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Farmers Resilience and Adaptation to Climate Change and Flooding – A Case Study of a Semi-Rural Settlement in Fiji

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Abstract

Climate change and flood hazards have been noted as the causes of a 91% decline in agricultural productivity for both crop and livestock farmers. Based on a survey of 80 smallholder farmers, this study offers important insight into how smallholder agricultural farmers are adapting to the effects of climate change and the variables influencing their decisions in Korociriciri Settlement, Fiji. The assessment indicates that to increase productivity, farmers have prioritized factors in their resilience and adaptation strategies by improving the drainage system, changing their planting techniques, practicing seasonal agriculture, increasing the use of targeted pesticides, and switching to organic farming. The socioeconomic characteristics of farmers, such as their age, education level, agricultural experience, landholding capacity, and access to extension and information services, all have a positive, considerable impact on how much they are conscious of climate change. This study suggests a practical route for policymakers and academics to take in order to establish vital plans and studies to offer farmers a range of facilities that might handle diverse climate threats. It is also recommended that mass media and information technologies be used to promote farmers' knowledge of climate change.

Keywords: Resilience, adaptation, Climate Change, Flooding

Introduction

The Pacific Islands are particularly vulnerable to the effects of climate change on ecosystems and the human communities that rely on them for survival (Nurse & McLean, 2014). According to the Intergovernmental Panel on Climate Change (IPCC, 2012), climate change is caused by natural processes or persistent anthropogenic changes in the composition of the atmosphere or land use. It is also defined by the IPCC as the variation of climate parameters (atmospheric temperature, rainfall, relative humidity, and so on) that can be identified by using statistical tests to change the mean and its properties over a period of nearly 30 years or longer.

Significant increases in rainfall and temperatures are a major climate variable that is introducing significant stress on water resources in small island environments (White & Falkland , 2010) and extreme weather and climate events such as tropical cyclones, flooding, and storm surges have negatively impacted local communities and human health (Nurse & McLean, 2014). In the absence of risk reduction systems, the risks of flooding and climate change are likely to become disastrous and devastating for rural communities (Nhemachena, Beilfuss RD, 2017). These changes are already having an impact on people living in the Pacific Islands region, and scientists predict that they will continue and accelerate in the long run, with further consequences for the ecosystems and their people (Knutson, 2010); (Hare, Cramer , Schaeffer , Battaglini, & Jaeger, 2011).

Within the Pacific Island region, research on global climate change impacts, vulnerability, and adaptation (IVA) has frequently focused on calculating or projecting the magnitudes of climate change for physical and biological systems; however, there has been less effort focused on the consequences for people and their livelihoods, as well as their capacity to adapt to changing conditions. Despite the development of grant opportunities to investigate such outcomes (for example (Sutherland, Smit, Wulf, & Nakalevu , 2005) in Samoa; (Mortreux & Barnett, 2009) in Tuvalu; (Warrick, 2011) in Vanuatu; (McNamara & Prasad, 2014) in Vanuatu and Fiji; (McCubbin, Smit, & Pearce, 2015) in Tuvalu, Our understanding of how to integrate global climate change and human well-being within the Pacific Islands is limited. As a result, we must improve our understanding of how people in the Pacific Island region are affected by and respond to climate change in terms of who and what is vulnerable, to what stresses, and in what way, as well as the capacity to adjust to or adapt to these changes or conditions.

In terms of production, marketing, and finance, the agricultural sector has faced a variety of climatic risks (Velandia, 2009) that have caused significant damage to forestry, livestock, fisheries, animal sheds, agricultural equipment, tube wells, fertilizers, seed stocks, houses, and infrastructure. Flooding is one of the most serious natural disasters caused by climate change, and it has a significant impact on the agricultural sector as well as the water resources to which communities are vulnerable (Singh, 2014). As a result, flooding is more complex than any other natural disaster that affects communities due to its geographic size and range. Therefore, the purpose of this research is to assess farmers' vulnerability to climate change and flooding in the Korociriciri farming settlement in southeast Viti Levu, Fiji, from the perspective of current societal and ecological changes.

The project was modeled by two approaches: the vulnerability approach, where the vulnerability of a system (e.g., communities) to harm a stimulus or stimuli relates to both the sensitivity to exposure and the capacity to adapt (Ford & Smit, 2004); (Smit & Wandel, 2006). The second approach is the resilience methodology, which may be a theory of change and seeks to recognize how difficult systems change, what controls the system's ability to engage the disturbances, and what capacity results from the change (Janssen & M, 2006). In this case, vulnerability and resilience are conceptualized as the purpose of exposure to biophysical changes, their sensitiveness, and the adaptive capacity to affect exposure. How individuals and communities will experience and respond to such exposures is going to be influenced by a variety of social, economic, political, and ecological conditions that are distinctive to a particular place and time (Smit & Wandel, 2006).

