3 | Formal | 11 (18.33) | 18 (30) | 28 (93.33) | 19 (63.33) | 76 | 42.22 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

Farmers of AP, especially, East Godavari, predominantly depended on informal sources of credit which led to indebtedness and credit traps. Most of the informal sources charged interest rates around 24 per cent which was significantly higher than the interest rates of banks. This resulted in the inferior economic status of farmers and low community resilience against natural hazards in the region. The results are in line with the works of Vasavi (2017) and Cariappa *et al.* (2020). Land reforms ensuring minimum ownership rights on cultivated lands for farmers could be a viable solution that required political will and appropriate legislations at the highest levels.

### 4.2.4. Utilization of Kisan Credit Card (KCC)

KCC formed an institutionalized innovation that supported farmers by providing them loans at a minimum interest rate of seven per cent, which will be further reduced to four per cent upon timely repayment of the loan by the farmers. The results on KCC utilization by rice farmers presented in Table 4.6 revealed that 30.56 per cent of the total farmers were availing credit using KCC. However, there was a contrasting picture on the use of KCC by farmers in the states of AP and Kerala. Most of the farmers (93.33-100%) in the AP districts did not avail KCC loans, whereas the majority (80-90%) of the farmers in Kerala availed KCC loans. Similar to the crop compensation scenario, for availing KCC loans, CCRC is necessary for the tenant farmers. This was the reason for lower rates of availing KCC loans in the East Godavari region. In the Kurnool region, the lack of awareness about KCC loans and the low credit worthiness of the farmers in the area because of their past credit history hindered the process and prevented the bankers from extending KCC loans to the farmers. Results of the study are in line with the work of Sarkar and Barman (2014).

**Table 4.6. Distribution rice farmers based on their utilization of KCC in the states of AP and Kerala (N=180)**

| Sl. No. | KCC utilization category | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | Availed loans | 4 (6.67) | 0 (0) | 27 (90) | 24 (80) | **55** | 30.56 |
| 2 | Not availed loans | 56 (93.33) | 60 (100) | 3 (10) | 6 (20) | **125** | 69.44 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

Thus, it could be inferred from the results that in order to increase the adoption of KCC loans, awareness campaigns must be set up in the districts of A.P., and provisions to cover the landless farmers under the KCC scheme needs to be introduced. Also, farmers should be educated about the importance of credit history, prompt repayment, which impacted their credit score and sanction of loans. Thus, credit literacy campaigns need to be introduced in AP to improve the community resilience against natural hazards as credit formed an important parameter in building community resilience.

### 4.2.5. Crop insurance

Crop insurance formed an important financial instrument enacted as a mitigating measure to benefit farmers against the risks of natural hazards. GOI has been promoting crop insurance mainly though Pradhan Mantri Fasal Bima Yojana (PMFBY) scheme with minimum premium prices. Recently, GOI (2023) reported that PMFBY has emerged as the third largest crop insurance scheme in the world based on gross premium collected and the number one scheme in the world based on the number of farmers enrolled (GOI, 2022). The statements from GOI finds validation in the results reported in Table 4.7. It could be observed from the table that the majority of the farmers (72.22%) of them were enrolled under the crop insurance. At the district level, Palakkad, Thrissur and Kurnool had 83.33, 86.67 and 88.33 percent of farmers respectively always adopted crop insurance. However, the crop insurance adoption in East Godavari of AP was relatively low compared to other districts, with only 43.33 per cent of them always adopting the crop insurance. The results were in line with the works of Tiwari *et al.* (2020) and Uvaneswaran and Mohanapriya (2014).

**Table 4.7. Distribution rice farmers based on their adoption of crop insurance in the states of AP and Kerala (N=180)**

| Sl. No. | Adoption category | District wise distribution of farmers adopted (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | Never | 20 (33.33) | 0 (0) | 0 (0) | 0 (0) | 20 | 11.11 |
| 2 | Often | 14 (23.33) | 7 (11.67) | 5 (16.67) | 4 (13.33) | 30 | 16.67 |
| 3 | Always | 26 (43.33) | 53 (88.33) | 25 (83.33) | 26 (86.67) | 130 | 72.22 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

The poor adoption of crop insurance in East Godavari was also linked to CCRC cards in AP. Similar in the case of source of credit and compensation received, crop insurance scheme could not be benefited by the leased land farmers. This resulted in lower insurance adoption in the East Godavari district which has been dominated by leased land farmers. However, it was important to note that in AP, the state government paid the crop insurance premium of all farmers, reducing the financial burden of the farmer. In the case of Kerala, farmers themselves had to pay the premium for crop insurance, but this was not preventing the farmers from adopting it and could be attributed to their awareness about the benefits of the scheme. Overall, it could be inferred that the scheme promoted community resilience of farmers against natural hazards.

### 4.2.6. Farm size

Land formed a critical factor of agricultural production and farm size formed an important element of analysis. The findings of farm size from the study presented in Table 4.8 revealed that the majority of the farmers (30.56%) were in the small landholding category with farm sizes 1-2 ha. Overall, landless, marginal and small landholders constituted 69.44 per cent of the total farmers. These results were consistent with the government statistics on landholders in India, where it is reported that the majority of the farmers in India belonged to the small and marginal categories.

The results of district wise analysis in the table indicated that in East Godavari, the majority of the farmers (55%) were landless who cultivated on leased lands, and in Kurnool, the dominant category (38.33%) was of small farmers. In Kerala districts, the majority of the farmers in Palakkad (30%) were semi-medium farmers with land holding sizes of 2-4 ha, and in Thrissur, the majority of them (50%) were small farmers. The results align with the work of Karangami *et al.* (2019) and Reshmi (2017).

**Table 4.8. Distribution rice farmers based on their farm size in the states of AP and Kerala (N=180)**

| Sl. No. | Category of Farm size | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | Landless | 33 (55) | 7 (11.67) | 0 (0) | 0 (0) | 40 | 22.22 |
| 2 | Marginal (<01 ha) | 13 (21.67) | 9 (15) | 6 (20) | 2 (6.67) | 30 | 16.67 |
| 3 | Small (1-2 ha) | 12 (20) | 23 (38.33) | 5 (16.67) | 15 (50) | 55 | 30.56 |
| 4 | Semi-medium (2-4 ha) | 1 (1.67) | 13 (21.67) | 9 (30) | 10 (33.33) | 33 | 18.33 |
| 5 | Medium (4-10 ha) | 1 (1.67) | 7 (11.67) | 7 (23.33) | 3 (10) | 18 | 10.00 |
| 6 | Large (>10 ha) | 0 (0) | 1 (1.67) | 3 (10) | 0 (0) | 4 | 2.22 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

The major point of inference from the results was that 96.67 per cent of the farmers in the East Godavari district of AP were in small and lower than small categories, out of which 55 per cent were landless. Hence, GoAP need to consider this majority of landless farmers in implementing schemes for farmers so that their inclusion is ensured through appropriate legislations. This formed essential to build community resilience against natural hazards in farming.

### 4.2.7. Type of tenancy

Type of land tenancy was another variable assumed to have influence on community resilience of farmers against natural hazards in the study. Results of the analysis presented in Table 4.9 indicated that the majority of the farmers (41.67%) cultivated on partly owned and partly leased lands, followed by 37.78 per cent of farmers who undertook farming on their own lands.

At the district level in AP, again, East Godavari revealed a dark picture, with 50 per cent of farmers in the area cultivating on fully leased lands, followed by 36.67 per cent cultivating on partly owned and partly leased lands. Only 13.33 per cent of the farmers in East Godavari were cultivating on their owned lands. This reflected that the landlords did not cultivate their lands but made money through non-formalised leasing. In Kurnool, cultivation on partly owned and partly leased lands was the prevailing feature, with 53.33 per cent of the farmers involved with in it.

**Table 4.9. Distribution rice farmers based on the type of tenancy in the states of AP and Kerala (N=180)**

| Sl. No. | Category of Farm size | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | Fully leased in | 30 (50) | 7 (11.67) | 0 (0) | 0 (0) | 37 | 20.56 |
| 2 | Partly owned and partly leased in | 22 (36.67) | 32 (53.33) | 8 (26.67) | 13 (43.33) | 75 | 41.67 |
| 3 | Fully owned | 8 (13.33) | 21 (35) | 22 (73.33) | 17 (56.67) | 68 | 37.78 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

In the case of Kerala, cultivation on own lands prevailed with 73.33 and 56.67 per cent respectively in the Palakkad and Thrissur districts, followed by cultivation on partly owned and partly leased lands by 26.67 and 43.33 per cent respectively. The land reforms enacted in the state was instrumental for the high land ownership status of farmers in the state as revealed by the results. However, farmers tend to adopt leased land farming in the state currently as a strategy to overcome the limits of economies of scale involved with small land farming. The results are in line with the works of Samarpitha et al. (2016) and Revathi (2014).

Though East Godavari, along with West Godavari, is considered as the rice bowl of AP, the contribution of landowners in the region directly to the rice production was inferred to be significantly low. However, the government schemes to improve the economic status of farmers, such as PM-KISAN, PM-FBY, and input subsidy, were entitled to the landowners. The original landless cultivators were not benefited in these schemes. Based on these inferences a targeted approach in scheme delivery to the farmers is recommended so that the real farming community get included as the scheme beneficiaries. This alone would support community resilience against natural hazards among all types of farmers irrespective of their tenancy status.

### 4.2.8. Education

Results on education of the farmers in the study are depicted in Table 4.10. The results revealed that the majority of the farmers (30.53%) had schooling between $8^{th}$ to $10^{th}$ standard, followed by 21.58 per cent illiterates. A district-wise analysis reflected the difference in education levels between the farmers in the two states. The majority of the farmers in the East Godavari district (53.33%) were illiterate. In the case of Kurnool, farmers were distributed across the categories, with the majority of them (28.33%) having education between 8th to 10th standard. Kurnool also had the highest percentage of farmers who had completed their graduation degree. This could be explained by the fact that farmers in the Kurnool region were young compared to those of other districts, and many of them had completed their degree programmes in recent years and were taking up agriculture as an occupation. In the Kerala districts, the results were relatively similar, with no illiteracy and most of the farmers having educational qualifications between 8th and 10th standard in Palakkad (66.67%) and Thrissur (43.33%). The results conformed with the results of Reshmi (2017) and Arya (2018).

**Table 4.10. Distribution rice farmers based on their education in the states of AP and Kerala (N=180)**

| Sl. No. | Level of education | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | Illiterate | 32 (53.33) | 9 (15) | 0 (0) | 0 (0) | 41 | 21.58 |
| 2 | Upto 7th | 7 (11.67) | 15 (25) | 3 (10) | 12 (40) | 37 | 19.47 |
| 3 | 8th to 10th | 8 (13.33) | 17 (28.33) | 20 (66.67) | 13 (43.33) | 58 | 30.53 |
| 4 | 11th to 12th | 8 (13.33) | 4 (6.67) | 2 (6.67) | 3 (10) | 17 | 8.95 |
| 5 | Graduation and above | 5 (8.33) | 15 (25) | 5 (16.67) | 2 (6.67 | 27 | 14.21 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

Education, which assists humans in efficiently performing activities, was lacking in the farmers of East Godavari. This could further be explained using previously mentioned variables such as annual income and farm size, where the district lagged behind compared to other districts. All these factors prevented the farmers of East Godavari from coming out of the vicious cycle of poverty and remain exploited by landlords. However, it was encouraging to find educated youth entering farming as a livelihood vocation in other districts, especially Kurnool.

### 4.2.9. Involvement in community action

Community cohesion among the farmers formed an essential factor that aided them in dealing with the uncertainties and problems in agriculture. This is often manifested in the form of community action that facilitated community resilience. As agriculture is faced with multitude of problems related to common resource management of soil, water, biodiversity, etc., it is of utmost importance for the farmers to come together as a group and resolve the issues. The results on involvement in community action given in Table 4.11 reflected a dire picture of

Andhra Pradesh on the variable. There was zero community action in both the districts of AP. However, the results from the districts of Kerala recorded a significantly higher levels of community action. 86 per cent of the Palakkad farmers and 56.67 per cent of Thrissur farmers participated in community action.

**Table 4.11. Distribution of rice farmers based on their involvement in community action in the states of AP and Kerala (N=180)**

| Sl. No. | Involvement in community action | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | No | 60 (100) | 60 (100) | 4 (13.33) | 13 (43.33) | 137 | 76.11 |
| 2 | Yes | 0 (0) | 0 (0) | 26 (86.67) | 17 (56.67) | 43 | 23.89 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

The results suggested the need for government of AP to promote community action among the farmers by making local farmer groups federated into FPOs at block and district levels. This will strengthen the farmers' unity so that they can resolve their problems as a community rather than as individuals. It could be observed that the Group Farming in rice implemented through farmer run Padashekara Samithies in Kerala enabled its high level of involvement in community action contributing to community resilience.

### 4.2.10. Knowledge of climate resilient varieties

Knowledge of climate resilient varieties is assumed to have a positive effect on community resilience in farming. The distribution of farmers based on their knowledge level of climate-resilient paddy varieties is presented in Table 4.12. The results in the table indicated that the majority of the farmers (46.67%) had low levels of knowledge followed by medium level (36.11%) and high level (17.22%). The pattern of distribution was also relatively similar across the districts, with the majority of the farmers in all the districts having lower levels of knowledge. This could be attributed to the fact that farmers in all the regions were cultivating the same varieties from many years irrespective of consideration to the factors of location specific climate resilient varieties. Many a time, it could be observed that it was the unavailability of desired varieties that posed impediment to its adoption by farmers.

**Table 4.12. Distribution of rice farmers based on their level of knowledge on climate resilient varieties in the states of AP and Kerala (N=180)**

| Sl. No. | Level of knowledge | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | Low | 25 (41.67) | 29 (48.33) | 19 (63.33) | 11 (36.67) | 84 | 46.67 |
| 2 | Medium | 34 (56.67) | 12 (20) | 4 (13.33) | 15 (50) | 65 | 36.11 |
| 3 | High | 1 (1.67) | 19 (31.67) | 7 (23.33) | 4 (13.33) | 31 | 17.22 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

Moreover, though farmers had knowledge of different varieties that were considered more climate resilient than the varieties that were currently grown by the farmers, factors such as yield and demand in the market prevented the farmers from adopting them. Therefore, research should focus on providing varieties with climate-resilient features, high yield potential, and market demand.

### 4.2.11. Availability of road access to farms

Availability of roads with access to the farms and connectivity to the nearby urban town was considered an essential factor that contributed to the resilience of the farmers. Results on availability of roads with access to the farms given in Table 4.13 indicated that most of the farmers (66.67%) had farm-paved roads, followed by 20.56

per cent with pucca roads. This reflected that most of the farms had required road infrastructure, which aided farmers in efficiently transporting produce to and from the farm. At the district level, too, the majority of the farmers in all the four districts had at least paved roads followed by pucca roads. The results indicated a positive sign for the farming communities as roads facilitated the efficient movement of farm goods while procuring and selling. The results are also in line with the achievements of the Pradhan Mantri Gram Sadak Yojana scheme, under which, all-weather roads are laid down all over India to improve the rural connectivity (GoI, 2022).

**Table 4.13. Distribution of rice farmers based on their availability of road access to farms in the states of AP and Kerala (N=180)**

| Sl. No. | Availability of road | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | No road | 4 (6.67) | 18 (30) | 1 (3.33) | 0 (0) | 23.00 | 12.78 |
| 2 | Farm paved road | 51 (85) | 35 (58.33) | 13 (43.33) | 21 (70) | 120 | 66.67 |
| 3 | Pucca road | 5 (8.33) | 7 (11.67) | 16 (53.33) | 9 (30) | 37 | 20.56 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

### 4.2.12. Access to weather info

Farming is often considered a gamble with the weather and weather information formed a crucial factor in guiding farmers on agricultural decisions. Forewarning information on weather actually helped the farmers to be prepared for the upcoming scenario. In case of having info about heavy rains in the coming days, farmers could drain the water present in their fields to accommodate the rainwater or delay sowing/ planting or could delay or even harvest the produce early as per the crop stage. In this way, access to weather info aided farmers in preplanning of the cultivation process thereby building system resilience. The classification of rice farmers based on their access to weather information is presented in Table 4.14.

**Table 4.14. Distribution of rice farmers based on their access to weather information in the states of AP and Kerala (N=180)**

| Sl. No. | Level of weather info access | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | Never | 16 (26.67) | 13 (21.67) | 6 (20) | 0 (0) | 35 | 19.44 |
| 2 | Often | 0 (0) | 2 (3.33) | 0 (0) | 2 (6.67) | 4 | 2.22 |
| 3 | Always | 44 (73.33) | 45 (75) | 24 (80) | 28 (93.33) | 141 | 78.34 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

Results from Table 4.14 indicated a convincing assertion that more than 78 per cent of the farmers had regular access to weather information. Even at the district level, the figures represented a similar pattern, with most of the farmers in all the districts having regular access to weather info. This high percentage of farmer access to weather info in all areas could be attributed to the diffusion of mobile phones and the internet. Most of the farmers were using mobile phones, T.V., and newspapers in order to obtain info about the weather. But East Godavari, Kurnool and Palakkad districts had 26.67, 21.67 and 20 per cent respectively of farmers who did not have any access to weather info, which need to be immediately redressed. Studies by Sansa-otim (2021) and Sharma *et al.* (2021) were reported to support the present findings.

Further, it was observed that even though farmers had regular access to the weather info, some revealed that the information was not specific to their region. Hence, it is highly recommended that regional weather stations should be set up at all places. Also, during the survey, an important observation was found in the East Godavari region, where farmers were receiving SMS from National Disaster Management Authority (NDMA) with immediate weather updates in regional languages. Farmers reported that the information in these messages were often accurate, and they found them very useful. Such a model could be implemented in all regions so that farmers, especially those with lower literacy levels and poor exposure to ICT tools, could also be informed about the weather info there by promoting resilience of the farming system.

