Perceptions of Climate Change and Adaptation by Smallholder, Highland Farmers in Fiji.

Fieldwork Practicum Final Report

In Collaboration with the Ministry of Agriculture, Fiji and International Fund for Agricultural Development (IFAD).

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Executive Summary

Introduction:

As a small-island developing state (SID) located in the tropical region of the Pacific, Fiji is particularly threatened by climate change and frequently referred to as a "barometer of climate change". Predicted climate changes for Fiji includes an increase in mean annual temperatures, an increase in rainfall intensity and variability, a decrease in cyclone frequency and an increase in cyclone strength. As mitigation has limited potential to prevent the onset of climate change in Fiji, a focus must instead be placed on climate adaptation and resilience. How this adaptation varies across different communities and different demographic groups will also be examined. This is especially true for the agricultural sector and those whose livelihoods depend upon agricultural production which constitutes most of the population of Fiji, in particular, those in highland areas. Furthermore, agriculture contributes a significant amount towards the GDP of Fiji although this share has fallen in recent years due to the rise of tourism.

Fiji is also an international climate leader having chaired the Conference of the Parties 23rd Meeting in Bonn, 2018, the first developing country to chair such a meeting, and was the first country to ratify the Paris Agreement. Policy at the national level is equally impressive in relation to climate change issues. Climate intersects across all sectors and policy documents with some notable examples including the Green-Growth Plan, the National Adaptation Plan, the 5 and 20 year development strategy for Fiji and the Nationally Determined Contribution for Fiji (NDC).

The research outlined in this study aims to examine the local level perceptions and understanding of climate in agricultural communities and how this compares to the national and international level in Fiji. This study, conducted alongside the Ministry of Agriculture (MoA), contributes towards the Fiji Agricultural Partnerships Project (FAPP), funded by IFAD. This project aims to facilitate agribusiness and the transition from subsistence farming to farming as a business for rural communities and therefore climate resilience and adaptation are vital for its sustainability and longevity. This study had two major research questions:

1. What are the perceptions of climate change of highland farmers in Fiji?
2. What climate adaptive practices are in place in agricultural systems of highland Fiji?

Methods:

The FAPP project area encompasses three provinces and seven districts across the highlands of Viti Levu and targets 2,000 households of subsistence farmers. Six villages from the project area were visited during FAPP extension service delivery. At each village, 20 farmers were randomly selected and semi-structured interviews and questionnaires conducted by the researcher in English. Each questionnaire consisted of over 50 questions and were anonymised before being transcribed. A total of 120 responses were recorded.

Results:

Respondent demographics were varied in terms of age (18-69 years), experience of farming (2-60 years) and years of education (0-23 years) however did not differ significantly between villages. Of the 7 impacts of climate change discussed specifically in this study, farmers reported observing an average of 5, showing that climate associated environmental impacts are already being experienced. However, perceived climate change responses varied and did not always align with meteorological data for the region except for cyclone intensity. Farm management showed a variety of climate resilient practices with the most common being intercropping, tree planting and crop rotations. Some other practices showed much lower adoption including irrigation, organic fertiliser application.

Conclusions:

The agricultural sector of Fiji must be equipped to adapt to future climate change impacts, some of which are already being felt. While farmers strongly agree that their climate is changing, the specific changes are not well understood or agreed upon. Climate adaptive practices are integral to traditional agriculture in the region which improve resilience but may limit the scope of future adaptation. Future extension services that equip farmers to combat climate changes will be most successful in creating a sustainable and resilient Fijian agricultural sector.

Introduction

Fiji is a country located in the South Pacific and is composed of over 300 islands of which 1/3 are inhabited. The total population is under 900,000, with most people living on the largest island, Viti Levu. As a lower-middle income country, Fiji has experienced rapid economic growth in recent years although agriculture's share of GDP has fallen to only 9.2% in 2012.[1]

Climate Change and Fiji

As a Small Island Developing State (SIDS), Fiji is often acknowledged as particularly vulnerable to climate change,[2] due to limited resources constraining adaptive capacity. Regional models predict that temperatures are set to rise, rainfall to become more unpredictable and cyclones decrease in frequency but increase in severity.[3-6] The impacts of these changes are predicted to include: increased flooding, landslides, drought, storms, sea level rise and ocean acidification.[7]

Contrary to greater vulnerability, other authors have argued that SIDS possess greater adaptive capacity and may be more resilient to climate changes.[3,8] This is due to strong traditional practice, rich indigenous knowledge, close-knit community and family groups and a diverse cropping systems.[9] Pacific islands can expect greater threats due to climate change compared to countries but may possess greater inherent adaptive capacity with which to respond.[8] Because of this, SIDS such as Fiji are frequently referred to as "barometers of climate change" in the literature.[4,10]

While many climate models cover the Pacific region, the resolution of these scenarios is too large to provide local level information for Fiji with its highly varied geography and small land area.[10] Regional models do allow for some Fiji-specific predictions. The country has a history of devastating tropical cyclones (TC) such as TC Kina 1993 causing $110m in damages, TC Ami 2003 causing $35m in damages and finally TC Winston 2016 causing $2bn in damages, almost the entire GDP of the country.[11,12] Flooding in 2004 caused damages to 50-70% of all crops in the country.[11] Should these extreme climate events become more severe, as predicted, the economic cost on the country is apparent. Incorporating climate change adaptation plans into pre-existing Disaster Risk Reduction plans is one top-down approach to tackling climate change threats.[13]

The severity of climate change is evident through its acknowledgement in recent Fijian policy. Fiji was the first country to sign and ratify the Paris Accord and presided over the 23rd Conference of the Parties in Bonn 2017.[12] Its first framework for climate change policy was produced in 2012 and has been updated since.[5] Climate change receives its own section of

importance in the 5 and 20 year development plan for the country (2016) and it also features heavily in the Fiji Green-Growth Plan, 2014. The National Adaptation Plan is also being drafted in accordance with the Paris Accord requirements.[1] Repeated reference is made across these policy documents that Fiji does not see mitigation and adaptation as opposed to sustainable development for the country, the 20 year development plan expects to quadruple GDP while cutting emissions by 30%.