Both approaches are contextually specific, with two stages of assessment. The primary phase assesses current vulnerability by documenting how people are exposed to and sensitive to climate variables (temperature, rainfall, etc.) as well as the adaptive strategies used to address these conditions. The second phase evaluates future susceptibility by incorporating future climate change and social opportunities to estimate changes in exposure sensitivities and associated adaptive capacities (Ford & Smit, 2004). It aims to respond to the key questions on factors to increase farmers' resilience and adaptation due to flood risk and climate change and hypothesizes that there is no difference or relationship between climate change and its effect on farmers. The objectives are to (1) determine the climate variability and trends concerning temperature and rainfall for the past 30 years; (2) determine how the changing climate affects farmers; and (3) analyze the factors affecting farmers' resilience and adaptation. Data on each stage of assessment were obtained primarily through questionnaires distributed to community members, as well as through participant observation and secondary data sources (e.g., weather and climate data, global climate change reports, etc.). The Korociriciri settlement was chosen as a case study due to its location in a wet region of Fiji and the author's previous research association with the settlement.

Research Methodology

1.1 Description of the Study Site

Fiji is an archipelago of more than 330 islands that is located near the equator at 17°52'04" south and 178°30'09" east. The South Pacific Convergence Zone (SPCZ), a zone associated with heavy rainfall, moves northeast and southwest of Fiji. It has an oceanic tropical climate with two seasons: one hot, humid, and rainy from December to April and one cooler from June to October.

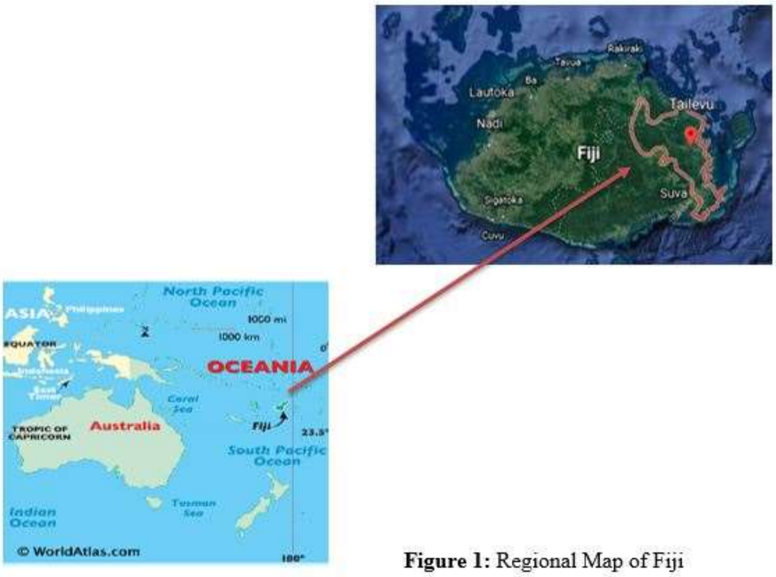


Figure 1: Regional Map of Fiji

Tailevu is one of the 14 provinces of Fiji located on Viti Levu, Fiji's largest island, with an area of 755 square kilometers that occupies the south-eastern peripheral of the island. It had a population of 64,552 people, according to the 2017 census, making it Fiji’s fifth-largest province. Tailevu’ s main urban area is Nausori, which had a population of 30,965 in 2017.

Within Tailevu is the settlement of Korociriciri, located at 18°00'09'' south and 178°33'05'' east at an elevation above sea level of 7 meters. According to the 2017 Fiji Population and Housing Census, the population of Korociriciri settlement is 791 people (FBOS, 2017) and about 5-7km away from Nausori town. Residents practice subsistence agriculture for their livelihoods, and they have been categorized in Table 1.