### 4.2.12. Training exposure

Training for farmers helped them gain new knowledge and skills that improved their expertise in farming. But the results from the study on training exposure presented in Table 4.15 presented mostly a low level of training exposure especially among farmers of AP. The level of training exposure among the majority of the farmers (47.22%) studied was low. However, at the district level, the distribution was quite varied. In East Godavari, 86.67 per cent of the farmers responded that they never received any kind of training. This could be explained by the fact that unlike in Kerala, there was a lack of institutional extension delivery system at the panchayat level in AP. This was a major hindrance for them in visiting and receiving any training classes. In Kerala, the majority of the farmers in Palakkad (56.67%) had a high level of training exposure compared to Thrissur, where the majority (60%) of the farmers had only a medium level of training exposure. The presence of Krishi Bhavans and their efficiency in working reflected in the results. Works done by Thangjam and Jha (2019), Haneef (2019) and Saikia and Barman (2013) justified the results in the present study.

Thus, in general, farmers in both the states were given training and classes regarding good agricultural practices, water conservation, plant protection, etc. Additionally, to improve the resilience of farmers, the government should provide training on resilient practices. Training on use of reliable weather forecasting tools and their interpretation, early warning systems, and post-harvest management can improve the farmer resilience.

**Table 4.15. Distribution of rice farmers based on their level of training exposure in the states of AP and Kerala (N=180)**

| Sl. No. | Level of training exposure | District wise distribution of farmers (%) in the states of | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | AP | | Kerala | | | |
| | | East Godavari | Kurnool | Palakkad | Thrissur | Frequency | % |
| 1 | Low | 52 (86.67) | 22 (36.67) | 6 (20) | 5 (16.67) | 85 | 47.22 |
| 2 | Medium | 2 (3.33) | 14 (23.330 | 7 (23.33) | 18 (60) | 41 | 22.78 |
| 3 | High | 6 (10) | 24 (40) | 17 (56.67) | 7 (23.33) | 54 | 30.00 |
| | Total | 60 (100) | 60 (100) | 30 (100) | 30 (100) | 180 | 100 |

### 4.3. Measurement of community resilience

Community resilience of paddy farmers was estimated using the community resilience index (CRI) developed by Jayadas and Ambujam, 2021. The index comprised of four dimensions, economic, social, technical and physical, which were used to calculate the overall community resilience of the paddy farmers. The index scores derived were further classified into low (0-0.3), medium (0.31-0.65) and high (0.66-1), as reported by Jayadas and Ambujam (2021). A high score in the index indicated higher resilience of the region; similarly, moderate and low scores indicated moderate and low resilience of the regions, respectively. Dimension-wise resilience scores were first calculated, and the results are given in the following subheads.

### 4.3.1. Dimension wise estimates of community resilience

**Table. 4.16. Dimension wise community resilience index scores across the selected districts of AP and Kerala (N=180)**

| States | Districts | Dimensional scores of community resilience | | | | CRI |
|---|---|---|---|---|---|---|
| | | Economical | Social | Technical | Physical | |
| AP | Kurnool | 0.43 | 0.26 | 0.55 | 0.69 | 0.48 |
| | East Godavari | 0.30 | 0.15 | 0.44 | 0.45 | 0.33 |
| Kerala | Thrissur | 0.73 | 0.48 | 0.65 | 0.70 | 0.64 |
| | Palakkad | 0.80 | 0.66 | 0.73 | 0.78 | 0.74 |
| **Mean score** | | 0.57 | 0.39 | 0.59 | 0.66 | 0.55 |

The dimension-wise resilience scores from Table 4.16 reflected that Palakkad district in the state of Kerala had the highest scores across all four dimensions, and East Godavari district of AP had the lowest scores across all the dimensions. Similarly in the overall CRI, Palakkad district had the highest score followed by Thrissur, Kurnool and East Godavari districts. An attempt was made to understand the factors influencing the community resilience dimensions across the elected districts and the findings are presented under the following subheads.

### 4.3.2. Community resilience index of Kurnool district, AP

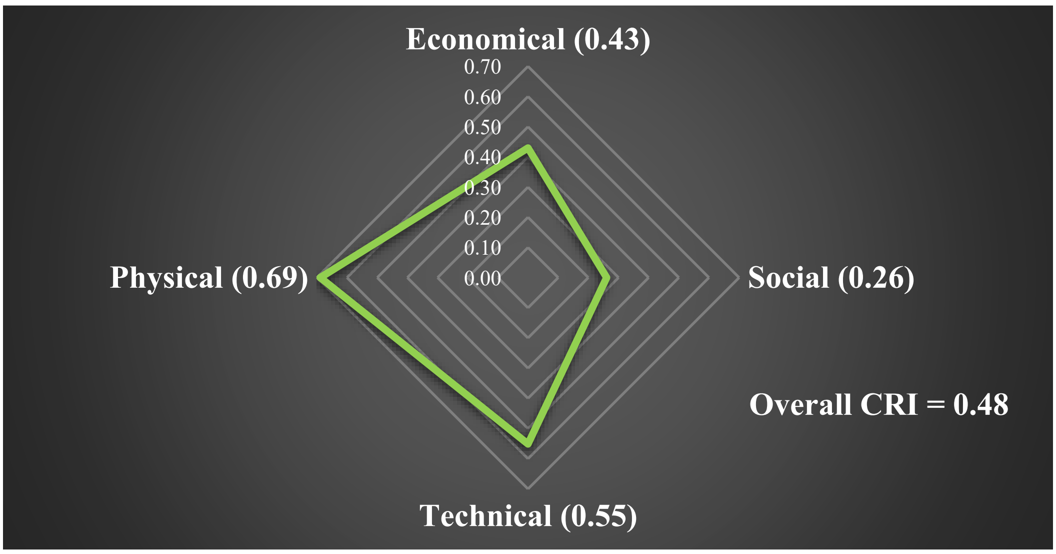



**Fig. 4.5. Dimension wise CRI of Kurnool district of AP**

The dimension-wise resilience scores of paddy farmers in the Kurnool district depicted in Figure 4.5 revealed that the score for the social dimension was low at 0.26, and the highest score was for the physical dimension at 0.69. While technical and economic dimensions exhibited moderate scores of 0.55 and 0.43. Though a low score was observed only in the social dimension, it had impacted the scores on the other dimensions by offsetting the overall scores of community resilience of the region. This skewed score can be clearly understood from the graph.

Overall, the CRI of the region was 0.48 (Table 4.16), which is considered as a moderate level of resilience. The results called for immediate efforts to increase the social resilience of the farmers in the region through interventions that improved the community cohesion, training exposure, and social participation of the farmers in the area. These aided in promoting the interaction between the farmers that enhanced the sharing of information and learning from each other's experiences and collectively addressing their challenges. During the survey, it was observed that there were no Farmer Interest Groups (FIGs) in the region. Therefore, mobilization of farmers into groups such as farmer-producer organizations or farmer interest groups would be beneficial to enhance community cohesion contributing to the social dimension of community resilience.

Though the scores were moderate in the other three dimensions, a deeper look could reveal the factors affecting the resilience. Economic factors such as annual income, insurance adoption, credit sources, and savings were found to be low in the region. With the majority of farmers being small landholders with agriculture as their primary source of income, the overall income of the farmers was low. In addition, with the predominant informal sourcing of credit from non-institutional sources such as money lenders, friends and family members, farmers were in debt traps of high interest rates and unreasonable repayment conditions which further deteriorated their economic status. Hence, it is imperative to improve the use of institutional credit by relaxing the credit conditions. This will improve the savings of farmers and their community resilience that aid them in absorbing the shocks caused by natural hazards.

### 4.3.3. Community resilience index of East Godavari district, AP

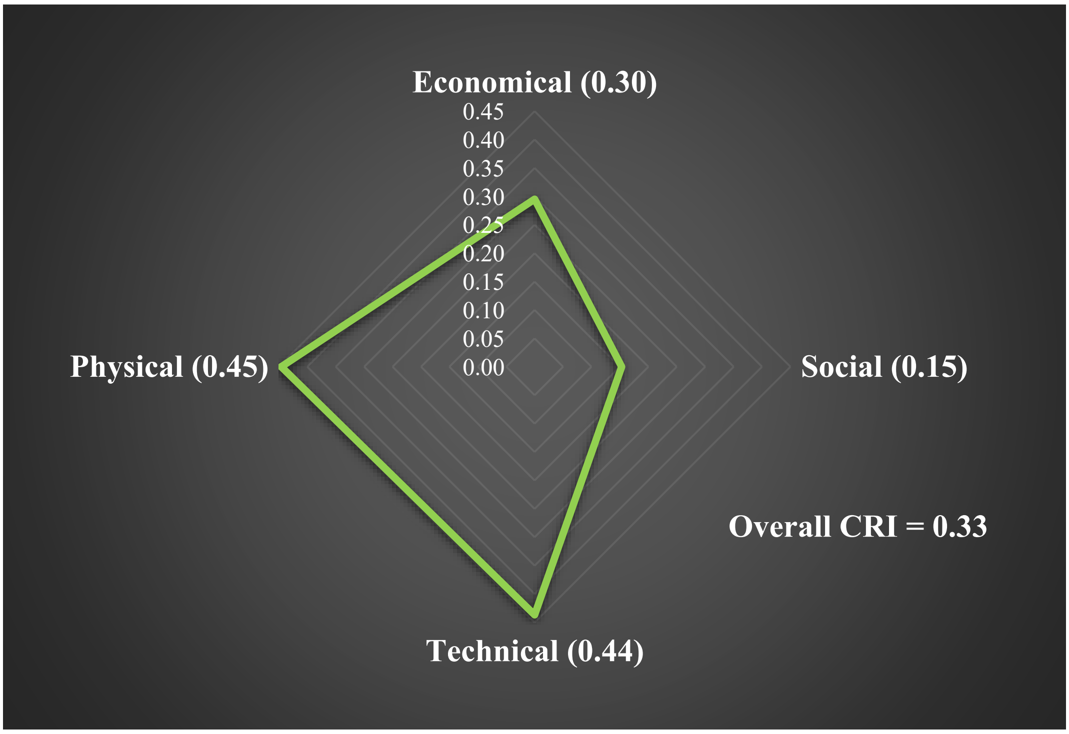



**Fig.4.6. Dimension wise CRI scores of East Godavari district, AP**

The dimension wise CRI of East Godavari district of AP presented in Figure 4.6 illustrated that the economic and social dimension scores were at 0.30 and 0.15, respectively, which are considered low. In the case of the other two dimensions, technical and physical, the scores were moderate at 0.44 and 0.45 respectively. It was also evident from the figure that the scores of social and economic dimensions were skewed and impacted the overall CRI value of 0.33 (Table 4.16). It result indicated that East Godavari, considered the rice bowl of Andhra Pradesh, had the lowest community resilience among all the districts in the study. This showed the dismal situation of paddy farmers in the region, who were highly affected by weather vagaries.

The main factor that affected the farmers in the region was the prevalence of tenant farming system. Most of the farmers cultivated on leased in lands, which restricted them from availing insurance, receiving compensation amounts for natural calamity losses, investing in machinery, diversification of crops, availing institutional credit and having savings. Primarily, the farmers in the region could not receive any compensation for crop losses because of the rules and regulations involved in availing insurance and compensation. Insurance could be availed by the farmers who had own lands primarily. Lease farmers had to have legal agreements with the lessor entitling them for Crop Cultivator Rights Cards (CCRC) to avail insurance and other formal compensation packages or credit as discussed earlier. However, the farmers seldom followed these procedures and all the entitlements were enjoyed by the land owners rather than the cultivators. It has been reported by Anuhya *et al.* (2022) that the diffusion of CCRC is very low, among the farmers of AP. This was mostly because the landlords were not ready to enter into any legal agreements with the lessee farmers. Many reasons were cited by the farmers in this aspect, the major one being landlords unwilling to give their land documents, foregoing the amounts they received from the government schemes. Thus, even the benefits of insurance coverage, which was reported to be high in the region got subverted to land owners without reaching the actual cultivators. Both insurance and crop loss compensation amounts got credited to the bank accounts of land owners and not the original cultivator, i.e., the lessee. The lessee incurring crop losses was at the mercy of the landlords; landlords who were concerned about the lessee provided the amount that got credited in their bank accounts to the lessee. But as there was no legal agreement, it was the landlord's decision. Many of the farmers revealed that landlords did not give any amounts to them; even if given, the amount would be significantly less compared to the loss they had incurred.

Along with insurance, other major factors that affected the resilience of the region were the credit sources and income levels of farmers. Farmers needed to have collateral to provide security to avail of bank loans. With the majority of the farmers in the region being lease land farmers, they did not possess adequate assets to offer as collateral to avail loans. Lease land farmers in the region do not have access to KCCs either. With this situation, farmers were moving towards non-institutional sources such as landlords, friends and family, and traders to avail credit. Similar to the Kurnool district, the prevailing interest rate in the region was around 24 per cent, which was very high compared to banks. Farmers in the region were already affected with low farm returns and no insurance and compensations. In addition, higher interest rates further deteriorated their income. This made the lives of lease land farmers in the region caught in a vicious cycle of poverty.

Social participation, community action, and access to training were important factors that could impact the community resilience of the region. Though the region was the major rice growing belt in AP, farmer groups were very scarce. The provision of training and classes to the farmers regarding resilient cultivation practices was totally lacking. Apart from the Rythu Bharosa Khendra (RBK), a regional agricultural office, no other institutions were present in the region. These RBKs were started in the year 2020 and were still in the nascent stage with respect to infrastructure and reach among farmers. Thus, the results called for an immediate solution to improve the resilience of the farmers, which, if not done, may result in landless farmers stopping agriculture and pursuing other occupations. This would have direct bearing on the food security and ecology of the state and nation at large.

### 4.3.4. Community resilience index of Thrissur district, Kerala

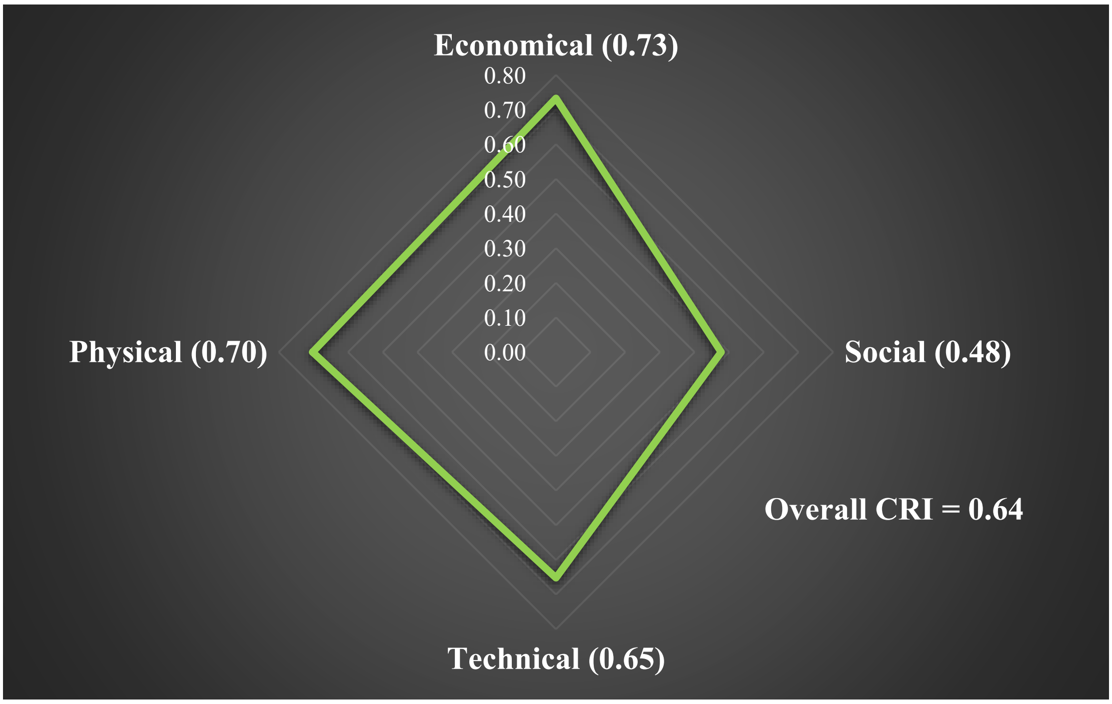



**Fig. 4.7. Dimension wise community resilience index of Thrissur district, Kerala**

The dimension wise resilience scores of the farmers of Thrissur district of Kerala are included as Figure 4.7. It is evident from the figure that scores of all the dimensions were of moderate and high levels. Social dimension with score of 0.48 and technical dimension with score of 0.65 were at moderate levels and the economic and physical dimension scores were high, at 0.73 and 0.70, respectively. The overall CRI score was 0.64 (Table 4.16), which was considered moderate. This implied that the farmers in the Thrissur district had moderate resilience against natural hazards. It was also apparent from the figure that except for the social dimension, which has a relatively low, the rest of the dimensions, i.e. economic, technical and physical, had almost similar scores.

It could be observed that the social dimension here also served as a major element effecting the overall community resilience. The significant factors of the social dimension that had an effect on CRI were community action and social participation. Though region had the presence of farmer groups such as farmer-producer organizations (*Padashekara Samithis*), their role was limited to certain common activities such as land preparation, water management, harvesting etc. Moreover, it was noticed that many interventions of the *samithi* had created conflicts among farmers of the region. Thus, it was not the actual absence of farmer organization but the trust and coherence shared by its members that created problems here. Hence, social participation and community coherence among the farmers in the region need to be promoted by depoliticizing the farmer organizations and conduct of regular and fair elections.

Farmers in the region were well placed in the other dimensions of CRI, mainly economic and physical dimensions. Almost all the farmers in the region were availing crop insurance and crop compensation amounts. Thereby, they could avert the financial shocks caused by the natural hazards. Farmers were also utilizing institutional sources such as commercial and cooperative banks as their primary source of credit. The adoption of KCC was also very high; thereby, farmers could avail credit for agricultural purposes at minimal rates of interest. Access to weather info by the farmers was also very high in the region, which could be explained by the high educational level of farmers in the region.