The government and policy makers in Fiji clearly acknowledge the growing threat of climate change and are incorporating across all sectors. Despite this strong top-down approach, there is much less literature available for bottom-up climate change perceptions from Fiji. The little that is available suggests that at the local level, understanding of climate change is patchy and inconsistent, confounded by the media and confused with excessive scientific language.[4,14]

Vulnerability and Resilience of Fijian Agriculture

Agriculture is a vital component of the Fijian economy and as much as 37% of the population derive a portion of their income from agricultural activities.[12] The 4th IPCC Climate Change Assessment outlined how climate change posed "a hindrance of agricultural productivity" and "a decrease in food security due to loss of food resources".[2] As temperatures increase, tropical cropping systems will experience greater temperature extremes and water scarcity.[15] As Pacific island agriculture is primarily red-fed, changes to water availability through precipitation and evapotranspiration have significant impacts on smallholder farmers and their livelihoods.[11,16]

These impacts may be dampened by Fiji's resilience; rich cultural heritage, diverse cropping systems, crop species and varieties, close family and community linkages and diverse income sources.[8,9] Diversity at the field, community and landscape scales improves agroecosystem resilience.[15,17] These "climate resilient" practices may not be recognised as such by those that practice them as Fiji has always experienced a variable climate.[4]

Mitigation and Adaptation of Fijian Agriculture

Mitigation and adaptation are seen as two parallel but separate approaches to combat climate change from climate finance and policy perspectives.[18] Fiji produces 0.04% of the global average emissions of greenhouse gases at 1.94 tCO_2 per person per year.[19,20]. Only 22% of Fiji's emissions are due to agricultural activity and so there is very little scope for the country

or agricultural sector to combat climate change through mitigation and instead a focus on adaptation for Fijian agriculture is essential.

Adaptation is defined by the IPCC 5th Assessment (2014) as "the process of adjustment to actual or expected climate and its effects" and this is the definition used in this study.[7] Adaptation can be directly associated with climate change impacts e.g. increased temperatures or can be an indirect response to other consequences of climate change e.g. soil erosion.

While adaptation options are numerous, they are not always beneficial and may be maladaptive or create conflict between management practices depending on the context. It is not enough to assume adaptation will always improve the agricultural setting where it is implemented. Examples of maladaptive adaptations include migration to urban areas depleting the local labour force or insurance schemes that facilitate more risk-prone farming.[11,21]

Adaptation is multi-actor, multi-sectoral and multi-temporal while many project implementation plans are focused on the local scale, over a finite time scale and targeting a single community group.[22] Greater integration of local level perspectives and priorities into project design and policy can help create more robust and efficient agricultural adaptation. This research project aims to help fill this knowledge gap for Fijian agricultural systems. The following sections explore the conceptual framework for this study.

Conceptual Framework

As smallholder farmers are dependent on their natural environment for their livelihoods, they are particularly sensitive to any changes, including climate.[8,23] There is no universal response for farmers experiencing climate change.[24] Instead, a number of factors influence how farmers perceive and respond to these changes. Factors influencing farmer decision making include: risk perception, previous experience, community networks, available resources, tools, education, information accessibility, financial constraints and psychology.[25,26]

Since different social groups within a community will experience climate change differently, there is heterogeneity within communities as well as between them. Any policy or project design that does not reflect this, will favour some social groups over others by default, creating maladaptive policy.[14] Climate forms one driver in a network of stresses smallholder farmers experience which together influence adaptation decisions.[27] Even when climate is identified as a threat to livelihoods, adaptation may not be implemented due to other constraints.[28]

This study builds on previous literature on the topic that proposes for farmers to adopt adaptation measures, a two-step process must occur:

1. Farmers perceive that climate is changing.
2. Farmers choose to implement adaptation measures they believe reduce their vulnerability to future climate variability.[22,29,30]

Socio-demographic considerations have been proposed to influence adaptation to climate changes in the following ways:

Age: Older farmers tend to have greater access to traditional knowledge of their local environment making them more sensitive to changes. However, this resilience can be undermined by an unwillingness to change from tradition.[31] Younger farmers tend to be less risk averse and more willing to innovate and try new technologies due to greater access and education.

Education: More educated farmers can access new information and technology more easily and more familiar with extension services and training.

Gender: Male farmers traditionally are involved in cash cropping compared to women who practice subsistence provisional farming.[32] Therefore men can be more susceptible to market conditions while women are more risk averse. In some settings, women may be discriminated against in formal education services.[33]

Experience: Those with greater experience with their local environment have a broader wealth of knowledge to draw upon.

Adaptation measures are also subject to different constraints. Some may be technologically intensive that limits implementation (soil-water conservation, new cropping practices), some are financially intensive that limit those unable to invest (irrigation schemes, new seeds, fertilisers) and other may be labour limited (soil-water conservation, weeding, post-harvest treatment).[33-35]

Future project implementation in the agricultural arena must consider how these socio-demographic factors and constraints intersect with climate. In order to capitalise on synergies between climate change adaptive measures and other pressures on the development of the agriculture sector, these considerations must be addressed.[36]

Research Questions

This study poses two questions:

1. What are highland, smallholder farmers' perceptions of climate change and do they align with meteorological data collected?
2. What, if any, climate adaptive practices are highland, smallholder famers employing?

Justification

Exploring the variation between highland famers in their perceptions and adaptations in response to climate change could reveal future priorities to be integrated within policy and project planning. The lack of previous literature for highland communities in the South Pacific has created a knowledge gap that limits effective policy being created.[37] Fiji has a wealth of literature from a top-down perspective but needs to be united with local level input into decision making to prevent "policy mis-match".[22]

"Climate-proofing" has become necessary for all development projects to ensure sustainability and this has a two-way synergy, as the success of other development projects improves the health, wealth and knowledge of communities, improving climate resilience.[38]

The few previous studies of climate perceptions in Fiji revealed that rural areas were uninformed about climate change and many attributed such changes to God's Will.[4] By understanding what farming practices are being implemented in highland Fiji and how they intersect with climate adaptation, the space for further adaptation can be explored and implemented into future extension services ad policy.[21,39,40]

Methodology

This project applied a mixed-methodology although with a greater focus on quantitative data collection. An extensive literature review of academic, grey and internal MoA and GoF literature was conducted before any research materials were composed. International and multi-sectoral guidelines and handbooks in survey construction were also referred to. [41,42] This allowed for narrowing of the research questions and more accurate tools to be constructed to ensure the best use of time and resources. Using both closed and open-ended questions in participant questionnaires allowed for greater interrogation of the data and a broad array of information to be collected.