Table 1: Types of Agricultural Production practiced in Korociriciri Farming Settlement

Crop Production:	**Livestock/ Animal Production**	**Aquaculture/ Fisheries**
Cassava (*Manihot esculenta*),	Poultry (*Gallus gallus domesticus*)	Tilapia fish farming (O*reochromis niloticus)*
Taro (*Colocasia esculenta*)	Goat (*Capra aegagrus hircus)*	Prawn/ Shrimp farming *(Caridea*).
Ginger (*Zingiber officinale*),	Pigs *(Sus)*	
Fruits & Vegetables	Ducks *(Anatidae)*	

1.2 Geology of the Study Site

Fiji's geological history is grounded on the submerged platform of a prehistoric formation of volcanic origin, sedimentary deposits, and the formation of corals. Viti Levu covers approximately 4,000 square miles (10,000 square kilometers) and accounts for a significant portion of Fiji's land area. The soil's parent material in Tailevu province is composed of intermediate igneous rocks with no surface rock outcrops. This means that the soil is highly rich with high subsoil nutrient status. The slope, which is a very important factor in determining the productive potential of the soil as it influences runoff rates and relates directly to the dangers of soil erosion, accounts for an angle of 8 to 11°, which does not impose many dangers and allows the use of farm machinery. Soils' primary textures are 0 to 15 cm of friable silt clay loam, 15 to 90 cm of very clay, and 90 to 140 cm of in-situ coarse angular basalt rubble, and they're highly well-drained without waterlogging or flooding (Pacific Soils portal, 2021).