### 4.3.5. Community resilience index of Palakkad district, Kerala

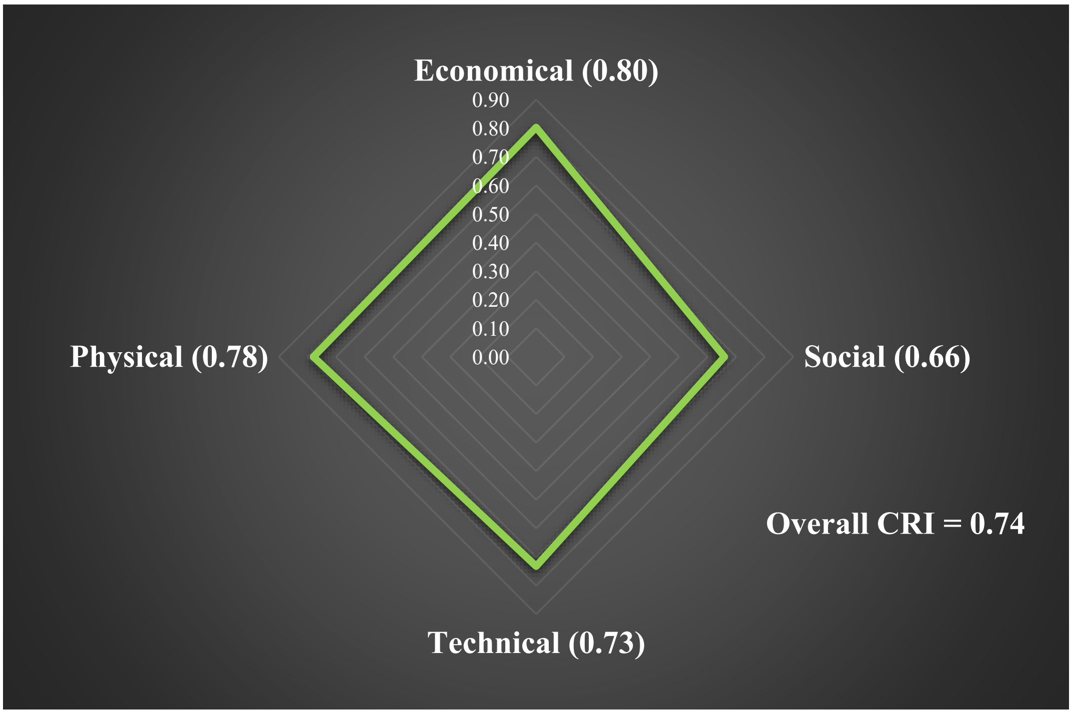



**Fig. 4.8. Dimension wise community resilience index of Palakkad district, Kerala**

A picture of dimension-wise community resilience scores and the overall CRI for the Palakkad region could be seen in Figure 4.8. It could be observed that scores of all the four dimensions of economic, social, technical, and physical were high, with respective values of 0.80, 0.66, 0.73 and 0.78. The overall CRI was also high for Palakkad, with an index score of 0.74 (Table 4.16), the highest among all the districts. The figure also showed that the scores across the four dimensions were relatively similar, making the resilience balanced across the dimensions.

The results could be well explained in terms of the farming attributes of Palakkad region. Farmers in Palakkad were full-time farmers, unlike those in Thrissur, where many of them had other sources of income also. Social participation of the farmers in the Palakkad region was also very high with the presence of an FPO, namely Palakkad Paddy Farmers Producer Company Limited, apart from the *Padashekara Samithis* (FIG). Almost all the farmers in the study area were members of this FPO and the *Samithi*, which enhanced their community cohesion. The FPO had an office in the region where farmers gathered in the evening every day and had informal conversations, enhancing their networks and knowledge. This was lacking in all the other three regions of study; therefore, forming farmers in the other regions into FPO could be considered as a major solution to improve the social resilience of the farming community, especially in rice.

### 4.3.6. Kruskal-Wallis test of significance for CRI scores in AP and Kerala

In order to find whether the difference in the CRI scores across the four districts of the two states of AP and Kerala was significant, the Kruskal-Wallis test was performed, and the results are given in Table 4.17 and 4.18.

**Table. 4.17. Independent-Samples Kruskal-Wallis Test Summary**

| | |
|---|---|
| Total N | 180 |
| Test Statistic | 103.213[a] |
| Degree Of Freedom | 3 |
| Asymptotic Sig.(2-sided test) | 0 |

a. The test statistic is adjusted for ties

**Table. 4.18. Hypothesis Test Summary**

| | Null Hypothesis | Test | Sig.a,b | Decision |
|---|---|---|---|---|
| 1 | The distribution of CRI is the same across categories of District. | Independent-Samples Kruskal-Wallis Test | 0 | Reject the null hypothesis. |

a The significance level is .050.

b Asymptotic significance is displayed.

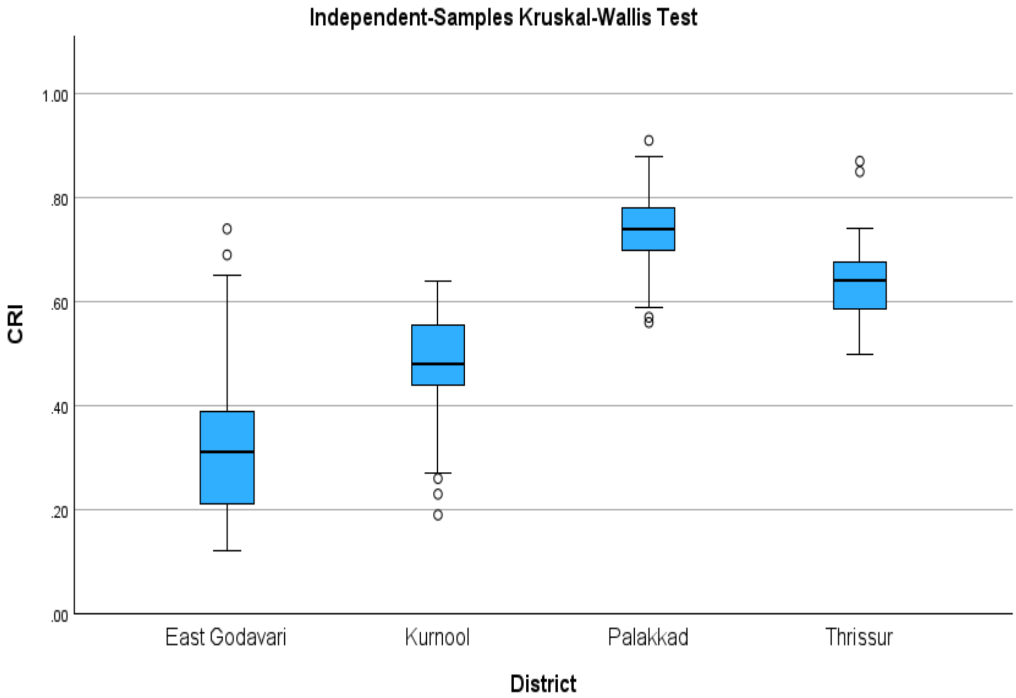



**Fig. 4.9. Box plot diagram showing the CRI scores across four districts**

**Table. 4.19. Summary of pairwise comparison of CRI scores across different regions**

| Sample 1-Sample 2 | Test Statistic | Std. Error | Std. Test Statistic | Sig. | Adj. Sig.a |
|---|---|---|---|---|---|
| East Godavari-Kurnool | -32.152 | 9.181 | -3.502 | <.001 | 0.003 |
| East Godavari-Thrissur | -76.429 | 11.138 | -6.862 | <.001 | 0 |
| East Godavari-Palakkad | -101.595 | 11.014 | -9.224 | 0 | 0 |
| Kurnool-Thrissur | -44.277 | 10.921 | -4.054 | <.001 | 0 |
| Kurnool-Palakkad | -69.443 | 10.795 | -6.433 | <.001 | 0 |
| Thrissur-Palakkad | 25.166 | 12.502 | 2.013 | 0.044 | 0.265 |

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.

Asymptotic significances (2-sided tests) are displayed. The significance level is .050.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

It can be concluded from the Fig that there is a significant difference existing across the scores of four districts. A look into Fig. shows the pairwise comparison of the differences. Table 4.19 shows the pairwise comparison of CRI across four districts. It can be observed from the Fig that the difference between the scores of Palakkad and Thrissur is not significant. The difference between the CRI scores of East Godavari and Kurnool, East Godavari and Palakkad, and East Godavari and Thrissur are significant at a 1 per cent significance level. Similarly, in the case of Kurnool, the difference with the rest of the three districts is statistically significant. Thereby, it can be concluded that the differences that are present between the four districts are not due to chance but due to the differences in the underlying factors that are related to resilience. This result is crucial for making regional-specific interventions and policies to improve their resilience.

### 4.3.7. Kruskal Wallis test of significance for CRI across different land holding categories

Another Kruskal-Wallis test has been performed to find whether there was any significant difference in the CRI scores across the farmers based on their landholding sizes. Results from running the test, as shown in Table. 4.20 and 4.21 indicated a statistically significant difference at a 1 per cent significance level. Further analysis using pairwise comparison (Table. 4.23) showed the categories across which the difference was significant.

**Table. 4.20. Independent-Samples Kruskal-Wallis Test Summary**

| **Total N** | **180** |
|---|---|
| Test Statistic | 95.681[a] |
| Degree Of Freedom | 5 |
| Asymptotic Sig.(2-sided test) | 0 |

a. The test statistic is adjusted for ties

**Table. 4.21. Hypothesis Test Summary**

| | **Null Hypothesis** | **Test** | **Sig.a ,b** | **Decision** |
|---|---|---|---|---|
| 1 | The distribution of CRI is the same across categories of Farms . | Independent-Samples Kruskal-Wallis Test | 0 | Reject the null hypothesis. |

a The significance level is .050.

b Asymptotic significance is displayed.

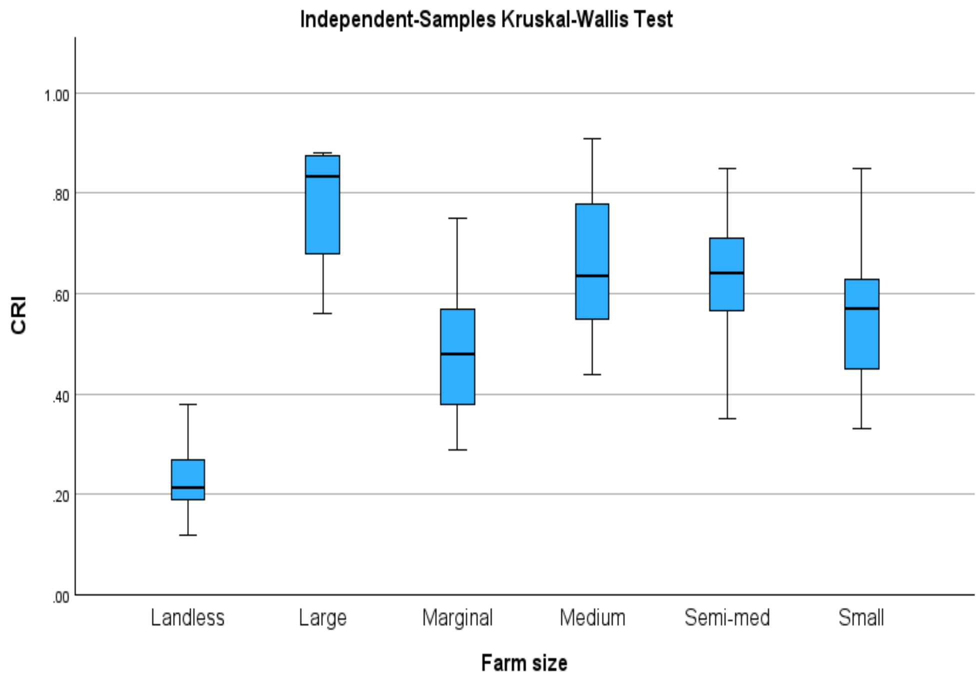



**Fig. 4.10. Box plot diagram showing the CRI scores across different landholding categories**

**Table. 4.23. Summary of pairwise comparison of CRI scores across different landholding categories**

| Sample 1-Sample 2 | Test Statistic | Std. Error | Std. Test Statistic | Sig. | Adj. Sig.a |
|---|---|---|---|---|---|
| Landless-Marginal | -57.895 | 12.432 | -4.657 | <.001 | 0 |
| Landless-Small | -72.02 | 10.447 | -6.894 | <.001 | 0 |
| Landless-Semi-med | -94.719 | 11.718 | -8.083 | <.001 | 0 |
| Landless-Medium | -102.124 | 13.754 | -7.425 | <.001 | 0 |
| Landless-Large | -123.485 | 24.942 | -4.951 | <.001 | 0 |
| Marginal-Small | -14.124 | 11.52 | -1.226 | 0.22 | 1 |
| Marginal-Semi-med | -36.824 | 12.684 | -2.903 | 0.004 | 0.055 |
| Marginal-Medium | -44.229 | 14.586 | -3.032 | 0.002 | 0.036 |
| Marginal-Large | 65.59 | 25.41 | 2.581 | 0.01 | 0.148 |
| Small-Semi-med | 22.7 | 10.746 | 2.112 | 0.035 | 0.52 |
| Small-Medium | 30.105 | 12.936 | 2.327 | 0.02 | 0.299 |
| Small-Large | 51.466 | 24.501 | 2.101 | 0.036 | 0.535 |
| Semi-med-Medium | 7.405 | 13.983 | 0.53 | 0.596 | 1 |
| Semi-med-Large | 28.766 | 25.069 | 1.147 | 0.251 | 1 |
| Medium-Large | 21.361 | 26.083 | 0.819 | 0.413 | 1 |

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.

Asymptotic significances (2-sided tests) are displayed. The significance level is .050.

a Significance values have been adjusted by the Bonferroni correction for multiple tests.

It can be seen from Table. 4.23 that the differences were significant only for the landless category of farmers. Though there are differences existing among all the classes, they are not statistically significant. From the Fig. 4.10 depicting the box plot diagram, it can be observed that landless farmers had the lowest score, followed by marginal farmers and small farmers. The scores of medium and semi-medium farmers are relatively similar, and finally, large farmers had the highest scores. These results are consistent with the work done by Jayadas and Ambujam (2021), where a similar trend is observed. It can be concluded that the landless farmers had very low levels of resilience compared to all the other categories. These results suggest the importance that should be given to landless farmers, who constitute around 8 per cent of total farmers in India (GOI, 2021).

## 4.4. Social networks of paddy farmers

Social networks were identified as an essential factor contributing to community resilience, as they improve the cooperation of people in shared activities, collective action, sharing of resources, and exchange of information and knowledge (Chapman et al., 2018). It is also reported from many studies that the social networks of farmers supported many social processes which had a positive association with the resilience of systems during times of environmental stress (Levy and Lubell, 2018). It was in this context, the social networks of the farmers in the four districts of the states of AP and Kerala were studied with respect to their information network, emotional support network and resource network. Social Network Analysis (SNA) using Gephi software was used to delineate the actors and linkages and the centrality measures in all three networks and the results are presented. In order to get a better understanding of the results, the conceptual meaning of each of the network properties and terms used to quantify and interpret the networks has been included in Table 4.24.

**Table 4.24. Conceptual meaning of major network properties and terms used in SNA analysis**

| Sl. No. | Network property | Meaning |
|---|---|---|
| 1 | Ties | Connections/links |
| 2 | Nodes | Actors |
| 3 | Density | Ratio between total no. of actual ties and potential ties in a network |
| 5 | Degree centrality | Total number of all the inward and outwards ties linked to the actor from other actors in the network |
| 6 | Betweenness centrality | Frequency with which a node lies in the geodesic path between two other nodes in a network |
| 7 | Closeness centrality | Reciprocal of geodesic distance of a node to other nodes in the network |
| 8 | Modularity | Strength of network division into different communities |
| 9. | Clusters | Groups of actors with higher internal connections and sparse external connections |
| 11 | In-degree | Number of ties a node received from other nodes of the network |
| 12 | Out-degree | Number of ties a node sends out to other nodes in the network |

**4.4.1. Social network properties of information network**

The network properties of information network delineated from the study area is given in Table 4.25. Density is considered as a measure of connectivity of nodes with other possible nodes in the network and the results in the table showed comparable low values in all the four districts. This suggested that there were quite many potential agencies who could be integrated into the information networks so that the overall resilience could be enhanced. Hence delineation and use of potential agencies which were yet to be utilized by the networks in both the states are recommended. The results also gave matrices of major centrality measures of betweeness centrality ($C_b$), degree centrality ($C_d$), and closeness centrality ($C_c$), which gave distinct measures of how close a node was to the center of whole network.

In betweenness centrality ($C_b$), a higher value implied that there were certain nodes in the network which occurred more in between the geodesic paths of two actors. This suggested that the networks had certain actors who were in strategic positions by which they could influence the whole network either positively or negatively (Newman, 2006). It could be observed from the table that Palakkad district of Kerala had the highest $C_b$ scores of 2.069 compared to Thrissur (0.616), Kurnool (0.746) or East Godavari (0.302). The high $C_b$ scores of Palakkad indicated that certain actors in the network were more influential suggesting high power brockerage in information flow. This implied the presence of multiple highly influential actors in the network which was further proved by the actor landscape of Palakkad with MLAs, Panchayat Presidents etc, delineated in the SNA mapping (Fig. 4.x). These actors with high $C_b$ values could serve as connecting bridges between clusters in the network and were critical in information dissemination pathways. Though information flow could be augmented by these bridges in the network with positive influence on community resilience, there were chances for these nodes to emerge as power centers of deciding the type of information exchanges. Hence, proper democratic mechanisms should be in place to control the power centers of networks. Also, opinion leaders improve the interconnections in the network by acting as bridges (Centola, 2010). These bridging actors need to be properly trained to upgrade their knowledge and skills. Further, these bridging actors will transfer their knowledge to the whole network of farmers through their influence in the network. With respect to AP districts, the presence of bridging actors was found to be very low; thereby, it is of utmost importance to improve the leadership and social participation among the farmers in those regions.

The results also showed a difference among the states with respect to degree centrality ($C_d$) measures. Both the Palakkad and Thrissur districts of Kerala had relatively higher average in-degree centrality values of 1.845 and 1.65 compared to AP districts. This suggested each actor in the Kerala network received information from diverse sources compared to AP. It could also be observed from the table 4.25

that the information network of Palakkad had the highest in-degree centrality of 1.845, followed by Thrissur (1.65), Kurnool (1.271) and East Godavari which had the least value of 0.961. This indicated that the Palakkad network had a relatively higher number of information sources within the network from which the farmers received inputs compared to other districts in the order. The overall low community resilience of East Godavari as already discussed could further be substantiated by the low in-degree centrality scores which indicated the few information sources with which they worked and needed to be redressed by strengthening the local extension system. This could primarily be attributed to the low social participation among the farmers in A.P. districts.