As this research was conducted under the IFAD funded Fiji Agricultural Partnerships Project (FAPP), the target community was the same as the project area outlined in FAPP. [43]

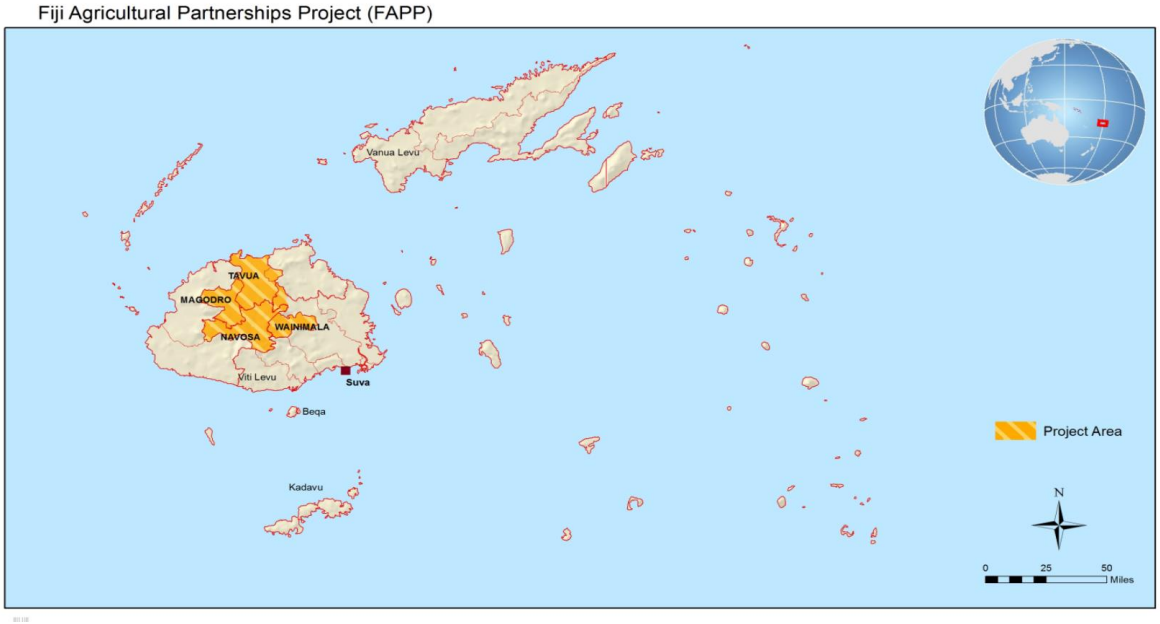

Fig. 1: Map of Fiji with highlighted FAPP project area in Viti Levu.[43]

This included 7 highland districts across 3 provinces (Ba, Naitasiri and Nadroga/Navosa) and targets 41 villages. As fieldwork was carried out at the same time as MoA and NGO extension service delivery, community members from the surrounding area as well as in the target village were accessible to the researcher. However, this limited the sample population to the FAPP project area and therefore is not representative of the entire highland population of Fiji. This sample frame is still useful as it includes 2000 households across the highlands of Fiji's largest island. Six villages (15% of project area villages) were selected due to no prior extension service delivery by FAPP and to cover a variety of communities and local geographies.

Triangulation of the data was used to confirm any trends revealed by the primary data collection and surveys. Data from climate modelling and meteorological trends was used to compare to climate perceptions of farmers.[2,6,7]

The FAPP project area encompasses roughly 2000 households and so a minimum sample size was calculated to be 92. This number was based on a 95% confidence level and a 10% confidence interval [44]. While a 5% confidence interval was desirable, this would have resulted in a minimum of 322 sample size which was not realistic given the constraints upon the researcher in terms of time, resources and access to communities.

Methods

An initial thorough literature review was carried out. Policy documents relating to Fiji's development plan and climate change were selected.[1,5,12,19,20,45] Keyword searches of the major databases SCOPUS, Web of Science and Google Scholar were then carried out to select the relevant literature. A snowball method was then used to find relevant papers that did not appear in the key word searches. Two previous M.Sc. theses were also consulted.[46,47] Two MoA publications were selected as previous climate change outreach examples and formed the basis for formulating questions related to climate change impacts. These publications were in the form of pamphlets as pictured in **Fig. 2**. The impacts were: Soil erosion, decrease of soil fertility, less water availability, new crop disease and pests, loss of other natural plants in local environment, lower yields, changes to the timing of the seasons.

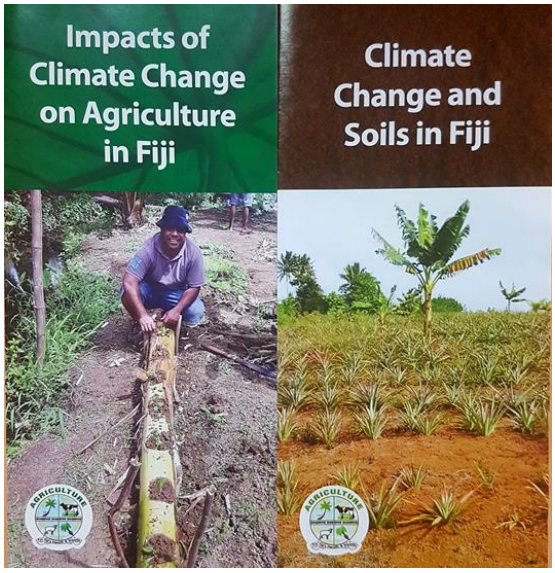

Fig. 2: Ministry of Agriculture publications used to inform survey design relating to climate change impacts on agriculture.

Informal, face-to-face interviews were carried out with the FAPP team in the MoA and their lead implementing partner NGO, Pacific Community Development Fund (PCDF). A subsequent household survey was then constructed of 36 main questions and over 50 sub-questions, to be carried out through in person interviews with farmers (**Appendix A**). Random sampling across the entire project area was not possible due to access and time constraints in rural communities. Community meetings and extension service delivery with FAPP, MoA and PCDF staff were used to facilitate data collection and random sampling was carried out

amongst those farmers attending. Some stratified sampling was carried out to ensure sufficient female respondents. Only one person per household was interviewed to avoid bias. As the first year of FAPP extension, respondents had not received extension services previously in any of the villages sampled. The schedule of village visits and districts is outlined in **Table 1.**

Table 1: Data collection schedule and locations in highland Fiji in the FAPP area.