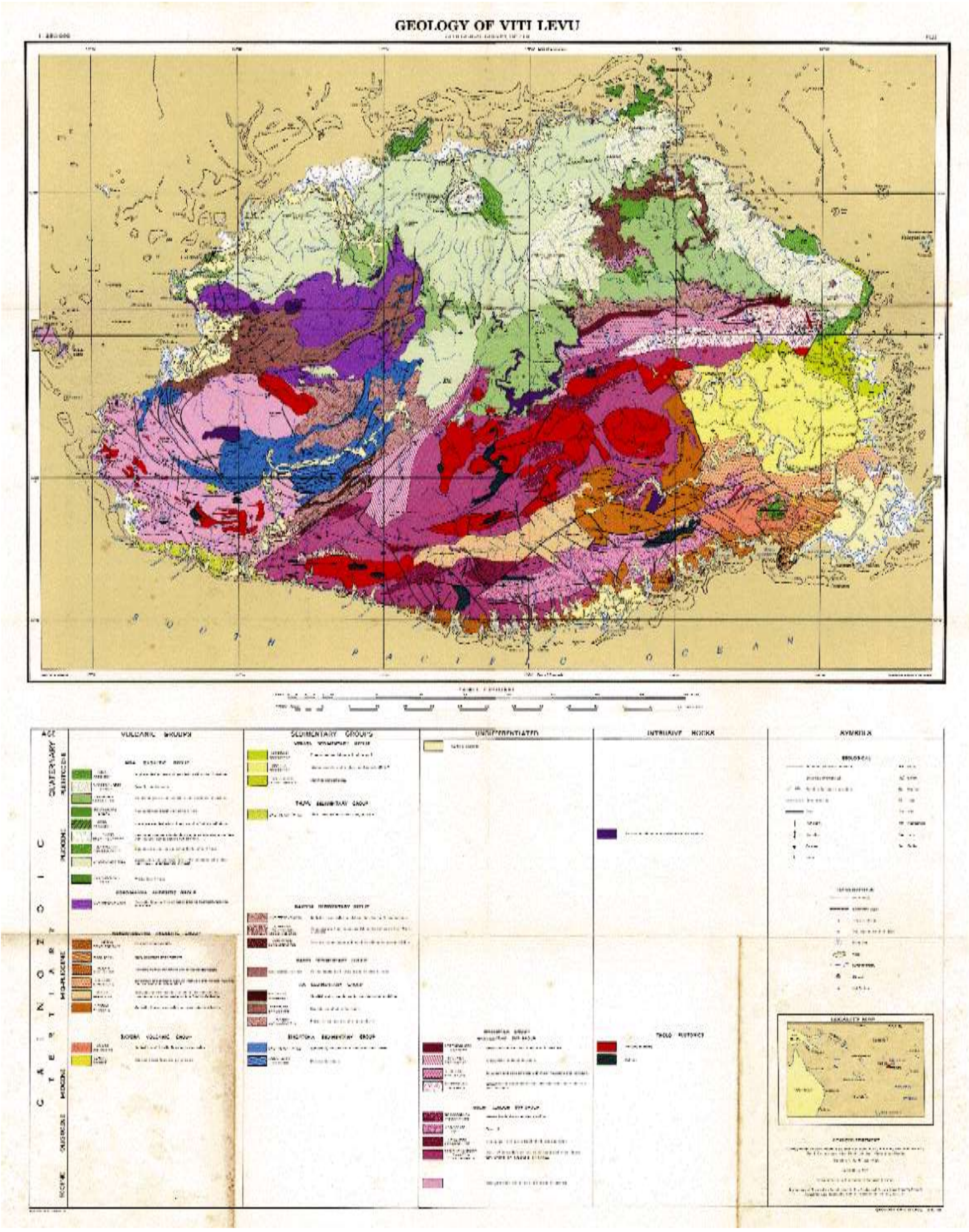
1.3 Method

This study's mixed-methods design was implemented in a sequential explanatory design. This method entails "collecting or analyzing both quantitative and qualitative data in a single study in which the data is collected concurrently or sequentially, is prioritized, and involves data integration at one or more stages in the research process" (Cresswell & John , 2012).

1.4 Meteorological Weather/ Climatic Data

The parameters considered for meteorological weather or climate data are temperature, rainfall, flooding, and tropical cyclone events in Tailevu, Fiji. They were requested through the Director of Fiji Meteorological Services' (FMS) Climate Division at the Nadi headquarters. Thirty years of monthly data analysis from January 1990 to January 2021 were provided by FMS via an Excel template for all the parameters mentioned (FMS, Nausori Airport Weather Data , 1990-2021).

Figure 2: Geology Map of Fiji



Source: Fiji Mineral Resource Department

1.5 Data Collection and Sampling Design

Data from farm households, as well as opportunistic and targeted sampling of male and female elders in the Korociriciri settlement, were collected using the Snowball sampling technique. A questionnaire was distributed to 10% of the 791 targeted population (FBOS, 2017), and approximately 64% responded. It seeks responses on their agricultural land area to provide a brief background on farmers, their products, the potential for diversifying land productivity, their perspectives on climate change, and their efforts to prioritize resilience and adaptation. The study sought people who had lived in the same place for at least 30 years, with the assumption that they would be able to share their experience in previous climates and compare it to the current situation. The other selection criterion was that respondents be at least 30-70 years old, with the assumption being that younger people would not necessarily have access to the range of information that older people would.

1.6 Data Analysis

All the climate data (temperature, rainfall, and flooding) issued by FMS was analyzed using MS Excel. A polynomial fourth-order design chart of temperature and rainfall patterns for the past 30 years was generated to show the trend line and also to display the equation for the future projection (2020–2030). The relationship between temperature and rainfall patterns was graphed using a scatter plot with a smooth line, with standard deviations of 0.46 and 0.43, respectively. In this case, temperature is the primary driver of climate change because it is the determining factor that influences sea-level rise, rainfall patterns, and flood devastation (IPCC, 2012). Tailevu' s flood events were counted and analyzed in a bar graph for monthly occurrences from 1990 to 2020. This was reflected in the Tropical Cyclone Report for Fiji between the seasons of 1969 and 2020 (FMS, List of Tropical Cyclones affecting Fiji, 1969-2021). MS Excel was also used to analyze the questionnaires. A horizontal bar diagram depicted the various types of agricultural productivity, whereas a pie chart depicted the various natural disasters that frequently occurred in the region and their effects on productivity. For proper representation of the responses gathered, the list of adaptation techniques and strategies used by the farmers was presented in a vertical bar diagram.

Results

1.7 Farmers' awareness and perception concerning Climate Change

Farm households were polled to determine their understanding of climate change and extreme weather events. Living near natural hazards does not always imply damage and vulnerability, but a lack of resilience, and thus the amount of information and perception of a population, is independent of the type and risk of causing damage (Javadinejad et al., 2020). As a result, risk perceptions are changing, and the dominant approach is to reduce vulnerability and increase resilience to disasters. The findings revealed that the vast majority of respondents (97 percent) were aware of climate change, with only 3% having insufficient knowledge. It is critical to obtain farmers' perspectives on climate change because climatic parameters such as temperature, rainfall, and humidity aid in the design of appropriate mitigation measures that are useful in making adaptive decisions and realizing current and future adaptation behaviors (Esham & Garforth, 2013). According to the findings in Table 2, respondents were acutely aware of climatic events.