**Table 4.25. Network properties of information networks of farmers across four districts of AP and Kerala (N=120)**

| Network properties | AP | | Kerala | |
|---|---|---|---|---|
| | Kurnool | East Godavari | Palakkad | Thrissur |
| Density | 0.022 | 0.033 | 0.031 | 0.026 |
| Betweenness centrality | 0.746 | 0.302 | 2.069 | 0.616 |
| Average in-degree centrality | 1.271 | 0.961 | 1.845 | 1.650 |
| Modularity | 0.608 | 0.511 | 0.416 | 0.435 |
| Clusters | 8.0 | 6.0 | 6.0 | 9.0 |
| Closeness centrality | 0.427 | 0.654 | 0.457 | 0.438 |

In the case of modularity, a higher value of modularity indicated that the network was divided into clusters of networks (Newman, 2006). A value closer to 1 indicated high modularity and that the connections were dense within the clusters compared to overall connections. Higher modularity values in the case of information networks may make it less resilient for information dissemination as the information had to first pass through the major actors in all the clusters. Table 4.25 showed that the modularity values of information networks was above 0.4 in all the four districts of AP and Kerala. This implied the presence of division into clusters in all the networks. However, the modularity score was the highest for Kurnool network (0.608), followed by East Godavari with 0.511 compared to the Kerala districts of Palakkad (0.416) and Thrissur (0.435). Thus overall, the districts of AP. had higher modularity compared to Kerala which indicated lower community resilience.

With respect to closeness centrality ($C_c$), a value closer to one represented high closeness among the actors in the networks. High closeness resulted in faster and more efficient transfer of information across the network. It also meant that the steps and time taken to reach any actor in the network was low when $C_c$ neared unity. The results in Table 4.25 showed that the East Godavari network had the highest closeness centrality value of 0.654 among all the districts. The other three districts, Kurnool, Palakkad and Thrissur, had almost similar values within the range of 0.4 to 0.5. It could be interpreted from the table results that actors in the East Godavari region are more closely connected to each other. This could be further justified using the value of the average in-degree of the East Godavari region, which is low compared to others. With fewer actors present in the region, it was easy to remain close and pass information in the network.

Thus, it could be concluded that all the four districts had certain actors in the information networks of farmers who played a significant role. However, the influence of these prominent actors in the network was not equally distributed across the districts. In districts of Kerala, because of the high in-degree value, these prominent actors were well placed to disseminate the information to the whole network. In the case of AP districts, especially East Godavari, the in-degree values were relatively low. So, dependence on the few major actors in the region was insufficient to disseminate the information to all the farmers in the region. Therefore, considering the closeness centrality values, which was high in the East Godavari region, it is suggested to simultaneously disseminate the information to as many farmers as possible in the region. Because of their closeness, further information spread could be efficiently achieved.

### 4.4.2. Mapping of information networks of paddy farmers

In order to have a visual representation of the information network of paddy farmers, separate information network maps were developed for the selected districts of AP and Kerala using Gephi software. The maps and the interpretation of findings are presented in the following subheads.

#### 4.4.2.1. Information network map of East Godavari district, AP

The map of information networks of rice farmers in the East Godavari district is presented in Fig.4.11. In the maps, the size of the circle represented an actor's importance in the network based on the in-degree values of those actors. It was evident from the landscape of actors delineated from the figure that input dealers were the major actors in East Godavari district for information dissemination among the farmers. Other major actors in the information dissemination as depicted in the map were National Disaster Management Authority (NDMA), Rythu Bharosa Khendra (RBK) and Reliance group in that order. Along with these agencies, there were a few farmers in the region who were depended by other farmers for information. Among these contact farmers, farmer 5 was considered as a major non-institutional actor in the network, with other farmers, 33, 34, 37, 38, 2, and 31, playing minor roles in the network as indicated by their network matrices.

The major inference drawn from the results was that though there was a government institutional source in the name of RBK in the district, farmers relied more on the input dealers for sourcing information. NDMA mostly provided information to the farmers about the weather through SMS services, while Reliance Group provided personal phone advisory services to the farmers directly. One of the primary reasons for the lower role of RBK compared to input dealers in information dissemination to farmers was that RBK was established in 2020. Earlier to that, farmers at the panchayat level were not having any extension institution to meet their needs. With this lack of institutional presence, farmers were sourcing information about cultivation practices from input dealers who are widely present in the location. Many researchers reported input dealers as the first point of contact for the farmers to access information about new agricultural technologies and improved inputs. But the chance of these input dealers providing skewed information that benefit them more than farmers was very high. Therefore, it was of utmost importance that the officers in the government institution in the region enhance their rapport with the farmers and provide reliable information so that they get the farmer's credibility. Input dealers could also be made more reliable by training them, such as a Diploma in Agricultural Extension Services for Input Dealers (DAESI) (Kumar et al., 2022). This diploma is given by the National Institute of Agricultural Extension Management (MANAGE), Hyderabad. Training input dealers under this program will certify the dealers as para-extension officials, making them a credible source of information for farmers. The role of NDMA and Reliance group in the information network must be emphasised here because they provide essential information about weather and cultivation practices to the farmers using mobile services in regional languages.

#### 4.4.2.2. Information network map of Kurnool district, AP

The Fig. 4.12 showed the network map for information sourcing of Kurnool paddy farmers of AP. Similar to the network of East Godavari paddy farmers, it could be seen that input dealers were playing a pivotal role in the Kurnool region, also. RBK was the second major source of information for the farmers in the region, followed by three farmers, 15, 1, and 61. As mentioned earlier in the East Godavari networks, the role of input dealers was high in the region because of less presence of institutional sources of information. Farmers 15 and 1 in the region need to be provided with more training in climate resilient agriculture as these farmers, with their closeness to the other farmers, could support efficient dissemination of information.

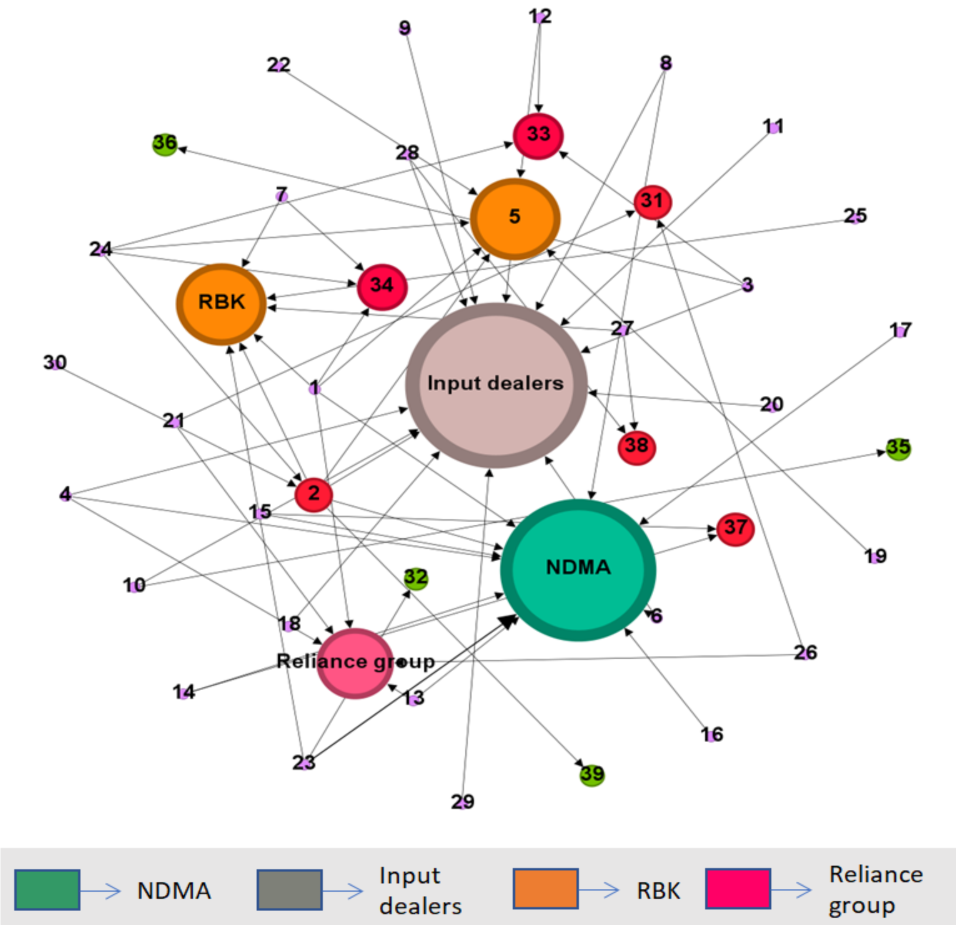



Fig. 4.11. Information network map of East Godavari paddy farmers in AP

**Table. 4.26. Landscape of major actors and their matrices - East Godavari information network**

| Major actor | Indegree | Authority |
|---|---|---|
| Input dealers | 13 | 0.607281 |
| NDMA | 12 | 0.622654 |
| RBK | 6 | 0.284598 |
| Farmer 5 | 6 | 0.24857 |
| Reliance group | 5 | 0.230178 |
| Farmer 34 | 3 | 0.127859 |
| Farmer 33 | 3 | 0.081832 |

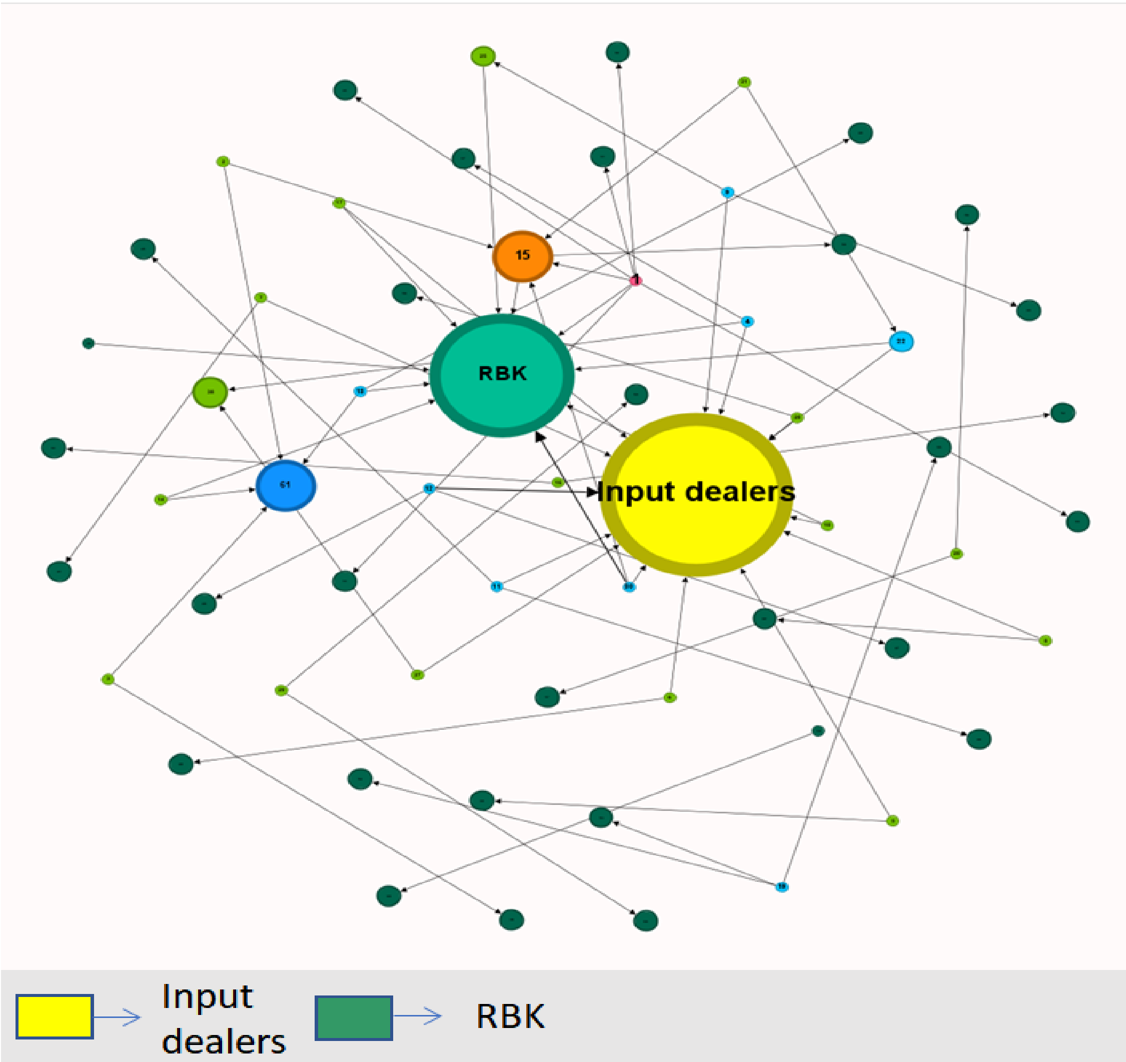



**Fig. 4. 12. Information network map of Kurnool paddy farmers in AP**

**Table. 4.27. Landscape of major actors and their matrices - Kurnool information network**

| Major actor | Indegree | Authority |
|---|---|---|
| Input dealers | 15 | 0.800886 |
| RBK | 11 | 0.517683 |
| Farmer 15 | 4 | 0.159525 |
| Farmer 38 | 2 | 0.104847 |

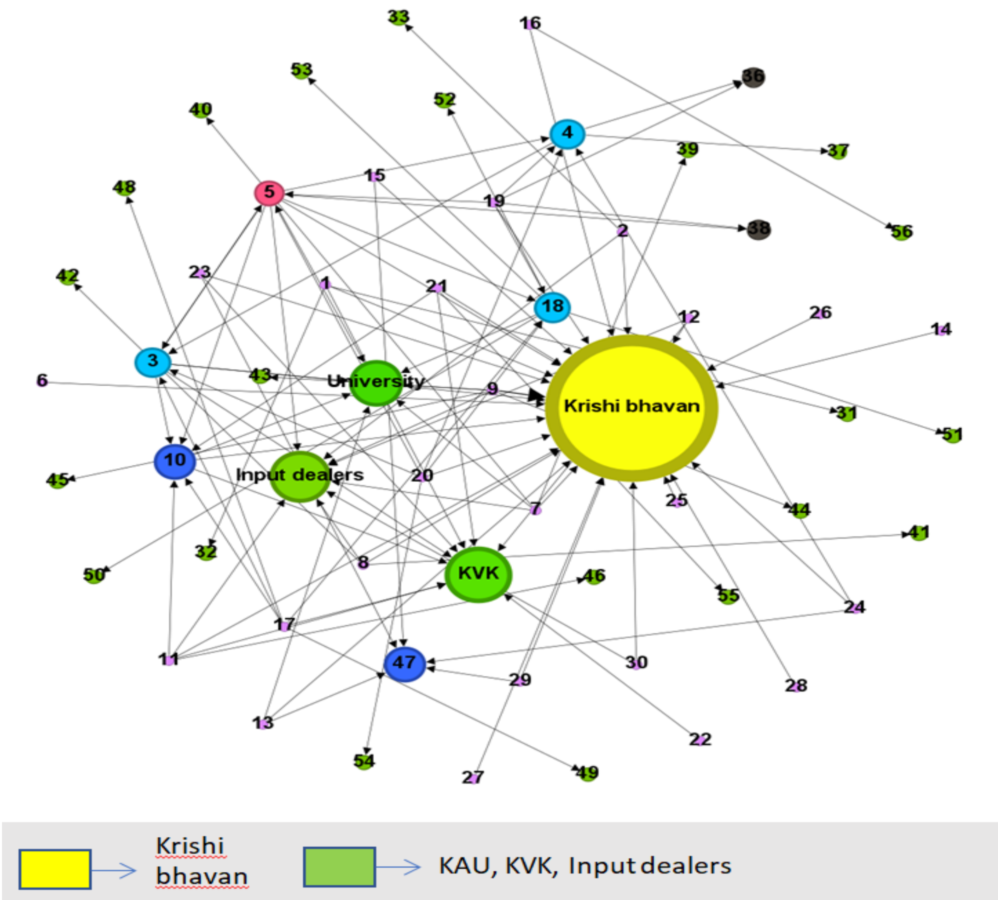



Fig. 4.13. Information network map of Palakkad paddy farmers in Kerala

**Table. 4.28. Landscape of major actors and their matrices - Palakkad information network**

| Major actor | Indegree | Authority |
|---|---|---|
| Krishi bhavan | 26 | 0.711993 |
| University | 14 | 0.454329 |
| KVK | 9 | 0.276405 |
| Input dealers | 8 | 0.25755 |
| Farmer 10 | 5 | 0.176256 |
| Farmer 47 | 5 | 0.126466 |
| Farmer 3 | 4 | 0.119781 |