Date: July 2018	**Region:**	**District:**	**Village:**	**No. Respondents**
10-11th	Naitisiri	Nabobuco	Rewasu	20
12-13th	Nadroga / Navosa	Navatusila	Nasauvakarua	20
17-18th	Ba	Magodro	Nasivikoso	20
19-20th	Nadroga / Navosa	Nasikawa	Wema	20
24-25th	Nadroga / Navosa	Noikoro	Nukuilau	20
26-27th	Nadroga / Navosa	Noikoro	Draubuta	20

Each questionnaire was completed through face-to-face interviews with the researcher, in English, and lasted 15-20 minutes. A total of 120 responses were recorded. This exceeded the 92 response minimum requirement and results in an 8% confidence interval rather than 10%. All responses were anonymised and coded using an ID number. Data was then coded in Microsoft Excel and analysed using Rstudio.

Results

Section 1: Demographics

A total of 120 questionnaires were conducted across 6 villages with exactly 20 responses collected per village.

Age

Fig. 3a-b shows the distribution of age across the sample population mean=37, range=18-69. To examine if the sample was a random sample of the overall FAPP area, an analysis of variance was carried out (**Fig. 3b).** There was no significant difference between the mean age of each village (F=0.5, p=0.7, df=5).

An analysis of normality was also conducted on the age distribution as shown in **Annex B** and a log transformation applied.

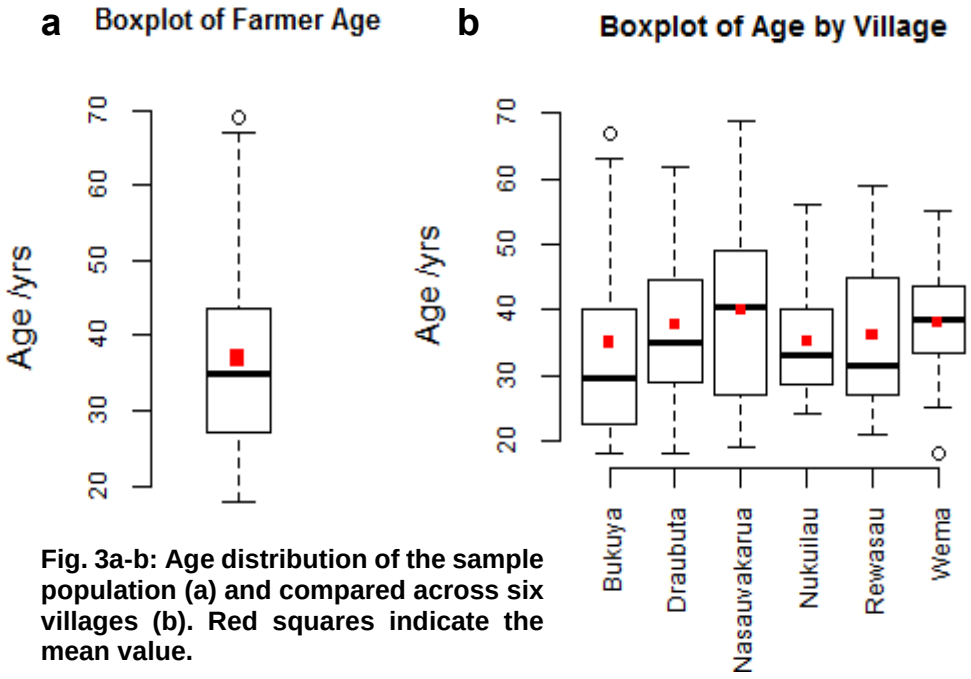

Fig. 3a-b: Age distribution of the sample population (a) and compared across six villages (b). Red squares indicate the mean value.

Education

Education was investigated using the number of years of school attended by each respondent, mean=11, range=0-20. The data is summarised in **Fig. 4a-b** showing the overall sample population and the difference between villages. An ANOVA test revealed no significant difference in education attained between villages (F=0.85, p=0.52, df=5). Normality was

examined using a histogram and QQ-plot (**Fig. 5a-b)** which showed a highly peaked (leptokurtic) distribution.

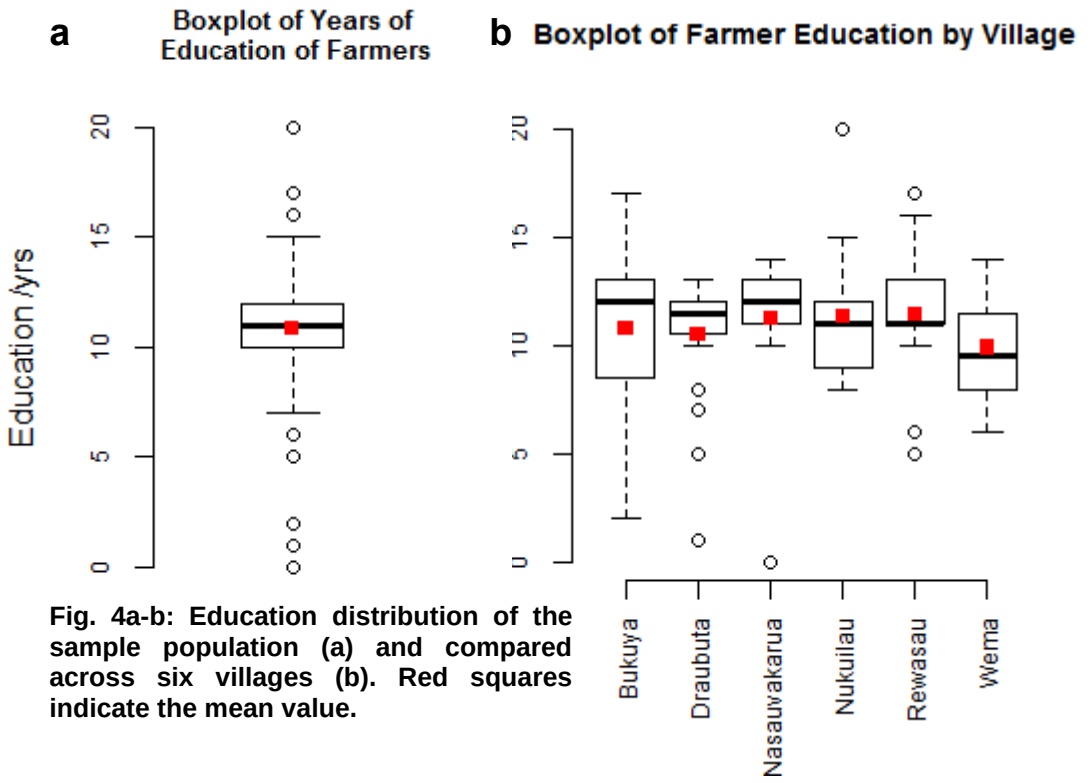

Fig. 4a-b: Education distribution of the sample population (a) and compared across six villages (b). Red squares indicate the mean value.