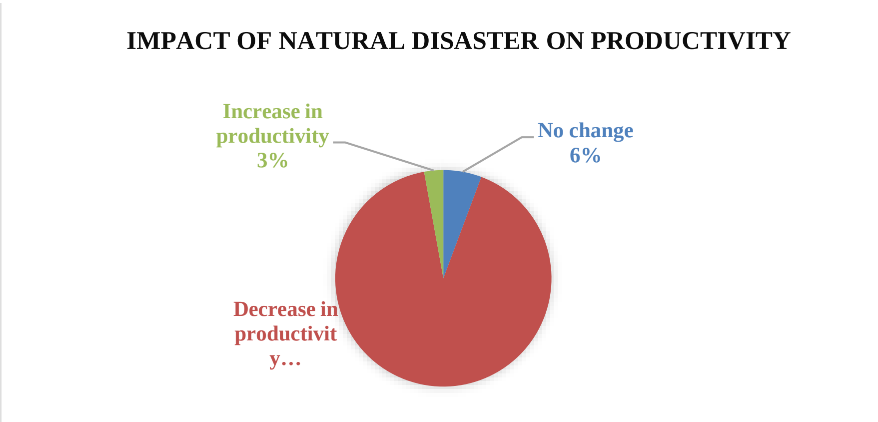
Table 2: Farmers' perception regarding Climate Change

Climatic Events	Percentage (%)
Flooding	48%
Tropical cyclone	50%
Storm Surge	2%

Source: Field Survey

Figure 3 depicts farmers' understanding of the effects of climate change on productivity. The findings indicated that 91 percent of farm households polled in Korociriciri settlement experienced a decrease in productivity, 3 percent showed an increase in productivity, and 6 percent experienced no change in their farm productivity. When looking at the temperature values, most of the respondents alleged that high temperatures, changes in precipitation patterns, and increases in flooding events, as well as frequent occurrences of tropical cyclones, adversely impact agricultural productivity, as shown in figure 3. The results were supported by data from the Fiji Meteorological Services on temperature, rainfall, and the number of flooding events in Tailevu over the last 30 years, as shown in Figure 4 (temperature and rainfall patterns with time).

Figure 3: Farmers' perception regarding climate change impact on farm productivity

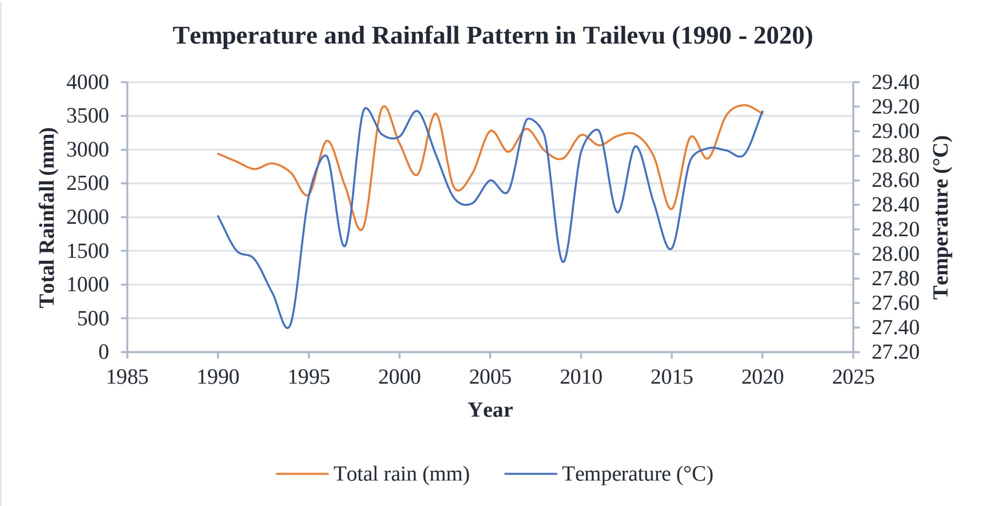


Source: Field Survey

1.8 Farm household's previous adaptation strategies and potential future adaptation strategies

Several adaptation measures were implemented on the farm in response to the unexpected climate events, which farmers indicated are shown in figure 6. Adaptation measures like improving drainage systems (30 percent), changing planting techniques (30 percent), seasonal agriculture (19 percent), using pesticides (11 percent), and organic farming (10 percent) have been identified as the most significant in the surveyed area. Tailevu province is an agricultural region where most farmers (72 percent) are tenants who lease the land, whereas 28 percent are landowners. Their land holding capacity is also limited, and approximately 35% rely on agriculture for a living. Farmers are most vulnerable to climate risks such as floods, storm surges, and high temperatures as shown in figures 4 and 5.