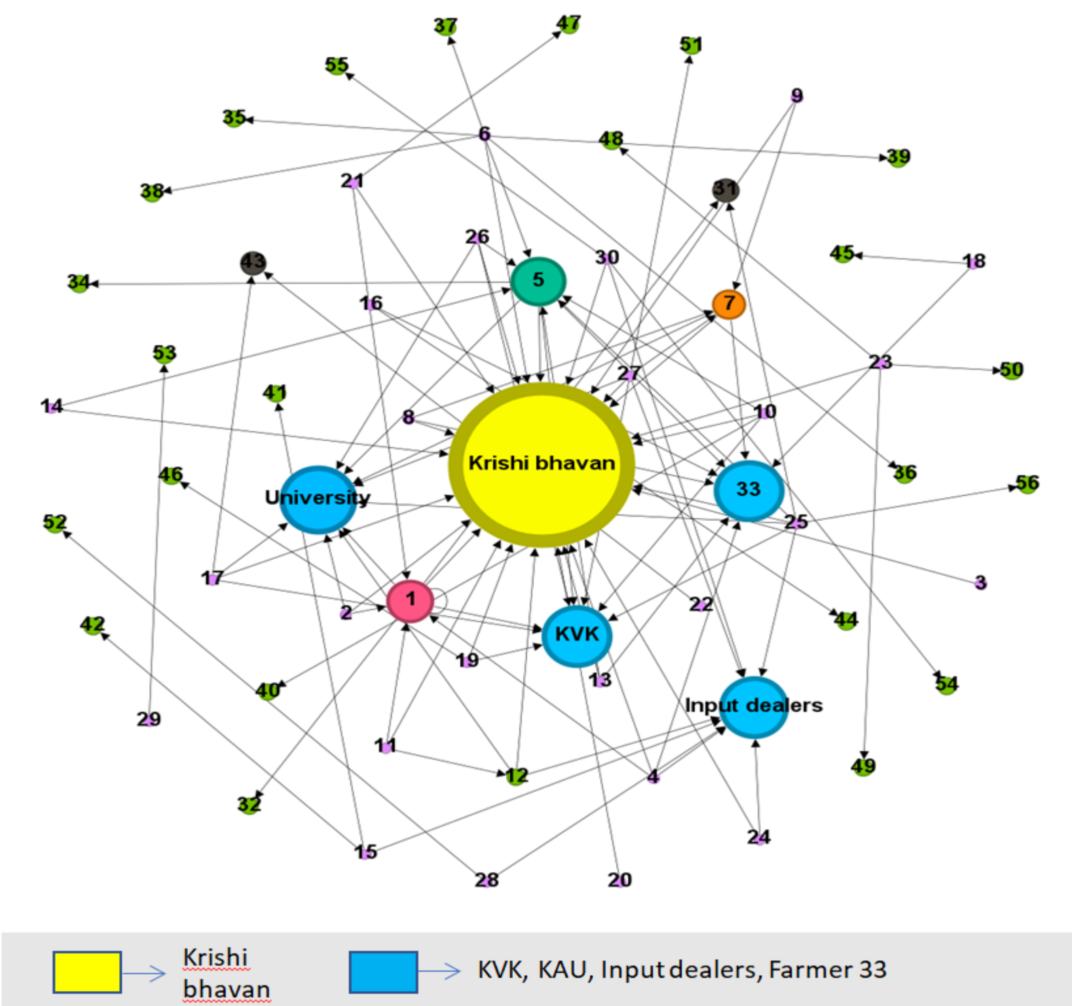



**Fig. 4.14. Information network map of Thrissur paddy farmers in Kerala**

**Table. 4.29. Landscape of major actors and their matrices - Thrissur information network**

| Major actor | Indegree | Authority |
|---|---|---|
| Krishi bhavan | 24 | 0.747063 |
| University | 9 | 0.366226 |
| KVK | 8 | 0.328684 |
| Farmer 33 | 8 | 0.228531 |
| Input dealers | 8 | 0.228161 |
| Farmer 5 | 6 | 0.216168 |
| Farmer 1 | 5 | 0.10916 |

### 4.4.2.3. Information network map of Palakkad paddy farmers, Kerala

It could be seen from Fig.4.13 that multiple actors were involved in the information networks of the paddy farmers of Palakkad district in Kerala. However, the actor with the highest in-degree value of 26 was Krishibhavan. The high in-degree centrality measure explained the importance of Krishibhavan in information dissemination to farmers. Other institutional actors such as Krishi Vigyan Khendra (KVK), and Kerala Agricultural University (KAU), also played important roles as evident from their respective tie values in the map. Along with these institutional actors, input dealers and the farmers 10, 47, 3, 4, and 18 were the other critical actors in the network whom other farmers highly depended for information sourcing. These farmers could be called opinion leaders as they were influential in the network without any formal authority. Thus, Palakkad farmers had access to a wide range of sources for gathering information, which was beneficial to the resilience of the system (Lambrecht *et al*., 2018)

With its presence at the panchayat level, Krishibhavan was the nearest and most reliable source of info for farmers of Palakkad. Although other institutional actors such as KVK and KAU had more specific and sporadic roles than Krishibhavan, they were also crucial in the network as they were considered highly reliable sources. Similar to the networks of AP, input dealers had a critical role in the Palakkad information network also, emphasising their cardinal role in both states. Another significant feature of the network was a relatively higher number of farmers with high in-degree values. These actors could be selected and trained by the institutions, which will ultimately result in efficient knowledge transfer to the whole network. The combination of formal and informal sources of information in social networks is considered a beneficial aspect for the resilience of the farming systems (Sumane et al., 2018).

### 4.4.2.4. Information network map of Thrissur paddy farmers, Kerala

The information network map of Thrissur paddy farmers given in the Fig.4.14 revealed that many influential actors were present in the network for information dissemination to farmers. With 24 in-degrees, Krishibhavan, was delineated as the actor with the highest influence in the network, followed by other institutions such as KAU and KVK, with 9 and 8 in-degrees, respectively. Input dealers in the district played a moderate role in informing farmers with an in-degree value of 8. In the case of farmers in the network, farmer 33 also recorded an in-degree value 8. The results implied that farmer 33 was on par with the input dealers in the district with respect to its importance in the information network of the region. Other farmers, 5 and 1, played a minor role in the network. Thus, the information network of farmers in Thrissur mostly consisted of reliable sources of information in the form of institutional actors. Farmers 33, 5 and 1 should be scaled up with respect to their knowledge and skills in agriculture, as they could serve as effective knowledge transmitters among farmers in the region.

### 4.4.3. Emotional support network of paddy farmers in AP and Kerala

Emotional support networks of farmers had a critical role in the community resilience of the farmers, especially at times of natural hazards. Therefore, the study attempted to map farmers' emotional support networks in the four districts of AP and Kerala. The results presented in Fig.4.15 revealed the major actors in the emotional support networks of AP's East Godavari paddy farmers as the family, friends, RBK and landlords. A family with their own blood relations and close relatives recorded an Eigen centrality value of 1, which was the major actor for the emotional support of the farmers. The second important actor for emotional support in the district were the friends of farmers, with an Eigenvalue of 0.667. Other actors, such as RBK and landlords, played a minor role in the support networks of farmers with Eigenvalues of 0.288 and 0.238, respectively. According to Aldrich (2012), ties with family, friends and farmers in the region were considered as bonding capital, ties with actors having political and leadership roles were regarded as bridging capital and ties with institutional actors were considered as linking capital. Thereby, family, friends and landlords were the actors that constituted the bonding capital of this region. Similarly, RBK was the institutional actor that served as the linking capital of the region. It was quite rational that most of the farmers sought emotional support from family and friends, with whom they had long-standing, intimate relations, explaining the higher Eigenvalues of these actors. In the case of landlords, as mentioned earlier, farmers in the district were mostly lease land farmers; they relied on landlords for emotional, financial and resource support. RBK, the only institutional actor in the panchayat level of A.P. regions, was also present in the network as farmers sought support from the institution during natural hazards for crop loss compensation and insurance claim settlements.

Like East Godavari, in the Kurnool district of AP, family and friends emerged as major actors in the emotional support networks with Eigenvalues 1 and 0.608, respectively (Fig.4.16). Also, RBK was in the network with a minor role explained by its lower Eigenvalue of 0.304. The absence of landlords in the network could be attributed to the predominance of landowner farmers in the district, unlike East Godavari. The major inference from the results was that the landscape of actors in a network depended on its sociometric profile.

The results of Fig.4.17, indicated the presence of five major actors in the emotional support network of Palakkad paddy farmers in Kerala. The major actors identified were family, followed by friends with Eigenvalues 1 and 0.857, respectively. Another actor in the region, not seen in AP districts, was *Padasekhara samithi*, with an Eigenvalue of 0.785. *Padasekhara Samithi* represented a group of farmers whose paddy lands were geographically positioned as a continuous stretch and could be operated as a single agro-ecological unit. The paddy farmers of each *padashekaram* were grouped into *Padasekhara samithies*, with formal structure and roles. These *samithies* served as farmer interest groups and played a significant role in the emotional support of farmers, especially in times of natural hazard loss. The network also showed the presence of Krishibhavan and MLA of the region with Eigenvalues 0.214 and 0.071, respectively. Though the Eigenvalue of these actors in the network was found to be low, their presence was significant for the bridging role played by them that brought assistance and relief from many external agencies. Though only very few farmers sought direct support from the MLA, the actor could play a role in the whole network, as all of the farmers were linked to each other.

The emotional network map of paddy farmers of the Thrissur district in Kerala is presented in Fig. 4.18. It could be observed from the map that the principal actors of the region were similar to that of the Palakkad district except for the presence of a new actor, i.e., the Panchayat President. Similar to the centrality measures of the Palakkad, the Eigenvalue of family was high (1), followed by friends (0.8), *padasekharam samithi* (0.667), and Krishibhavan (0.333). MLA and Panchayat President were equal in terms of their influence with Eigen centrality value of 0.067 each.

Overall, there were apparent differences in the emotional support network maps of AP and Kerala. In the case of the districts of AP, the important actors were family, friends, and RBK. In Kerala, along with family, friends and Krishibhavan, there were other actors such as *padasekhara samithi*, MLA, and panchayat president. Thus it could be concluded that the social capital, comprised of actors involved in bonding, bridging and linking capital, was higher in the districts of Kerala than in AP. Extension strategies to mobilise the paddy farmers of AP into farmer interest groups under RBK will be beneficial in improving the social capital.

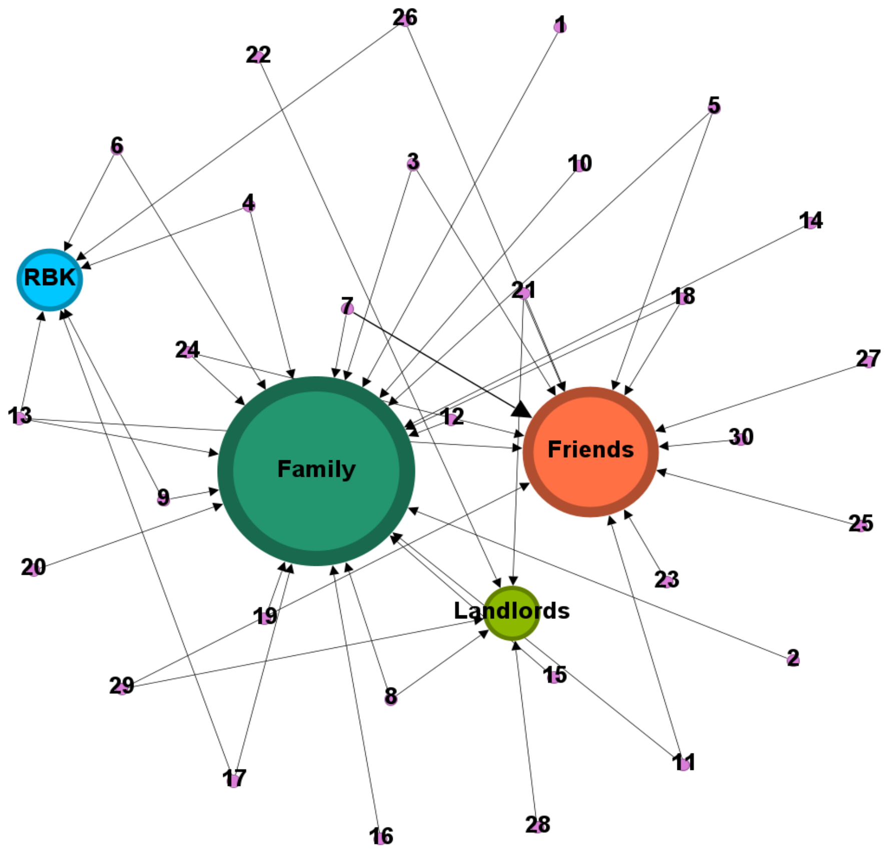



**Fig. 4.15. Support network map of East Godavari paddy farmers in AP**

**Table. 4.30. Landscape of major actors and their matrices - East Godavari support network**

| Major actor | Indegree | Eigencentrality |
|---|---|---|
| Family | 21 | 1 |
| Friends | 14 | 0.666667 |
| RBK | 6 | 0.285714 |
| Landlords | 5 | 0.238095 |


**Fig. 4. 16. Support network map of Kurnool paddy farmers in AP**

**Table. 4.31. Landscape of major actors and their matrices - Kurnool support network**

| Major actor | Indegree | Eigencentrality |
|---|---|---|
| Family | 23 | 1 |
| Friends | 14 | 0.608696 |
| RBK | 7 | 0.304348 |

Table. 4.32. Landscape of major actors and their matrices - Palakkad support network

| Major actor | Indegree | Eigencentrality |
|---|---|---|
| Family | 14 | 1 |
| Friends | 12 | 0.857143 |
| Padasekharam members | 11 | 0.785714 |
| Krishi bhavan | 3 | 0.214286 |
| MLA | 1 | 0.071429 |

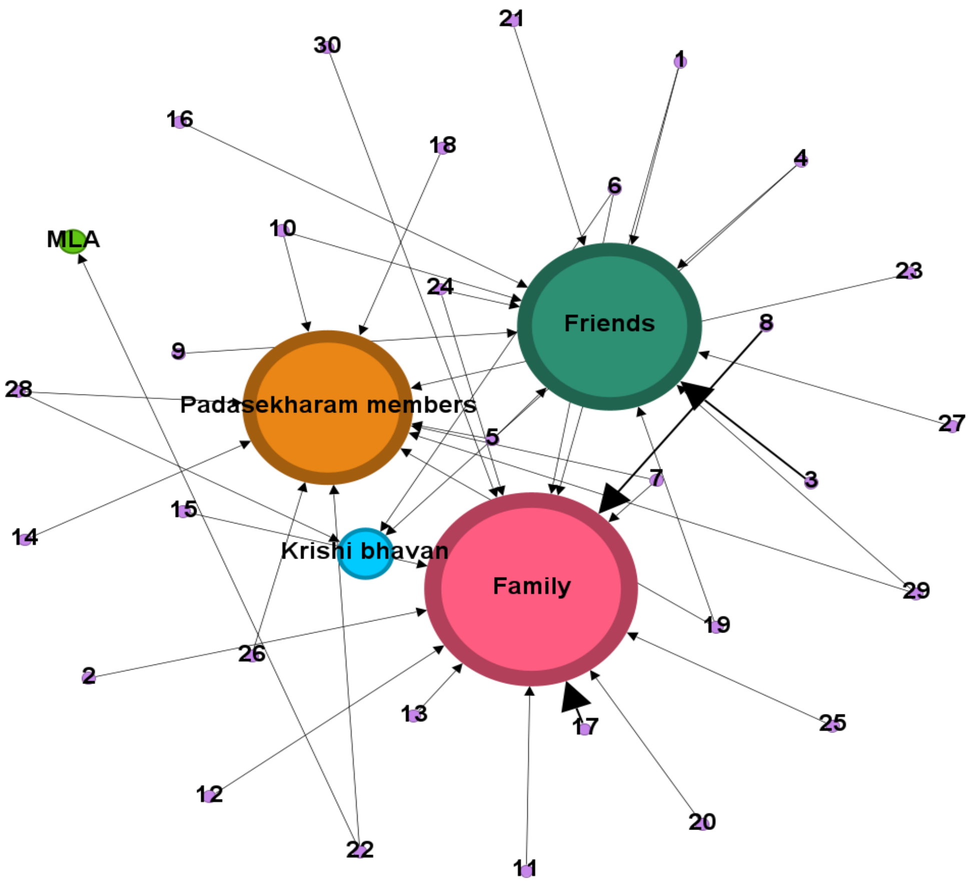



Fig. 4.17. Support network map of Palakkad paddy farmers in Kerala

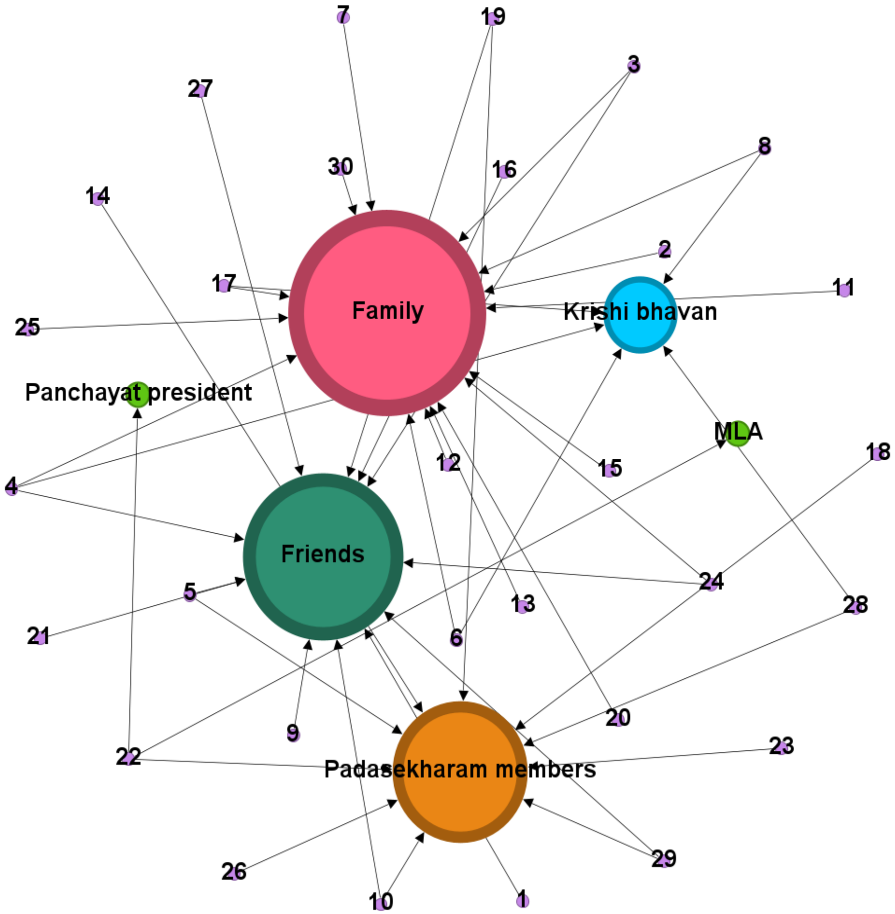



**Fig. 4.18. Support network map of Thrissur paddy farmers in Kerala**

**Table. 4.33. Landscape of major actors and their matrices - Thrissur support network**

| Major actor | Indegree | Eigencentrality |
|---|---|---|
| Family | 15 | 1 |
| Friends | 12 | 0.8 |
| Padasekharam members | 10 | 0.667 |
| Krishi bhavan | 5 | 0.333 |

### 4.4.4. Social capital of paddy farming communities in AP and Kerala

Social capital was measured using the Aldrich (2012) framework wherein the authority values of actors that were involved in the bonding, bridging and linking capital were used. Social capital is considered critical to the resilience of farmers, as cited in the works of Moody and Paxton (2009) and Adger (2010). Categorisation of the actors into bonding, bridging and linking capital was done based on the works done by Aldrich (2012) and Cofre-Bravo (2019).