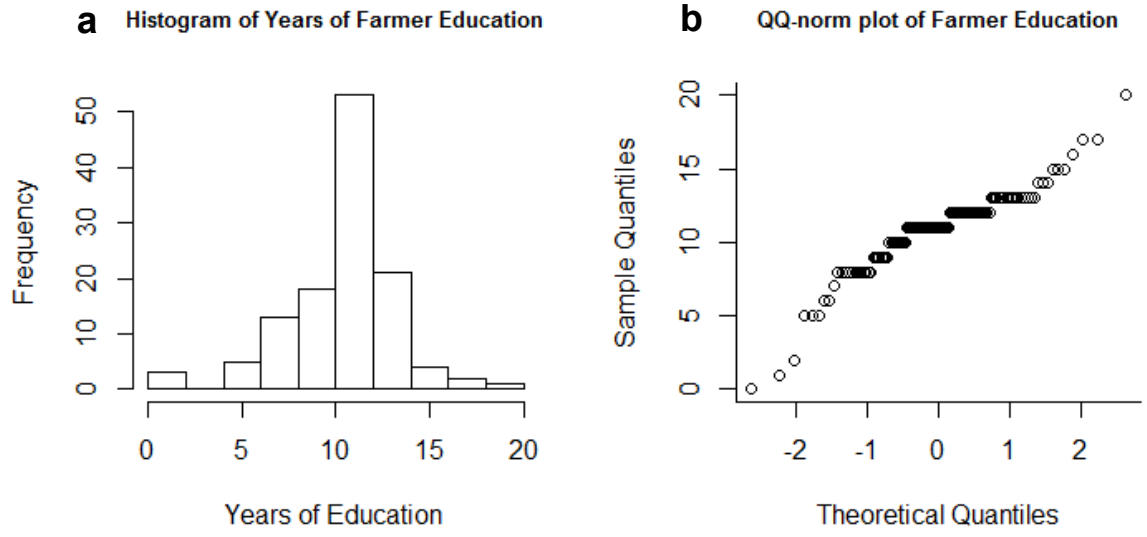

Fig. 5a) Histogram of years of education for the entire sample population and b) assessment of normality using a QQ-norm plot.

Experience of local area

Experience was examined by asking respondents how many years they have been living in their village (mean=19, range=1-69). The resulting distribution and comparison between villages are presented in **Fig. 6a-b.** Normality of experience was then examined (See **Annex B)** and a log transformation applied. An ANOVA test was conducted on the mean experience between villages and showed no significant difference (F=0.97, p=0.48, df=5).

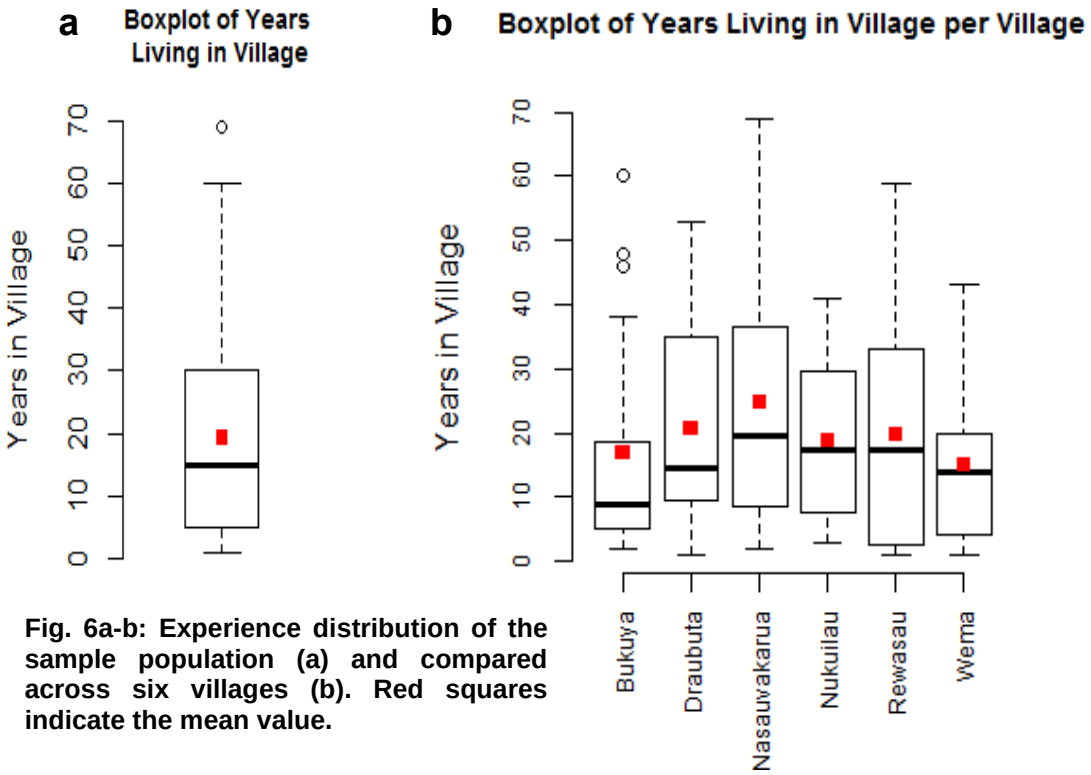

Fig. 6a-b: Experience distribution of the sample population (a) and compared across six villages (b). Red squares indicate the mean value.

Gender

While more men attended extension services and village meetings, an effort was made to capture more female respondents, to give an overall number of 81 men and 39 women. **Table 2** shows the gender breakdown within each village. A chi-squared test was used to compare the gender breakdown at each village and showed no significant difference between villages (χ^2=3.99, p=0.56, df=5).

Table 2: Gender breakdown of farmer respondents in each village.