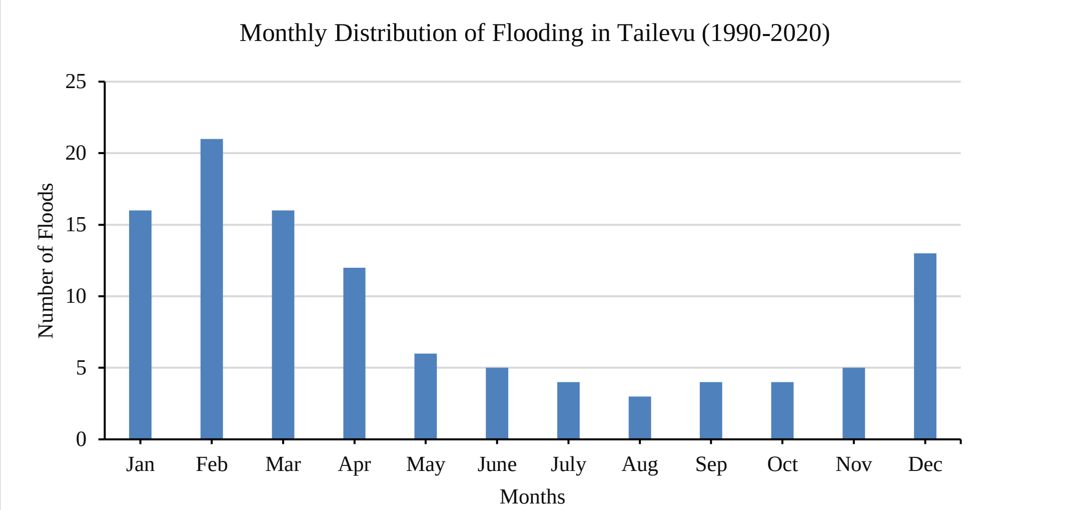
Figure 4: Descriptive Analysis of Temperature and Rainfall trends in Tailevu for the past 30 years



Source: Fiji Meteorological Services

According to the findings, 82 percent of farmers increased farm productivity by implementing the adaptation strategies mentioned in figure 6; however, approximately 18 percent did not prioritize any type of adaptation measures, indicating that they were still unable to implement or adopt new agricultural patterns. Some potential constraints identified by (Jain, 2015) in remote areas include a lack of resources, inadequate agricultural information, and associated skills. This situation is particularly applicable as 55 percent stated that they were not able to access basic services, skill development training, or improved farming technology from the government or other stakeholders.

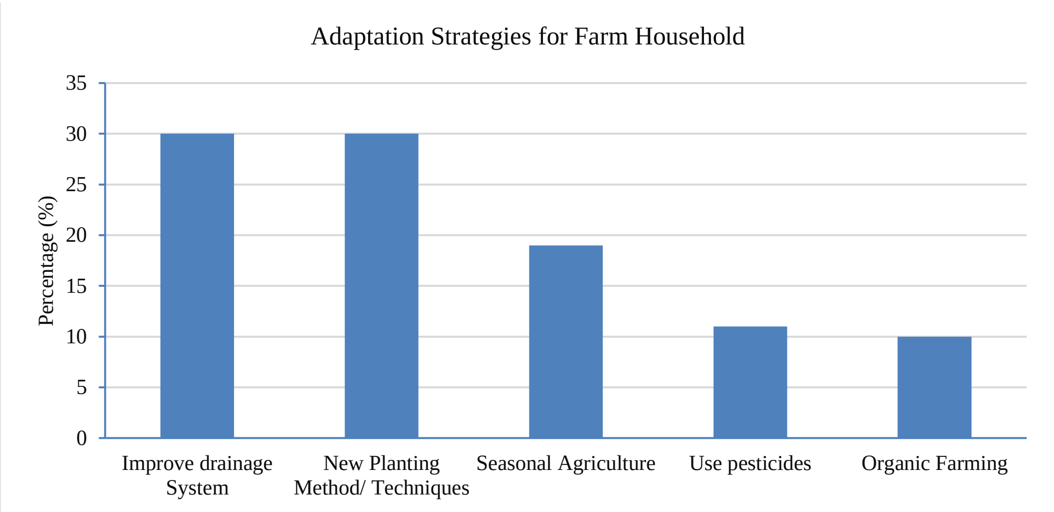
Figure 5: Descriptive Analysis of the number of flood events recorded Monthly for Tailevu.