**Table.4.34. Distribution of the selected districts of AP and Kerala on social capital**

| State | Districts | Social capital |
|---|---|---|
| AP | Kurnool | 4.48 |
| | East Godavari | 4.26 |
| Kerala | Palakkad | 5.05 |
| | Thrissur | 4.90 |

Table 4.34 showed the social capital calculated for the selected four districts based on the roles of actors involved in information and emotional support networks. It could be observed that Palakkad had the highest social capital value among the four districts, with a total authority value of 5.05. Thrissur followed Palakkad with 4.90 and Kurnool and East Godavari districts of AP with social capital scores of 4.48 and 4.26 in that order. The social capital scores represented the strength of the bonding, bridging and linking capitals of the networks. It could be observed that both the districts in Kerala had higher social capital scores compared to the districts of AP. As seen earlier in the results of the network maps, the presence of institutional actors which served as the linking capital was higher in Kerala districts than those of AP. Further, the number of opinion leaders in the networks of Kerala regions who constituted the bonding capital was also high. This explained the higher social capital value of the districts of Kerala compared to AP. Higher social capital in the selected districts of Kerala could generate a collective response of the community during times of natural hazards. This improved the community's resilience while maintaining the structure of the system (Ruiu *et al*., 2017).

### 4.4.5. Resource networks of paddy farmers of AP and Kerala

Along with information networks and emotional support networks of paddy farmers that were used to calculate the social capital, resource networks of paddy farmers were also mapped to analyse the differences in the regions further.

A summary of all major actors in each of the resource networks of paddy farmers in the four districts of AP and Kerala are presented in Table 4.35. It could be observed that commercial banks are the common source of financial resources for farmers in all the districts, with cooperative banks also playing an almost equal role in the Palakkad region. In the seed network, in the case of A.P. districts, private dealers and neighbouring farmers in the regions were the major actors in Kurnool and East Godavari, respectively. While in districts of Kerala, Krishibhavan was the major actor. In networks of other inputs, private dealers were the main actors in the districts of A.P.. At the same time, FPOs and cooperatives played the major roles in the Palakkad and Thrissur districts, respectively.

**Table 4.35. Major actors in the resource networks of paddy farmers in AP and Kerala**

| **State** | **District** | **Financial resources*** | **Seeds*** | **Other inputs*** |
|---|---|---|---|---|
| **AP** | **Kurnool** | Commercial banks (1) | Private dealers (0.57) | Private dealers (0.75) |
| | **East Godavari** | Commercial banks (0.57) | Neighbouring farmers (0.52) | Private dealers (1), Cooperatives (1) |
| **Kerala** | **Palakkad** | Commercial (0.96) and co-operative banks (0.96) | Krishi Bhavan (0.87) | Farmer Producer Organisation (FPO) (1) |
| | **Thrissur** | Commerical banks (1) | Krishi Bhavan (0.67) | Cooperatives (0.95) |

*Eigen centrality values ()

The major actors of the resource networks of Kurnool paddy farmers in AP are given in Table. 4.35. The results showed that Commercial banks were the major actors in providing farmers with financial resources in both the states. Regarding seeds and other inputs, private dealers were the major actors with significant eigen centrality values of 0.57 and 0.75, respectively. Even though there was the presence of primary agricultural cooperative banks (PACS) in the area, the majority of the farmers were not utilising it to obtain their resources, both financial and inputs. This could be observed from the low eigen centrality value of PACS (0.21). The main reason for the poor dependence was the inefficient functioning of the PACS in the region. Even in the case of the seeds and other inputs, farmers of AP preferred to source it from private dealers despite the high prices as institutionalized agencies such as RBK had limited role in the distribution of seeds and inputs, unlike Kerala's Krishibhavans. In Kerala, Krishibhavans served as the major source of seeds for paddy farmers and for other inputs, FPOs and PACS were depended upon by the farmers. The results implied that there was lot of scope to upscale the institutional actors such as RBK and PACS, with the motive of providing better services to farmers and making them function efficiently. RBK should take up the role of providing quality seeds as done by Krishibhavans of Kerala along with necessary inputs based on regional preferences so that dependence on private dealers could be reduced.

It was evident from Table 4.35. and Fig. 4.20. and 4.19. that East Godavari and Kurnool districts of AP, had the commercial banks as the principal actors in the financial network, followed by landlords and PACS. The presence of landlords in the network of East Godavari district was significant considering the tenant status of paddy farmers in the district, as most of them were landless farmers. Moreover, majority of the farmers in the region sourced their seeds from other farmers in the village. In the case of other inputs, both private dealers and PACS play an essential role in the network.

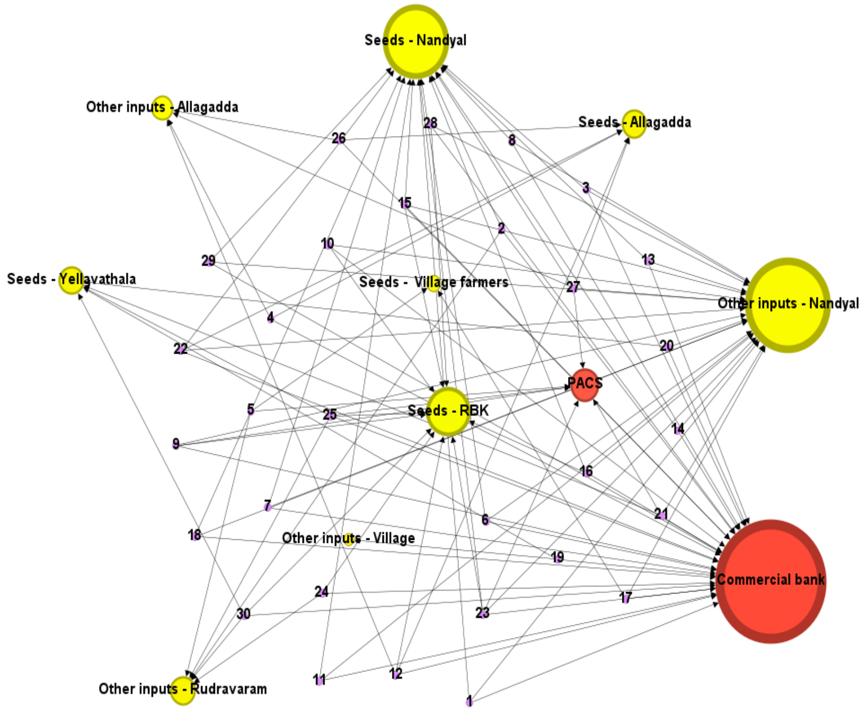



**Fig. 4.19. Resource network map of Kurnool paddy farmers, AP**

**Table 4.36. Landscape of major actors and matrices - Kurnool resource network**

| **Major actors** | **Eigen centrality** |
|---|---|
| Commercial bank | 1 |
| Other inputs – Nandyal (private dealers) | 0.75 |
| Seeds – Nandyal (private dealers) | 0.57 |
| Seeds - RBK | 0.36 |
| PACS | 0.21 |
| Other inputs - Rudravaram | 0.18 |
| Seeds – Allagadda (private dealers) | 0.18 |
| Seeds – Yellavathala (private dealers) | 0.18 |
| Other inputs - Allagadda(private dealers) | 0.14 |
| Seeds - Village farmers | 0.07 |
| Other inputs – Village (private dealers) | 0.04 |

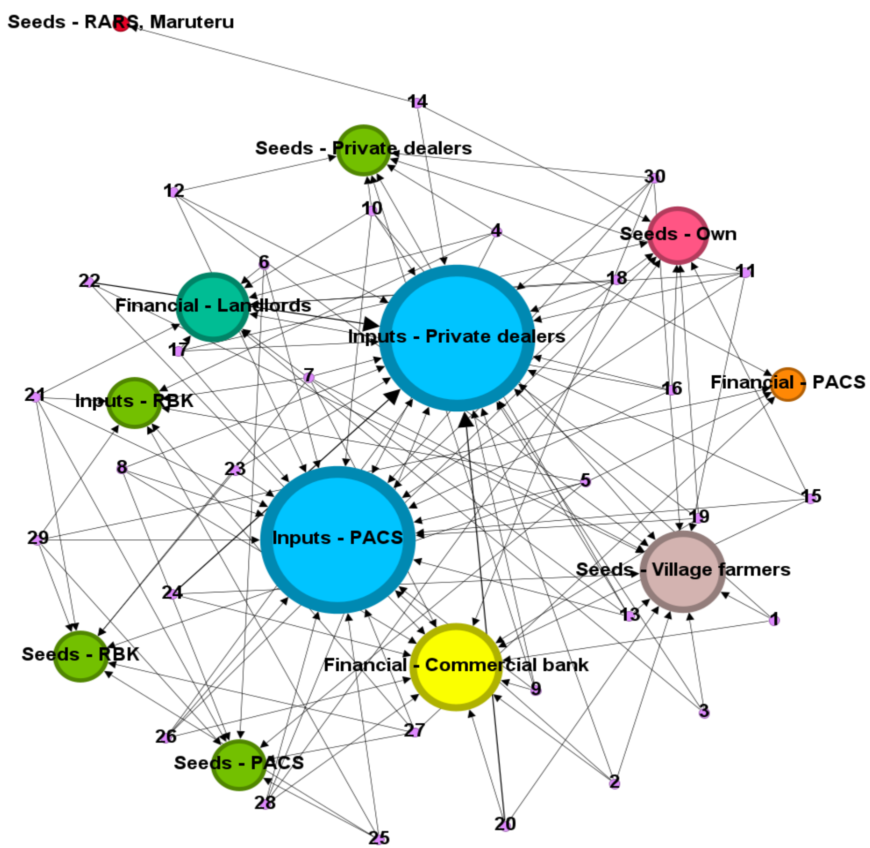



Fig. 4.20. Resource network map of East Godavari paddy farmers, AP

**Table 4.37. Landscape of major actors and matrices - East Godavari resource network**

| Major actors | Eigen centrality |
|---|---|
| Inputs - Private dealers | 1 |
| Inputs - PACS | 1 |
| Financial - Commercial bank | 0.57 |
| Seeds - Village farmers | 0.52 |
| Financial - Landlords | 0.43 |
| Seeds - Own | 0.35 |
| Seeds - Private dealers | 0.3 |
| Inputs - RBK | 0.3 |
| Seeds - RBK | 0.3 |
| Seeds - PACS | 0.3 |
| Financial - PACS | 0.17 |
| Seeds - RARS, Maruteru | 0.04 |

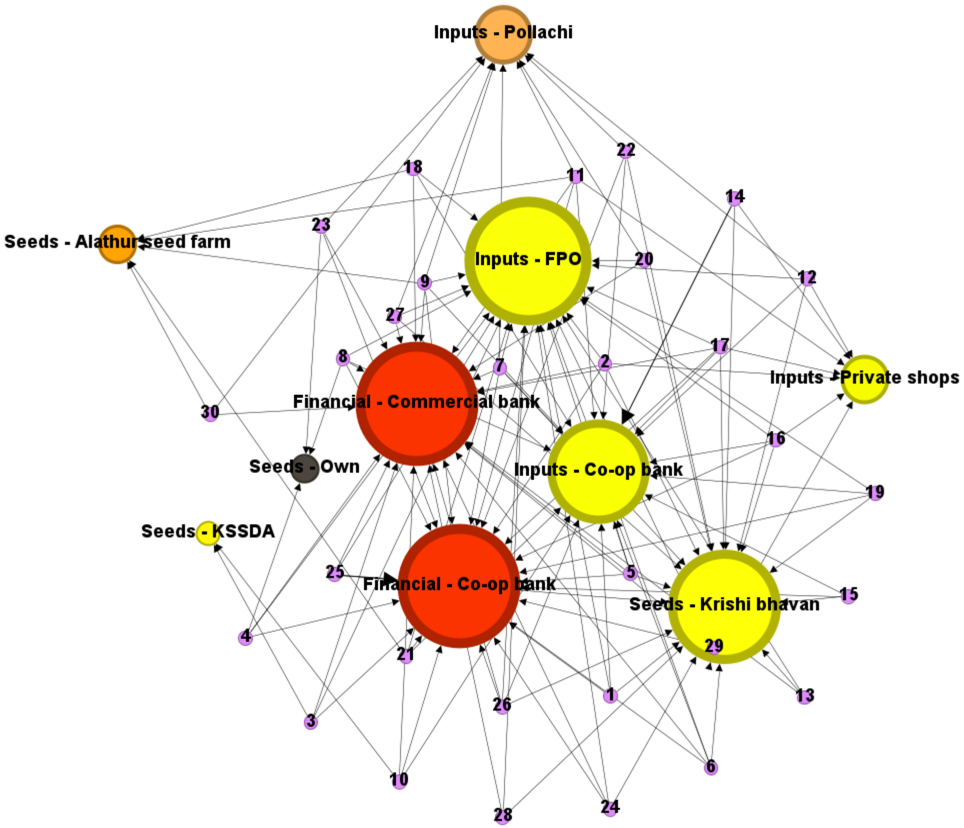



Fig. 4.21. Resource network map of Palakkad paddy farmers, Kerala

**Table 4.38. Landscape of major actors and matrices - Palakkad resource network**

| Major actors | Eigen centrality |
|---|---|
| Inputs - FPO | 1 |
| Financial - Co-op bank | 0.96 |
| Financial - Commercial bank | 0.96 |
| Seeds - Krishi bhavan | 0.87 |
| Inputs - Co-op bank | 0.78 |
| Inputs - Pollachi | 0.39 |
| Inputs - Private shops | 0.3 |
| Seeds - Alathur seed farm | 0.22 |
| Seeds - Own | 0.13 |
| Seeds - KSSDA | 0.09 |

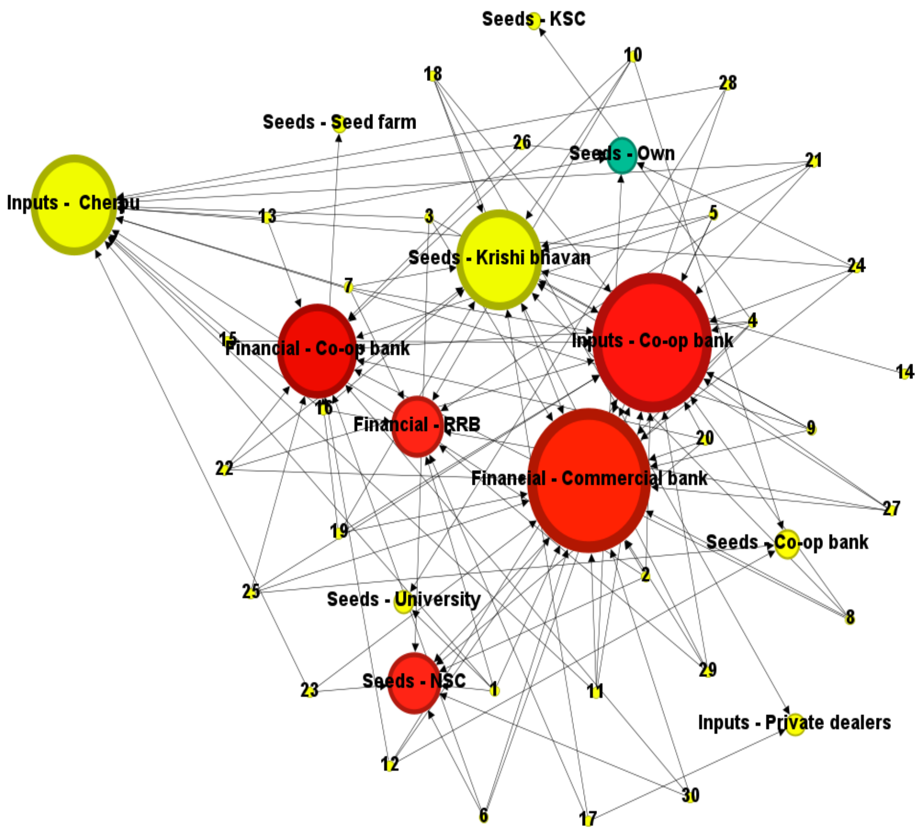



**Fig. 4.22. Resource network map of Thrissur paddy farmers, Kerala**

**Table 4.39. Landscape of major actors and matrices - Thrissur resource network**

| Major actors | Eigen centrality |
|---|---|
| Financial - Commercial bank | 1 |
| Inputs - Co-op bank | 0.95 |
| Inputs - Cherpu | 0.67 |
| Seeds - Krishi bhavan | 0.67 |
| Financial - Co-op bank | 0.62 |
| Seeds - NSC | 0.38 |
| Financial - RRB | 0.38 |
| Seeds - Own | 0.19 |
| Seeds - Co-op bank | 0.14 |
| Seeds - KAU | 0.1 |
| Inputs - Private dealers | 0.1 |
| Seeds - KSC | 0.05 |
| Seeds - Seed farm | 0.05 |

The resource sourcing network maps of paddy farmers in the four districts Kurnool, East Godavari, Thrissur and Palakkad were given in Fig. 19, 20, 21, and 22 respectively. The networks consisted of the actors involved in sourcing financial resources, seeds and other inputs such as fertilizers and pesticides.

In Kurnool region, from Fig. 19, it could be observed that commercial banks were the primary source of paddy farmers' financial resources in the district, which was reflected by the Eigencentrality value of 1. Though PACS was also present in the network, its influence was significantly low in the network, as evident from the Eigenvalue of 0.21. This could be mostly attributed to the poor functioning of the PACS in the region, as mentioned earlier in the socio-economic variables section. In the case of seeds, private dealers in the nearby town were the major actors, followed by RBK and neighbouring farmers. RBK, though played a major role with an Eigenvalue of 0.36 in the seeds sourcing network of the farmers, its role is less compared to private dealers in Nandyal town with an Eigenvalue of 0.57. This was mostly because the RBK's supply of seeds was in limited quantity which normally did not meet the requirements to the farmers. This made the farmers to rely on private sources and purchase seeds from other farmers. Similarly, in other inputs, private dealers in Nandyal town were the major actors with a value of 0.75, followed by private dealers in Rudravaram village. A significant factor that needed to be considered in this context was that in all three networks, major actors were located in nearby towns and villages. This increased the cultivation costs because of the logistic charges the farmer incurred in transporting the resources. Hence, it is imperative to improve the status of actors that were regionally present in the network, such as PACS, RBK and private dealers in the village.