	Bukuya	Draubuta	Nasauvakarua	Nukuilau	Rewasau	Wema
No. Male	12	12	13	13	17	14
No. Female	8	8	7	7	3	6

Log-Age, education and log-experience were all compared between male and female respondents using a t-test; log-age: t=-0.71, df=70, p-value=0.48, education: t=-0.52, df=89, p-value=0.6, log-experience: t = 0.02, df = 95, p-value = 0.98. There was no significant difference between the mean of male and female groups for any of the three variables (**Fig. 7a-c)**.

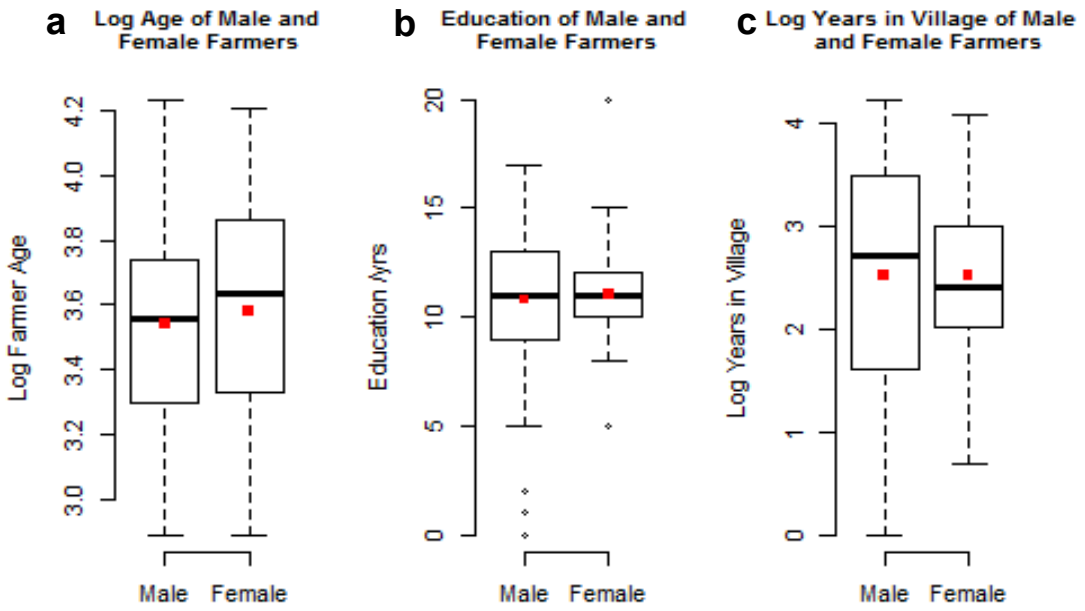

Fig. 7a-c: Comparison of male and female respondents and their a) age distribution, b) education distribution and c) experience distribution.

Simple Regressions

The relationships between age-experience and age-education were examined using regression analysis. The interaction of gender was also considered using an ANCOVA model.

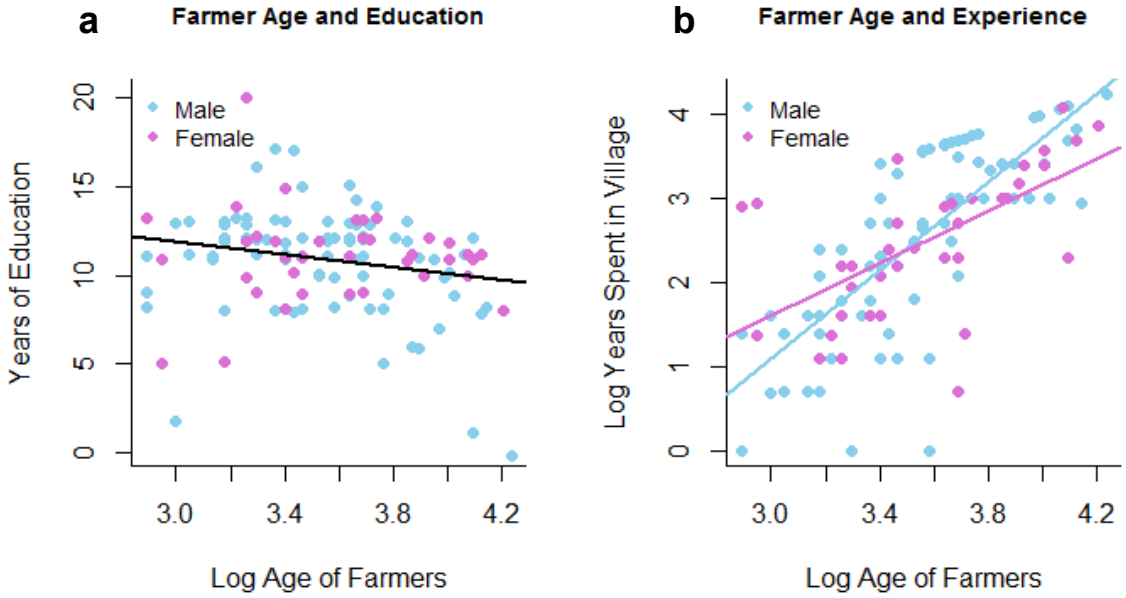

Fig. 8a Regression analysis examining farmer age and education. No gender interaction was found and a simple linear model was selected. 8b Regression analysis examining farmer age and experience. A significant, age-gender interaction was found as shown by two different lines plotted.

The results are presented in **Fig. 8a-b** and the full regression tables are presented in **Annex C**. A significant negative correlation was found between age and education indicating older respondents had received fewer years of education (p=0.02). A significant positive correlation was found between age and experience of the village. This relationship was significantly different between gender groups as shown in **Fig. 8b**.

Financial Services

The questionnaire asked if respondents had access to financial services (banking, lending, credit etc.). The results are shown in **Fig. 9.** Over 61% reported having access, 38% did not while 1% were unsure.

A chi-squared test was conducted to examine access to financial services per village and showed no significant different (χ^2=4.2, p=0.53, df=5).

A chi-squared test was also conducted to examine the difference between access to financial services and gender. The result showed no significant difference (χ^2=0.05, p=0.81, df=5) indicating men and women reported equal access to financial services.