Source: Fiji Meteorological Services

The findings revealed that agricultural workers are very aware of previous weather changes and are aware that more changes may occur in the future. Farmers are taking the lead in adapting to farm management adaptation practices that may have been adopted to practice non-climate change with additional farm productivity benefits, in addition to increasing resilience (Sterrett, 2011). More research is needed to better understand how farmers prioritize and choose which adaptation measures to implement.

Figure 6: Farm household's potential adaptation strategies

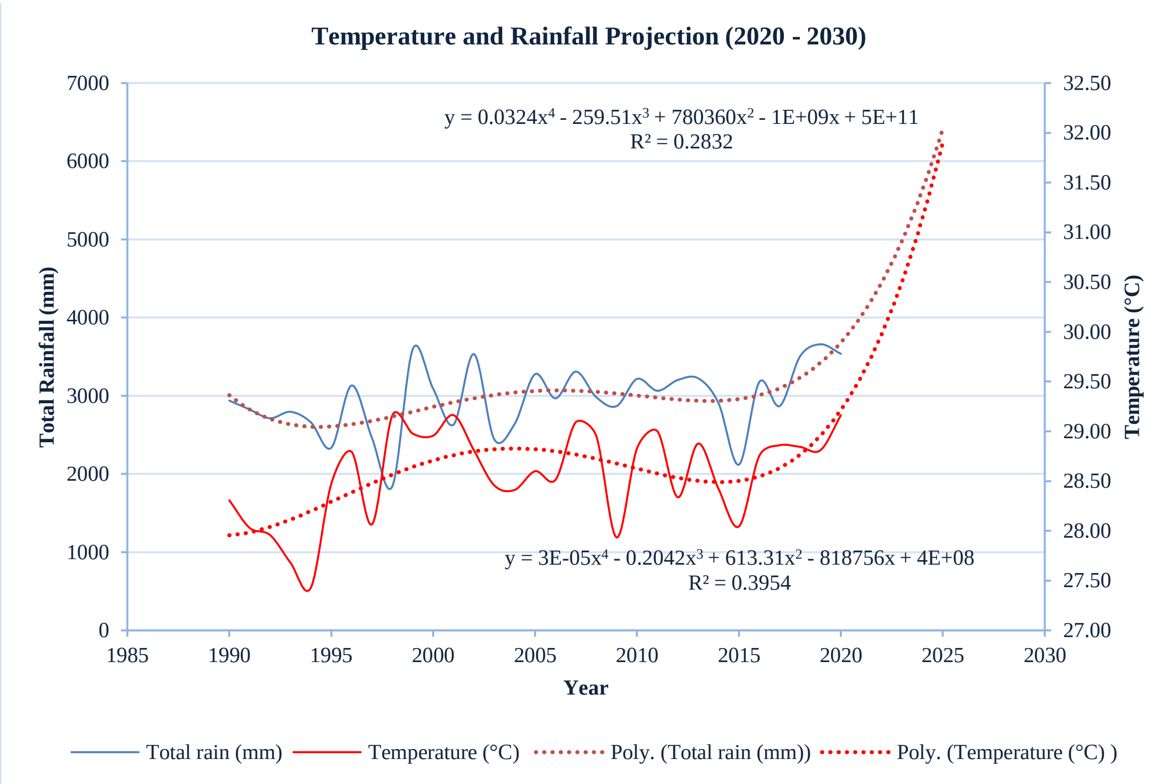


Source: Field Survey

1.9 Future projections for climate variables – Temperature and Rainfall Patterns

A descriptive analysis in which the climate variables for temperature and rainfall patterns were displayed in figure 7. Given the historical data of the past 30 years for the province of Tailevu, projections were drawn for the conditions of temperature and rainfall patterns for the next 5-10 years. The results show an increasing trend for both variables, with a confidence level of 95% and deviations of 0.46 and 0.43, respectively. This situation can be reflected in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2021), which projects that in the coming decades, climate change will increase in all regions. For 1.5°C of global warming, there will be increased heat waves, longer warm seasons, and shorter cold seasons.

Figure 7: Polynomial Regression of Temperature and Rainfall Pattern projected for the next 10 years.



Source: Fiji Meteorological Services

Discussion

Among all socioeconomic variables, the most significant relationship between climate change awareness and age is highly valued. The findings confirmed that older farmers are more aware of climate change than younger farmers. Another important factor in spreading climate change awareness is farmers' educational background, and our research revealed an increase in adaptation strategies, which also increases their farming experience.