In East Godavari (Fig.4.20), similar to that of Kurnool, commercial banks were the main actors for the financial resources sourcing of farmers with an Eigen centrality value of 0.57. Landlords in the regions were the next major actors with an Eigenvalue of 0.43. PACS were also present in the network but had relatively lower importance than the other two actors. In the case of seeds, the majority of the farmers are sourcing seeds from the neighbouring farmers (0.52) in the village. Other actors involved in the farmers' seed networks were self-owned seeds, private dealers, RBK and PACS, with all the actors relatively of equal importance with Eigenvalue 0.3. Regional Agricultural Research Station, Maruteru, also played a minor role in the network with a value of 0.04. For sourcing other inputs, the majority of the farmers depended on private dealers and PACS in the region. Both the actors had an Eigenvalue of 1 each, showing their equal and high importance in the network. RBK was also an actor in the supply of other inputs with an Eigenvalue of 0.3.

Further, contrary to the Kurnool network, all the major actors in financial, seeds and other input sourcing of the East Godavari farmers were present within the region itself. PACS in the region with its high prominence as an input sourcing actor of the farmers, need to further widen its influence into the financial and seed networks of the farmers. Presence of landlords in the financial sourcing network was another point that needed to be emphasised. As mentioned earlier, most of the farmers in the region were landless, and as they could not provide collateral security, the institutional sources did not provide them loans. It was in this context, landlords extended informal loans to farmers, even though at higher interest rates. The importance of these non-institutional sources in such instances was evident in the network map. Non-institutional sources did not emphasize the provision of collateral as security, and the repayment period would also be flexible (Chandra, 2013). Therefore, even if the interest rates charged by them were high, they played a crucial role in the credit sources of farmers.

Fig. 4.21 showed the resource network map of farmers of the Palakkad region in Kerala. Co-operative banks and commercial banks both were found significant actors in the financial network of farmers of equal importance. The Eigenvalue of both actors was 0.96. In seeds, Krishibhavan played a significant role with an Eigenvalue of 0.87, followed by government seed farm, Alathur (0.22). Own seeds and seeds of Kerala State Seeds Development Authority (KSSDA) also showed significant role. For other inputs, FPO in the region was the major actor with an Eigenvalue of 1, followed by cooperative banks (0.96) and private dealers (0.3) in the Pollachi district of the neighbouring state of Tamil Nadu.

Thus it could be concluded that the institutional sources, which were considered the most reliable option for sourcing credit, served as the major actors in this region. For seeds, farmers also relied on state-run institutional sources with no private dealers in the network. Regarding other inputs, an FPO, namely, Paddy Farmers Producers Company in the region, was the major actor. The FPO was running an input supply shop along with other agriculture-related activities. Most of the farmers in the region were registered members of this FPO and were utilizing the services of the FPO. This model need to be replicated in the districts of AP regions where farmers relied on private dealers from other villages and towns. FPO also shared the benefits to its shareholders, further supporting the region's farmers economically.

The resource network map of paddy farmers of the Thrissur district in Kerala is given in Fig. 4.22. It could be seen that commercial banks, followed by cooperative cooperatives, were the only actors present in the network with Eigenvalues 1 and 0.62, respectively. With respect to seeds, similar to Palakkad, Krishibhavan was the principal actor, followed by National Seed Corporation (NSC), with Eigenvalues of 0.67 and 0.38, respectively. For other inputs, the majority of the farmers purchased from the co-operative banks, followed by private dealers in Cherpu, a nearby town. The results conclusively proved that institutional sources were the principal actors in all three resource networks of financial, seeds and other inputs and the positive influence could be found reflected in the high community resilience scores of the district.

### 4.5. Local adaptation plans to improve the community resilience

Based on the inferences drawn from the results discussed in the foregoing sections, district wise natural hazard adaptation plans were developed and are presented in the following sub heads.

#### 4.5.1. Grey Relation Analysis (GRA) to rank the social networks

GRA was performed on all three social networks delineated viz. information, support and resource networks of the paddy farmers in the four districts of AP and Kerala. The analysis was done to rank the networks in each category using their eigen centrality values. The results are given in the Table 4.40.

**Table 4.40. Ranking of social networks of paddy farmers in AP and Kerala**

| State | District | GRA matrices of social networks | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Information | | | Support | | | Resource | | |
| | | Sum | Grade | Rank | Sum | Grade | Rank | Sum | Grade | Rank |
| AP | Kurnool | 0.585 | 0.146 | 2 | 0.58 | 0.145 | 3 | 0.497 | 0.502 | 1 |
| | East Godavari | 0.48 | 0.12 | 4 | 0.607 | 0.152 | 2 | 0.895 | 0.279 | 4 |
| Kerala | Palakkad | 0.629 | 0.157 | 1 | 0.509 | 0.127 | 4 | 0.602 | 0.414 | 2 |
| | Thrissur | 0.582 | 0.146 | 3 | 0.687 | 0.172 | 1 | 0.641 | 0.389 | 3 |

The results from the table 4.40 indicated the ranking of the three networks based on their eigen centrality values. As mentioned earlier, the centrality value denoted how well connected the network is with potential major actors with a higher degree of influence. These major actors and their connectedness with other actors in the network aided the efficient flow of information, resources and support to the farmers. The results in the table revealed the ranking of the three social networks derived by GRA. The information network of the Palakkad region was considered the best among the others as per the results. Thereby, the type of actors present in the information network of Palakkad should be taken as a model and implemented in all the other regions for efficient transfer of information. As already explained, there was a wide presence of institutional actors in the information network map of Thrissur, along with the presence of a few important farmers that were necessary to efficiently transfer the information into the network (Lambrecht *et al*., 2018; Sumane *et al*., 2018). Similarly, in the case of support networks, the network of Thrissur was considered the best, with a ranking of 1. Support network of Thrissur farmers had important bridging actors such as MLA and the panchayat president. Though the Eigen centrality value did not reflect the influence of these actors, their linking role remained critical and need to be emphasized. The presence of these bridging actors in the network indirectly served the needs of the whole network through the presence of opinion leaders in the networks. Regarding resource networks, the Kurnool network was the best among the networks of all regions. This could be attributed to the presence of multiple actors that would spread the influence among them rather than relying on a few major actors. It helped to spread the brokerage power among different actors thereby enabling farmer-farmer linkages that facilitated the horizontal spread of resources.

#### 4.5.2. Regional adaptation plans based on the CRI

Regional adaptation plans to promote community resilience was devised independently for the selected districts of AP where CRI scores were found to be low. With respect to the districts in Kerala, farmers were well placed on all dimensions of CRI with leading scores for Palakkad district. Timely settlement of procurement prices and insurance claims by the government were the main issues from the state. These could be resolved to further improve the community resilience by streamlining the FPO interventions in the state so that these issues of farmers could be resolved locally. In Thrissur district, mobilising the farmers' into FPOs will enhance their social participation, making them more resilient at the community level. The presence of public institutional agencies at the panchayat level could very well augment the farmer group dynamics to facilitate community resilience in the state.

However, the state of AP required district specific adaptation plans based on the prevalent trend of natural hazard occurrence and intensity. The specific strategies evolved for the districts of Kurnool and East Godavari are included under the following subheads.

##### 4.5.2.1. Adaptation plans for community resilience in Kurnool district, AP

The major strategies recommended for Kurnool district to improve the community resilience against natural hazards were the promotion of dwarf and short-duration rice varieties, timely settlement of insurance claims, awareness campaigns on KCC loans, strengthening of PACS, formation of FPO's, increasing the efficiency of RBKs, and linking of progressive farmers with institutional sources through training.

As the major cause of crop loss in the Kurnool district was heavy rains and floods leading to complete lodging of plants, dwarf varieties that were tolerant to lodging are recommended for cultivation in the area. Also, cultivating short-duration varieties will give the farmers a period to grow fallow crops for additional income. Varieties that were tolerant to Brown Plant Hopper are also recommended, as it was the major pest affecting the paddy farmers in the region.

Early settlement of insurance claims within a stipulated period was essential as the farmers required the amount to cultivate the next crop. Late settlements lead the farmers to avail credit, especially from non-institutional sources, as no formalities were required unlike bank credit that might delay the crop.

Farmers in the Kurnool district were unaware of the KCC loans, though a few were aware; they claimed that banks were not ready to provide them with the KCC loans because of their unacceptable credit history and Cibil score. Financial literacy should be improved among the farmers, to make them aware of the importance of thrift, credit history and schemes available to the farmers.

Strengthening of PACS would be another intervention required in the district. Though there was the presence of PACS in the region, their influence in the resource networks, both inputs and financial, was very low as evident from the eigen centrality values. These PACS should be upscaled with additional funds and rigorous norms to escape the vicious cycle of nepotism and mismanagement. They could play a major role by providing inputs and financial resources to the farmers in the region, as they were located at the village level.

Formation of FPO’s to improve the social participation of farmers will be another important strategy devised for Kurnool district. Agriculture being the primary occupation in the district, with paddy being the major crop, a paddy farmer producer company would be a viable option to improve community resilience. Currently, there was no FPOs in the region. Formation of FPOs is highly recommended as it would improve the group cohesion among the farmers.

Increasing the efficiency of RBKs which have a presence at the village levels would serve as an efficient strategy. It should be further scaled up to provide inputs to the farmers in required amounts. RBK should also increase the rapport with farmers and inform the farmers about the advances in technology and information on schemes on regular basis. Adequate training programs for the farmers at the village level to teach them about climate-resilient practices should be a priority area of extension.

Linking of progressive farmers with institutional sources through training would aid in improving the community resilience. Social capital of the region was found to be low compared to those of districts of Kerala; thereby, few farmers in the region, especially the opinion leaders in the region, should be given adequate training. These opinion leaders should be well-linked with the actors in institutions such as Universities and KVKs so they could bridge and connect other farmers in the region with institutions.

#### 4.5.2.2. Adaptation plans for community resilience in East Godavari, AP

Promotion of short duration varieties, inclusion of landless farmers into government schemes, and information dissemination through SMS were the major strategies devised for the district of East Godavari in AP.

The farmers in the area have an abundant source of water, but because of the longer duration of the varieties that they currently used, farmers could not grow fallow crops such as pulses, which provided additional income. Therefore short, duration and lodging-resistant varieties must be promoted in the region.

Inclusion of landless farmers into government schemes would be another priority in the district to improve community resilience. In place of the CCRC agreement that was mandatory for the landless farmers to avail benefits of public schemes, a more simple mechanism should be implemented in the region. The presence of RBKs could be utilised to streamline the mechanism and check whether the benefits reached the actual cultivator and not the land owner.

Information dissemination through SMS could be another option to ensure the last mile connectivity of farmers. Though the literacy levels in the region were comparatively low, the presence of NDMA in the information network provided scope for further utilising SMS services to keep the farmers informed. Likewise, NDMA SMS messages about weather information in regional languages, information about crop cultivation practices, and new technologies could be designed to reach the farmers as mobile SMS.

Also, other strategies such as organising financial literacy campaigns, linking progressive farmers with institutions through training, forming farmers into FPOs, and improving the efficiency of RBKs are recommended in the Kurnool region to enhance the community resilience among farmers.

# Summary and conclusion

## Chapter 5

## SUMMARY AND CONCLUSION

In the fight against climate change, goal 13 of the Sustainable Development Goals (SDGs) 2030 by the United Nations emphasises the urgent action that is necessary to tackle climate change. Agriculture, which heavily relies on climatic factors such as rainfall, temperature, humidity, etc., is at the back end, with extreme weather events impacting production levels across the globe. In a nation such as India, which hosts a population of around 1.4 billion, sustainable production levels of agriculture to meet the demand of the population are necessary. At the individual level, extreme weather events threaten the livelihood of farmers as a result of crop losses faced by them. Hence, it is imperative at both individual and national levels to develop the resilience of the food systems, which is the ability to withstand stress and bounce back while retaining existing structures and functions.

Rice, which is grown in around 40 million hectares in India, is also the principal source of calories for the Indian population. India, which has production levels more than required to meet the domestic demand, has a share of around 40 per cent in the global rice export markets. But with extreme weather events leading to crop losses and reducing production levels, India’s role in maintaining global food security is also threatened. Under this context, the current study entitled “Community resilience against natural hazards in rice farming systems: A social network analysis” was undertaken.

Districts East Godavari and Kurnool of Andhra Pradesh (AP) and Palakkad and Thrissur of Kerala were selected for the study based on their vulnerability to natural hazards and area under rice production in the districts. Proportionately, two villages from each district of AP and one village from each district of Kerala were selected. Random sampling was used for selecting 30 paddy farmers per each village studied. Thus, making a total sample size of 180 farmers. Additionally, ten facilitators per district were studied to gather the study relevant information.

A pretested schedule was used for gathering the data from the respondents. Secondary data was also collected wherever necessary. Relevant statistical tools were used in data analysis to arrive at the interpretations of data.

### 5.1. Trend of natural hazards in rice farming systems

Analysis of area under crop losses due to natural hazards from 2019 to 2023 has revealed no trend, while the existence of spatial and temporal variation was evident. East Godavari suffered the highest area under crop loss of 64,823 ha during the year 2022-23, while Kurnool suffered the highest loss of 23,240 ha during the years 2020-21. In the case of Kerala, Palakkad suffered the highest loss of 4341 ha during 2019-20, and Thrissur had a crop loss of 4598 ha during 2021-22.

While heavy rains and floods were the only natural hazards during 2019-2023 in districts of AP, those of Kerala had instances of droughts and pests and diseases leading to crop losses. In Palakkad, the majority of the crop losses were caused by heavy rains and floods, contributing to more than 80 per cent of the total loss for the years 2019, 2020 and 2022. Instances of droughts were seen during all the years, while their contribution to total loss is relatively less. Similarly, in Thrissur, heavy rains and floods were contributing to more than 65 per cent of the total crop losses, followed by pests and diseases and droughts.

A combined value loss of 979 crore has occurred in East Godavari due to crop losses in Paddy due to natural hazards, followed by 317 crore in Kurnool, 66 crore in Palakkad and 64 crore in Thrissur.

In total average production losses due to natural hazards during the period 2019-2023, Palakkad had the highest average production loss of 8.9 per cent to the total production, followed by 7.2 per cent in Kurnool, East Godavari with 5.9 per cent and Thrissur with 2.7 per cent.

### 5.2. Socio-economic profile of the paddy farmers

Concerning the annual income of the farmers, the majority of the farmers in the study (61.11%) had an annual income of less than 1 lakh, followed by 27.22 per cent having an annual income between 1 to 2 lakhs, 6.11 per cent with income between 2 to 3 lakhs, 3.33 per cent between 3 to 4 lakhs and only 2.22 per cent with more than four lakhs. At the district level, the majority of the farmers both in East Godavari (88.33%) and Kurnool (66.67%) had an income of less than 1 lakh, while the majority in Palakkad (36.67%) and Thrissur (50%) had an annual income between 1 to 2 lakhs.

More than 60 per cent of the total farmers in the study had received crop loss compensation, while the rest did not. At the district level, the majority of the farmers (66.67%) in East Godavari did not receive crop loss compensation, while the majority of the farmers in Kurnool (56.67%), Palakkad (90%) and Thrissur (93.33%) had received.

Regarding the sources of credit of the paddy farmers, the majority of the farmers (42.22%) were sourcing credit only from formal sources, followed by 37.22 per cent sourcing from both formal and informal sources and 20.56 per cent sourcing only from informal sources. At the district level, in East Godavari, informal sourcing of credit is the prevailing feature, with more than 55 per cent of the farmers sourcing from informal sources, while in Kurnool, the majority (65%) were sourcing from both formal and informal sources. In the case of Kerala, the majority of the farmers in both Palakkad (93.33%) and Thrissur (63.33%) were sourcing their credit only from formal sources.

The majority of the farmers in East Godavari (93.33%) and Kurnool (100%) did not have Kisan Credit Cards (KCC), while in Palakkad (90%) and Thrissur (80%) had KCC and availed loans using it.

With respect to crop insurance, the majority of the farmers (72.22%) of the total farmers had adopted crop insurance.

Landless farmers constitute 55 per cent of the total farmers in East Godavari, explaining the prevalence of lease land farming in the region. In the case of other districts, most of the farmers in Kurnool (38.33%) were small farmers, 30 per cent of the farmers in Palakkad, and 33.33 per cent of farmers in Thrissur were semi-medium farmers.

Cultivation of paddy on partly owned and partly leased in land was the major type of farming (41.67%), followed by cultivation on wholly-owned land (37.78%) and 20.56 per cent cultivating on fully leased in land.

Majority of the farmers in the study (30.53%) had an education between 8th and 10th standard. At the district level, 53.33 per cent of the farmers in the East Godavari region were illiterate, while the majority of the farmers in Kurnool (28.33%), Palakkad (66.67%) and Thrissur (43.33%) had education between 8th and 10th standard.

Regarding involvement in community action, more than 76 per cent of the farmers in the study were never involved in community action, while only 24 per cent of them had participated in community action.

Majority of the farmers in the study (46.67%) had low knowledge with respect to climate-resilient varieties, followed by 36.11 per cent having medium and 17.22 per cent having a high level of knowledge.

Farm paved roads were the primary kind of road available near the farms of farmers to the majority in the study (66.67%), followed by 20.56 per cent having pucca roads and 12.78 per cent of the farmers having no access to roads near their farms.

Majority of the farmers in the study, 78.33 per cent, had access to daily weather info, followed by 19.44 per cent not having access.

With respect to training exposure, the majority of the farmers in East Godavari (86.67%) had a low level of training exposure. In comparison, the majority (40%) in Kurnool district and Palakkad (56.67%) had a high level of exposure, and 60 per cent of the farmers in Thrissur had a medium level of training exposure.

### 5.3. Community resilience of paddy farming systems

The Paddy farming community in Palakkad district had the highest Community Resilience Index (CRI) score of 0.74, followed by Thrissur (0.64), Kurnool (0.48) and East Godavari (0.33). Overall, the districts of Kerala had higher resilience levels than those of AP districts.

Paddy farming communities of AP districts were lacking in both economic dimension and social dimensions when compared to those of Kerala districts. With the differences in the CRI scores among the districts found to be statistically significant at 0.05 level of significance, policy interventions in the indicators of the economic and social dimension of AP districts are recommended for improving the resilience of the communities.