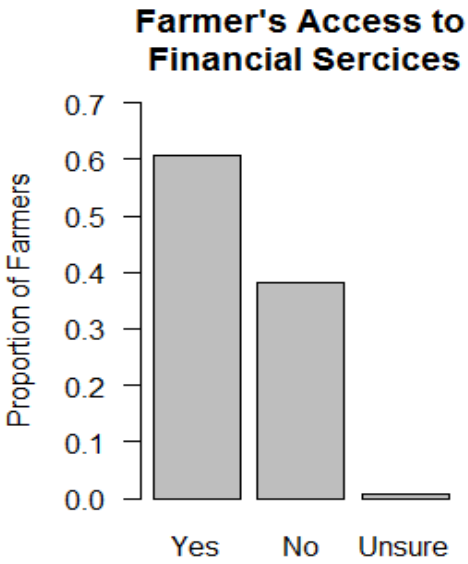

Fig. 9: Summary of farmers' responses to access to financial services.

Crop Selection and Diversity

Farmers were asked about what crops they grow. The most common responses were kava, dalo and cassava (**Fig. 10a)**. Vegetables were grouped into one bracket for clarity due to low frequency of individual crops. The crop diversity was then defined as the total number of crop types grown per farmer. The mean per village was calculated along with the variation (**Fig.10b**).

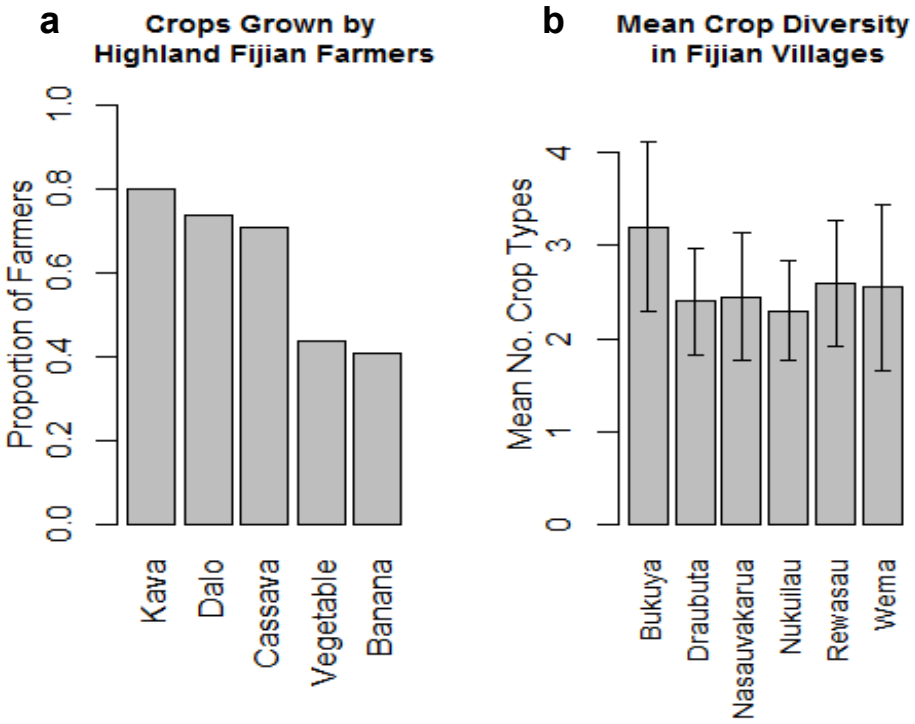

Fig. 10a-b: Summary of farmer crops. a) shows the proportion of farmers who reported growing the five most common crops. b) shows the mean number of crop types grown in each village. Error bars represent the variance.

Section 2: Climate Perceptions and Environmental Impacts

To explore climate perceptions of farmers, a series of questions was asked relating to different aspects of climate and how they have changed since the respondent's childhood. The results are shown in **Table 3** and **Fig. 11.**

Table 3: Perceptions of changes to climate reported by Fijian farmers in highland villages

	Climate Characteristic				
Response (% farmers)	Temperature	Rainfall (total)	Rainfall (frequency)	Cyclone frequency	Cyclone Intensity
Increase	55	36	37	48	75
Decrease	32	49	43	34	18
No Change	13	15	20	18	7

A majority of respondents felt that temperature has increased. Rainfall, rain frequency and cyclone frequency all showed mixed results with no clear consensus. 75% of respondents felt cyclones have become more severe which was the highest level of agreement recorded.

The environmental impacts explored focused on the seven climate related environmental changes identified by the MoA as being detrimental for agriculture in Fiji. Each farmer was

asked how many of these seven impacts they had observed in their local environment. A summary of the results is presented in **Figs. 11-12**.

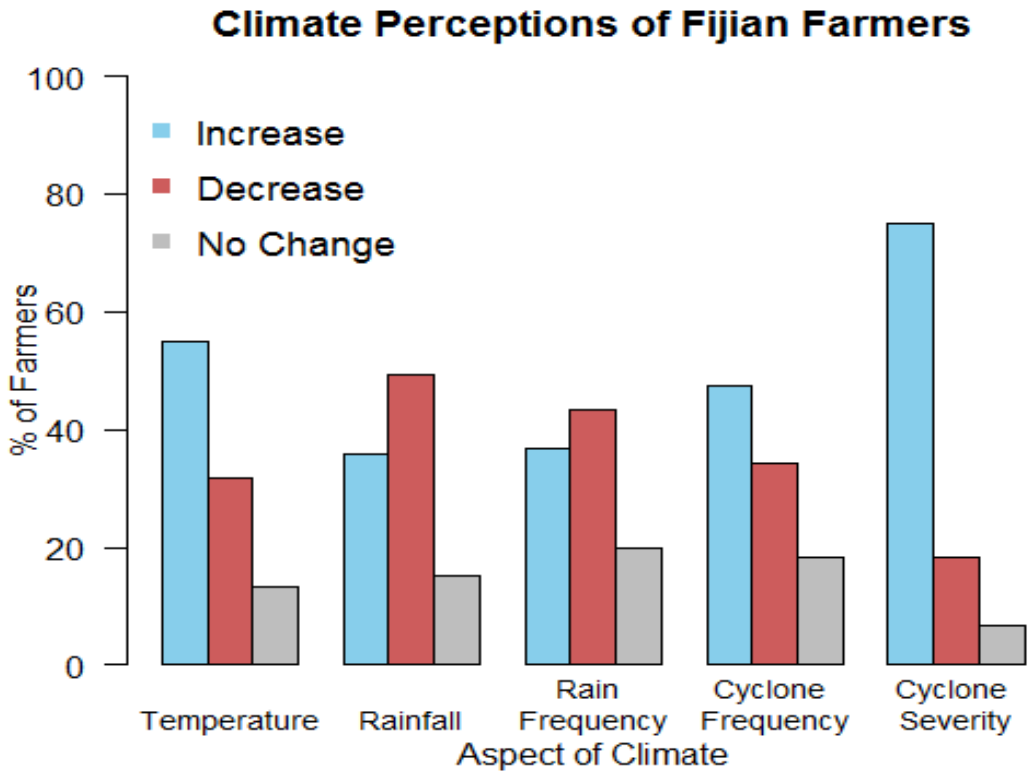

Fig. 11: Summary of perceived climate changes by Fijian farmers.