In terms of exposure to flooding and tropical cyclones, all the respondents are currently living in flood-prone areas and are exposed to floods each year, most notably in the cyclone months of Fiji from November to April. Reports compiled by the FMS indicated that most floods in Fiji are associated with La Niña events. The flood record also shows that major floods have been caused by a variety of meteorological phenomena or combinations of meteorological phenomena. Tropical disturbances (tropical cyclones and depressions); a southwestward displaced South Pacific Convergence Zone (SPCZ); an embedded tropical depression in a trough or the SPCZ; and the convergence of synoptic systems over Fiji are examples of these and synoptic systems retrogressing over the country. In addition to the flooding simulation based on historical temperature and rainfall patterns, the impact of projected climate change on flooding has received increased attention. However, it is difficult to quantify the number of flood events under climate change effects because of the high level of uncertainty.

Climate change and flood hazards have been noted as the causes of a 91% decline in agricultural productivity for both crop and livestock farmers. Some of the impacts are the introduction of vector diseases such as Coryza eye infection in chickens, parasitic worm infestation in pigs, and pests on crops. The historical data for the various periods of flooding and tropical cyclone was reflected in the adaptation measures; however, farmers have already implemented these approaches themselves. To increase productivity, farmers have implemented effective factors in their resilience and adaptation strategies by improving the drainage system, changing their planting techniques, for example, crop rotation, pruning, intercropping, and contour planting, seasonal agriculture, where farmers indicated that they raise livestock during the drier seasons and cultivate crops during the cooler seasons; increase in the use of targeted pesticides to kill unwanted pests; and switching to organic farming like green manure, compost, and animal manure.

Conclusion And Recommendation

Many factors influence farmers' level of awareness, including socio-economic and demographic factors. Eighty farm households in Korociriciri Settlement, Tailevu, were chosen for this study using the snowball sampling technique. The findings indicated that most farmers in the study area are cognizant of climate change. It also indicated that farmers perceived that their agricultural productivity had previously been affected by climate change. Age, education, agricultural experience, and landholding capacity of farmers are socioeconomic factors that significantly affect how aware they are of climate change. The results demonstrated that farmers are already utilizing dynamic adaptation techniques. Moreover, studying and analyzing the adaptation and perceptions of farmers' behavior also helps provide a substantial awareness level of climate change in determining agricultural plans to improve productivity. Agricultural ministries and government planners may find the findings useful in expanding their climate change services in exposed regions. The results of this study can be used in other districts where efforts to adapt to and mitigate climate change are still ineffective, despite the fact that it was only limited to Korociriciri and Tailevu. The study suggests a useful path for policymakers and academics to develop critical strategies and research to provide various facilities to farmers that could handle various climatic hazards, such as soil adaptation to flooding, the impact of flooding on plant physiology, crop stress levels, and so on. However, we need to take the necessary actions to raise awareness of climate change and its impacts on the agricultural sector. To strengthen this, it is necessary to strongly Implement policies and methods that are fully supported in order to improve farmers' ability to participate in adaptation plans. It is also suggested that farmers' awareness of climate change be increased through the use of information technology and mass communication. This approach, as mentioned by Javadinejad, Dara, and Jafary in "Potential Impact of Climate Change on Temperature and Humidity Related Human Health Effects During Extreme Conditions," 2020, should seek hazard reduction programs to create resilience in communities and specialize in disaster management within the sense of local community resilience and sustainability.

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Statements & Declarations:

Ethical Approval

The manuscript is agreed upon when publishing results of scientific research and other scholarly work as cited and according to the Committee on Publication Ethics (COPE) guidelines.

Consent to Participate

The participant's formal, written consent was approved and endorsed by all the participants of this manuscript.

Consent to Publish

The Fiji Meteorological Services approved the author's written formal consent and has the author's permission to publish research findings.

Author Contributions

The study's inception and design involved input from all authors. Adimaitoga Rabuku (AR) and Vilive Cagivinaka (VC) prepared the materials, collected the data, and conducted the analysis. Adimaitoga Rabuku (AR) wrote the first draft of the manuscript, and Vilive Cagivinaka (VC) offered comments on earlier drafts. The final manuscript was read and approved by all writers.

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Competing Interests

There are no material financial or non-financial interests to disclose for the authors.

Data Availability and Materials

The datasets generated during the current study are available in the Fiji Meteorological Services repository, Nadi Headquarters, Fiji Islands. The datasets are available from the associated author on a justifiable request; however, they are not publicly accessible due to manual storage in the archived area.

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