Also, landless farmers had very low levels of resilience, which is also statistically significant at 0.05 level of significance. These results call for urgent policy interventions targeting landless farmers to lift their resilience levels.

**5.4. Social network analysis of paddy farming systems**

The information network of Palakkad had the highest betweenness centrality value (2.069), average in-degree centrality value (1.845) and lowest modularity value (0.511), which are positively associated with aspects of resilience in information networks.

East Godavari had the highest value (0.654) in closeness centrality, which can be triggered to improve their resilience in information networks as actors were located close to each other in the network compared to those of other networks.

In the information network of East Godavari paddy farmers, input dealers were the major actors, followed by the National Disaster Management Authority (NDMA) Rythu Bharosa Khendra (RBK). In the network of Kurnool, similarly, input dealers were the major actors, followed by RBK and opinion leaders in the region. In the information network of both Palakkad and Thrissur, Krishi Bhavan was the principal actor, followed by Kerala Agricultural Univerisity (KAU), Krishi Vigyan Khendra (KVK), and input dealers.

In the emotional support networks of all four districts, family is the primary actor, followed by friends. Following family and friends, RBK and landlords are the other actors in the network of East Godavari farmers, while only RBK was the other major actor in the network of Kurnool farmers. In the case of Palakkad, padasekharam members and Krishi Bhavan were the major actors after family and friends. Similarly, in Thrissur, padasekharam members, Krishi Bhavan, panchayat president and MLA followed family and friends.

The social capital of the Palakkad paddy farming community was the highest (5.05), followed by Thrissur (4.90), Kurnool (4.48) and East Godavari (4.26).

In the resource network, commercial banks were the major actors in sourcing financial resources for East Godavari farmers, neighbouring farmers in the village were major actors in sourcing seeds, and private dealers and cooperatives were major actors in sourcing other inputs. In Kurnool, again, commercial banks were major actors in financial resources, private dealers for both seeds and other inputs. In Palakkad, commercial and cooperative banks were major actors in financial resources, Krishi Bhavan for seeds and farmer producer organisation for sourcing other inputs. In Thrissur, commercial banks were the major actors in financial resources, Krishi Bhavan for seeds and cooperatives for sourcing other inputs.

**5.4. Grey Relation Analysis (GRA) of social networks**

GRA of social networks was used for ranking the social networks. In the case of the information network, the network of Palakkad had rank 1, indicating the network as the best among all the other networks. Likewise, in support networks, the network of Thrissur had rank one, and in resource networks, the network of Kurnool had rank 1.

Palakkad information network had a wider presence of institutional actors compared to other region networks; thereby, the type of actors and connections present in the Palakkad network should be implemented in all the other regions' information networks for efficient transfer of information.

Concerning the support network, the Thrissur network had multiple bridging actors, such as the panchayat president and MLA, which was observed to be lacking in the networks of other regions. In the case of the resources network, the Kurnool network was the best among all the networks; this is due to the presence of multiple actors. Thereby, reliance on various actors for sourcing resources was seen instead of relying on a few significant actors.

## 5.5. Policy interventions

For the districts of Kerala, timely settlement of procurement prices and insurance claim settlement must be resolved to improve the resilience of the farmers further. In the Thrissur region, farmers' organisation into FPOs must be taken up to enhance their social participation.

**Policy interventions for the East Godavari region**

- Promotion of dwarf and short-duration paddy varieties
- Inclusion of landless farmers into government schemes such as crop insurance and crop loss compensation
- Information dissemination through SMS in regional languages to farmers
- Organisation of financial literacy campaigns
- Grouping of farmers into FPOs
- Improving the efficiency of government institutions such as RBKs in the region

**Policy interventions for the Kurnool region**

- Promotion of dwarf and short-duration paddy varieties
- Timely settlement of insurance claims
- Organisation of financial literacy campaigns
- Strengthening of PACS in the region
- Formation of FPOs
- Linking of progressive farmers in the area with institutional sources by organising training

## 5.6. Conclusion

From this study, it is concluded that the paddy farmers of Kerala districts had higher resilience against natural hazards compared to AP districts. Within AP, the East Godavari region had the lowest resilience. With East Godavari playing a massive role in rice production in AP, the current study reveals a saddening situation for the farmers in the region. East Godavari also had the lowest social capital among all the other regions. Therefore, the government needs to intervene and improve the resilience of farmers. Otherwise, the paddy farmers may leave agriculture in pursuit of different occupations. As farmers of Kerala were placed high on most of the indicators contributing to resilience, the intervention models followed in the districts of Kerala can be further studied in detail. The same can be implemented in the regions of AP to improve their resilience.

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# *Plates*

**Plate 1. Survey of farmers in AP districts**

**Plate 2. Survey of farmers in Kerala districts**

# Appendices

**APPENDIX - I**
**Interview schedule**

**“Community resilience against natural hazards in rice farming systems: A social network analysis”**

State: District: Block:

Farmer ID:

**A. General information**

**1. Name of the respondent:**

**2. Address:**

**3. Phone number:**

**4. Age:**

**5. Sex: Male Female Transgender**

**6. Type of rice farming practiced, variety grown_____________**

| **Type** | **Tick** |
|---|---|
| Wet land flooded cultivation | |
| Upland dry rice cultivation | |
| Wet land intermittent irrigated cultivation | |
| Others specify | |

**7. Area under subsistence farming _________ in acres**

**8. Area under fallow land __________ in acres**

**9. Details of extreme events that occurred in the last 5 years**

| **Event** | **2018** | **2019** | **2020** | **2021** | **2022** |
|---|---|---|---|---|---|
| Drought | | | | | |
| Flood | | | | | |
| Erratic and unseasonal rains | | | | | |
| Severe pest and disease attack | | | | | |
| Others (Specify) | | | | | |

**B. Community resilience**

**1. Economic dimensions**

**1.1. Details of occurrence of recent natural hazard**

Year and season ________ Type_________

| **Income loss** | **Tick** |
|---|---|
| Nothing or very less (<10%) | |
| Some of it (10-30%) | |
| About half | |
| Most of the income (>60%) | |

**1.2. Diversity of income**

| **Income source** | **Tick** |
|---|---|
| Crop production | |
| Livestock farming | |
| Leasing out of land | |
| Labour wages | |
| Non-farm business | |
| Machinery rental leasing | |
| Employment | |
| Others (Specify) | |

**1.3. Net annual income**

< 1 lakh 1-2 lakh 2-3 lakh 3-4 lakh >4 lakh

**1.4. Access to credit facilities for farming activities:** Yes No If yes,

| **Source of credit** | **Tick** | **Amount received (Fully Sufficient/Adequate/Inadequate)** | **Loan status** |
|---|---|---|---|
| Commercial banks | | | |
| Regional rural banks | | | |

| | | | |
|---|---|---|---|
| Cooperative banks | | | |
| Friends and relatives | | | |
| Money lenders | | | |
| Others (specify) | | | |

**1.5. Do you have a Kisan credit card:** Yes No

**1.6. Resourcefulness to meet natural hazard contingencies:**

| **Details of savings** | **Tick** |
|---|---|
| Bank deposits | |
| Gold | |
| Cash | |
| Others (Specify) | |

**1.7. Did you insure your crop:** Yes No If yes, always/sometimes

**1.8. Compensation received for crop loss because of natural hazards**

Fully received Partly received Not at all received

**1.9. Availability of subsidies**

| **Purpose of subsidy** | **Tick** |
|---|---|
| Purchase of resistant varieties | |
| Reclamation of natural hazard affected lands | |
| Field drainage infrastructure | |
| Others (Specify) | |

**1.10. Marketing of rice produced**

| **Market** | **Tick** |
|---|---|
| Government procurement | |
| Private markets | |
| Community level aggregated marketing | |
| Contract farming | |
| Others (specify) | |

**2. Social dimensions**

**2.1. Availability of household members to farm labour? ______ in numbers**

**2.2. Do you trust that your community members will help you in times of need?**

Never Sometimes Always

**2.3. In the last 5 years, was there any event that affected your community and required collective action?** Yes No If yes, specify the events:

**2.3.a. Did you join others in addressing the problem?** Yes No

**2.4. Participation in organizations (Non-member 0, Member 1, Office bearer 2)**

| **Sl. No.** | **Name of the organization** | **Office bearer** | **No. of years of association** |
|---|---|---|---|
| 1 | Farmer producer organization | | |
| 2 | Co-operative societies | | |
| 3 | NGO | | |
| Others (Specify) | | | |
| 5 | SHG | | |
| 6 | | | |
| 7 | | | |

### 2.5. Educational qualification

| **Education** | **Member 1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| Primary school (Up to 7th standard) | | | | | |
| High school (8th to 10th standard) | | | | | |
| Higher secondary (11th and 12th standard) | | | | | |
| College and above (Graduate) | | | | | |

### 2.6. Perceived changes in weather and crop parameters

| **Weather and crop parameters** | **Increased** | **Decreased** | **No change** |
|---|---|---|---|
| Unseasonal rains | | | |
| Drought events | | | |
| Temperature | | | |
| Rainfall | | | |
| Pest and diseases | | | |
| Yield | | | |
| Soil quality | | | |

### 2.7. Participation in climate resilience technology and management trainings:

Yes No

If yes,

| **Theme** | **Agency** |
|---|---|
| | |
| | |
| | |

**2.8. Farming experience**

| **Years of experience** | **Tick** |
|---|---|
| < 5 years | |
| 5 – 10 years | |
| > 10 years | |

**2.9. During the natural hazard events that affected your crop production in the last 5 years, how many days did it take for the household to recover?**

< 1 month 1-3 months 3-6 months >6 months Could not recover

**3. Technical dimension**

**3.1. Knowledge on seed varieties**

| **Seed varieties** | **Name of the variety** | **Status of adoption (planning to adopt/currently under adoption/discontinued/did not try as the seeds were not available)** |
|---|---|---|
| Flood resistant/tolerant varieties | | |
| Drought resistant/tolerant varieties | | |
| Early and late maturing varieties | | |
| Pest and disease resistant varieties | | |
| Problematic soil tolerant varieties | | |

**3.2. Knowledge on crop diversification**

| Diversification practices | Aware | Aware and adopted |
|---|---|---|
| Intercropping | | |
| Integrated farming system | | |
| Relay cropping | | |

**3.3. Knowledge on adjustment in planting dates:** Yes No

**3.4. Access to daily weather data:** Yes No

**3.5. In the last 12 months, did you have access to information on weather warnings?**

Yes No

**3.6. Major sources of weather information**

| Sources | Tick | Type of info |
|---|---|---|
| News papers | | |
| T.V. news | | |
| Radio news | | |
| Extension workers | | |
| Farmer friends | | |
| Weather apps | | |
| SMS alerts | | |
| Others (specify) | | |

**3.7. Was the information received correct and helpful in predicting and handling the events?**

Fully Somewhat Not at all

**3.8. Knowledge about websites and applications for weather data**

Yes No

If yes,

| Name of the website | Frequency of use<br>(Regular/Occasional/Seldom) |
|---|---|
| | |
| | |
| | |

## 4. Physical dimension

### 4.1. Farm size

| Farmer category | Tick |
|---|---|
| Marginal farmer (< 1 ha) | |
| Small farmer (1-2 ha) | |
| Semi-medium farmer (2-4 ha) | |
| Medium farmer (4-10 ha) | |
| Large farmer (>10 ha) | |

### 4.2. Operational land holding in the last 3 years

| Operational land holding | Tick |
|---|---|
| Fully owned land | |
| Partly owned and party leased in | |
| Fully leased in | |

Type of lease: In cash/ In kind

### 4.3. Type of rice farming

| Type | Tick |
|---|---|
| Subsistence farming | |
| Partly subsistence farming | |
| Fully commercial farming | |

**4.4. Assets available at the household**

| Asset | Tick |
|---|---|
| T.V. | |
| Radio | |
| Mobile without internet | |
| Mobile with internet | |
| Computer with internet | |
| Motor vehicle | |

**4.5. Farm machinery available**

| Type of machinery | Tick |
|---|---|
| Tractor | |
| Soil preparation machinery | |
| Seeding and planting | |
| Plant protection | |
| Harvesting and threshing | |

**4.6. Farm implements**

**4.6. Field drainage availability (Bunds/Canals):** Yes No

**4.7. Access to roads from farm:** Yes No

**4.8. Access to electricity for agricultural purposes:** Yes No

If yes, Free Paid

**4.9. Irrigation sources River Dam reservoir ponds irrigation canals others….**

| Sources | Individual/Community level | Sufficient/Somewhat sufficient/Not at all sufficient |
|---|---|---|
| | | |
| | | |
| | | |

**C. Social Network Analysis**

**1. Information networks (Input supply, Technical, Marketing)**

**1.1 From whom do you get information related to rice production? (List the names of the actors)**

| | |
|---|---|
| | |
| | |
| | |
| | |
| | |

**2. Resource sourcing networks (Financial, Inputs, Machinery)**

**2.1 From whom do you get any resources related to rice production from? (List the names of the actors)**

| | |
|---|---|
| | |
| | |
| | |
| | |
| | |

**3. Emotional support networks (Recovery times, rehabilitation)**

**3.1 From whom do you get assurance, emotional support during difficult times? (List the names of the actors)**

| | |
|---|---|
| | |
| | |
| | |
| | |
| | |

**APPENDIX - II**

Monthly rainfall (in mm) trends for Thrissur from Jan-2019 to Dec-2022

| Year | Normal rainfall | Actual rainfall |
|---|---|---|
| 2019 | 3077.3 | 3303.04 |
| 2020 | 3077.3 | 2520.76 |
| 2021 | 3077.3 | 3261.01 |
| 2022 | 3077.3 | 2633.57 |

Source: IWRIS, 2023

Monthly rainfall (in mm) trends for Palakkad from Jan-2019 to Dec-2022

| Year | Normal rainfall | Actual rainfall |
|---|---|---|
| 2019 | 2142.5 | 2314.2 |
| 2020 | 2142.5 | 1724.68 |
| 2021 | 2142.5 | 2319.28 |
| 2022 | 2142.5 | 2164.5 |

Source: IWRIS, 2023

# COMMUNITY RESILIENCE AGAINST NATURAL HAZARDS IN RICE FARMING SYSTEMS: A SOCIAL NETWORK ANALYSIS

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**ABSTRACT OF THE THESIS**

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# ABSTRACT

With the world falling back in keeping the global temperature rise below the two degrees Celsius limit, compared to the pre-industrial levels, the vagaries of climate change are becoming more prevalent than ever. Agriculture, which depends on climatic factors, such as rainfall, temperature, humidity, etc., will be affected by the erratic play of these factors with higher intensity and frequency of extreme weather events. Hazards of these natural events in the form of heavy rains and floods, droughts, pests and diseases result in crop losses, leading to distress to farmers at the individual level and affecting production at the national level. Hence, it is imperative to make agri-food systems, especially rice systems, resilient, as they form the major source of calories for the Indian population.

In this context, the present study was undertaken to understand the factors that contribute to resilience and assess the level of resilience of paddy farmers in the states of Kerala and Andhra Pradesh (AP). Purposive sampling was used to select East Godavari and Kurnool districts of AP and Palakkad and Thrissur districts of Kerala. The criteria used are the area of production under paddy and exposure of the districts to natural hazards. Proportionate random sampling was used in selecting 60 farmers per district of AP, and 30 farmers per district of Kerala.

Analysis of the natural hazards trend in the districts has revealed no distinct trend in the intensity of natural hazards. But, a presence of spatial and temporal variation across the four districts was evident. It was observed that heavy rains and floods were the hazard that recurred in all the years from 2019 to 2022 in all the regions. While heavy rains and floods were the only natural hazards that affected the districts of AP during the period 2019-2022, in Kerala, instances of droughts and severe pest and disease attacks were also seen. In Palakkad, heavy rains and floods resulted in more than 80 per cent of the total losses for 2019, 2020 and 2022. Though Palakkad is traditionally considered a drought-prone area, the losses due to droughts were very low compared to those of heavy rains and floods. In the case of Thrissur, more than 65 per cent of the losses were contributed by heavy rains and floods, followed by pests, diseases, and droughts. Overall, there was a total average

production loss in paddy of 5.9, 7.2, 8.9, and 2.7 per cent in East Godavari, Kurnool, Palakkad and Thrissur districts, respectively, over the period 2019-2022.

The community resilience of the farmers in the four regions was assessed using Community Resilience Index (CRI), and the results revealed that the Palakkad farming community had the highest resilience with an index score of 0.78, followed by Thrissur with 0.64, Kurnool with 0.48 and East Godavari with the lowest score of 0.33. The results indicated lower levels of resilience among the paddy farming community of AP districts compared to Kerala farming communities. Paddy farmers in AP were found lacking in many indicators affecting resilience, such as annual income, adoption of crop insurance, credit sources, farm size, type of tenancy, education levels, community action, training exposure, etc. The results implied regional-specific interventions and policies to improve the resilience of farming communities of these regions.

Social network analysis of the farmers in the four regions also revealed the same picture concerning resilience. The network measures of districts of Kerala were highly favourable in relation to resilience compared to those of AP districts. The social capital of the Palakkad region was 5.05, the highest among all the four districts, followed by 4.90 for Thrissur, 4.48 for Kurnool and 4.26 for East Godavari farming communities. In the case of information networks, the farmers of Kerala districts were sourcing their information from institutional sources such as Krishi Bhavan, Kerala Agricultural University (KAU) and Krishi Vigyan Kendra (KVK), while farmers in AP were highly relying on input dealers with lower presence of institutional actors. In support networks, the presence of linking actors such as MLA and panchayat president was seen in the network of Kerala farmers, which was lacking in those of AP networks. Also, the presence of bridging actors is relatively scarce in AP networks. These results imply implementing policies that improve social participation among the farmers, leading to enhanced cohesion and social capital among the farming community that contributes to resilience.

Grey Relation Analysis of the social networks indicated the ranking of social networks based on their average eigen-centrality values. The information network of the Palakkad region was considered the best among the networks of other regions. The region's broader presence of institutional actors and contact farmers contributed to the highest rank. In the case of support networks, the network of Thrissur was considered the best among others. This may be attributed to the presence of important bridging actors such as MLA and panchayat president in the network of Thrissur. Finally, in resource networks, the network of Kurnool farmers was the best. This could be attributed to multiple actors that would spread the influence among them rather than relying on a few significant actors. In conclusion, the type of actors and connections in the best networks in the three types of networks should be replicated in all the other regions to improve their resilience.