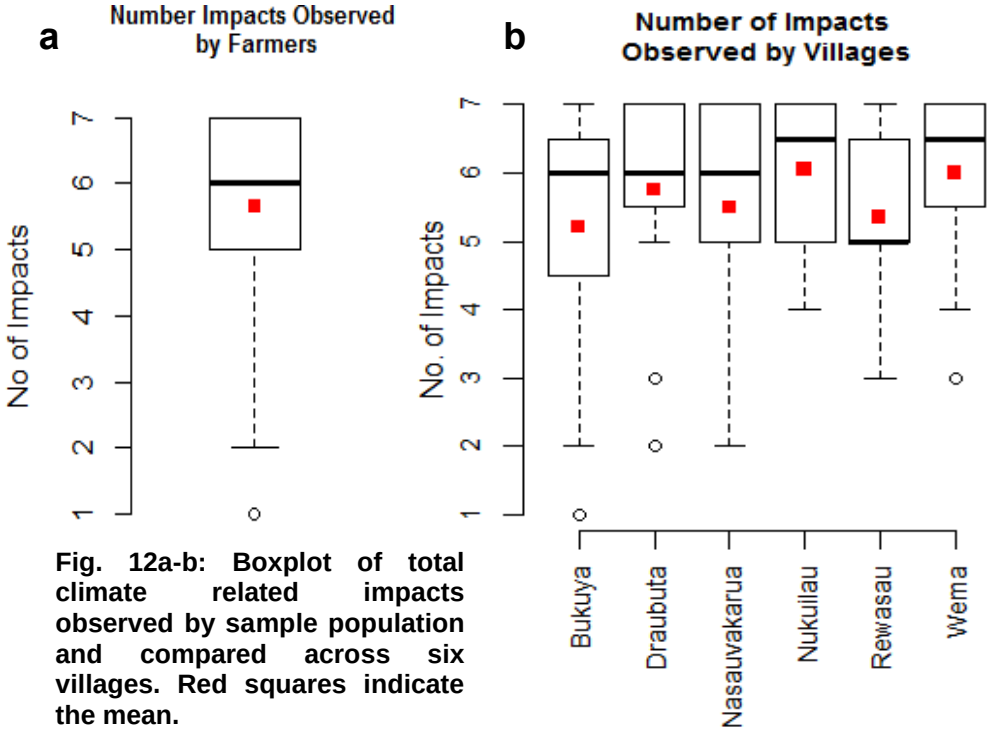

Fig. 12a-b: Boxplot of total climate related impacts observed by sample population and compared across six villages. Red squares indicate the mean.

All seven impacts investigated had been observed by most respondents. The mean number of impacts observed was 5.6 and ranged from 1-7. An ANOVA test was conducted to compare the mean number of impacts observed between villages. The results showed no statistically significant difference (F=1.11, p=0.36, df=5). When asked if changes to climate would make farming more difficult in their village, farmers responded with a large majority (86%) that they thought so.

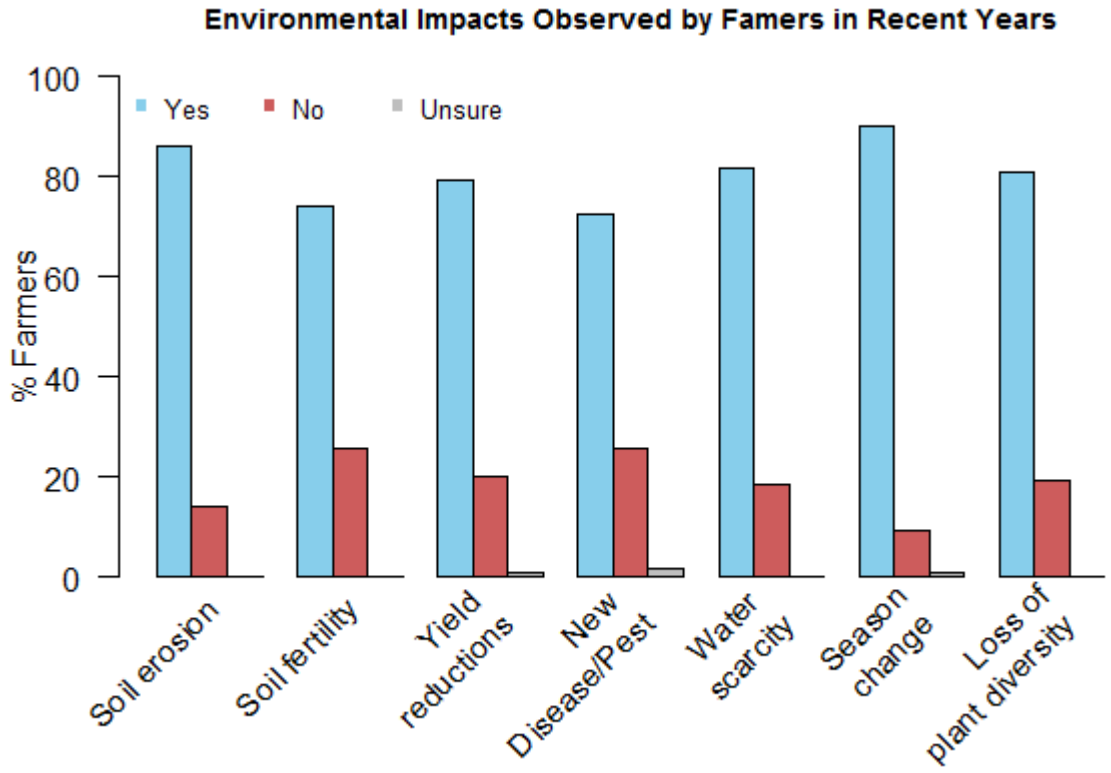

Fig. 13: Observation of seven environmental degradations that have climate interactions by Fijian farmers.

Section 3: Knowledge of Climate Change

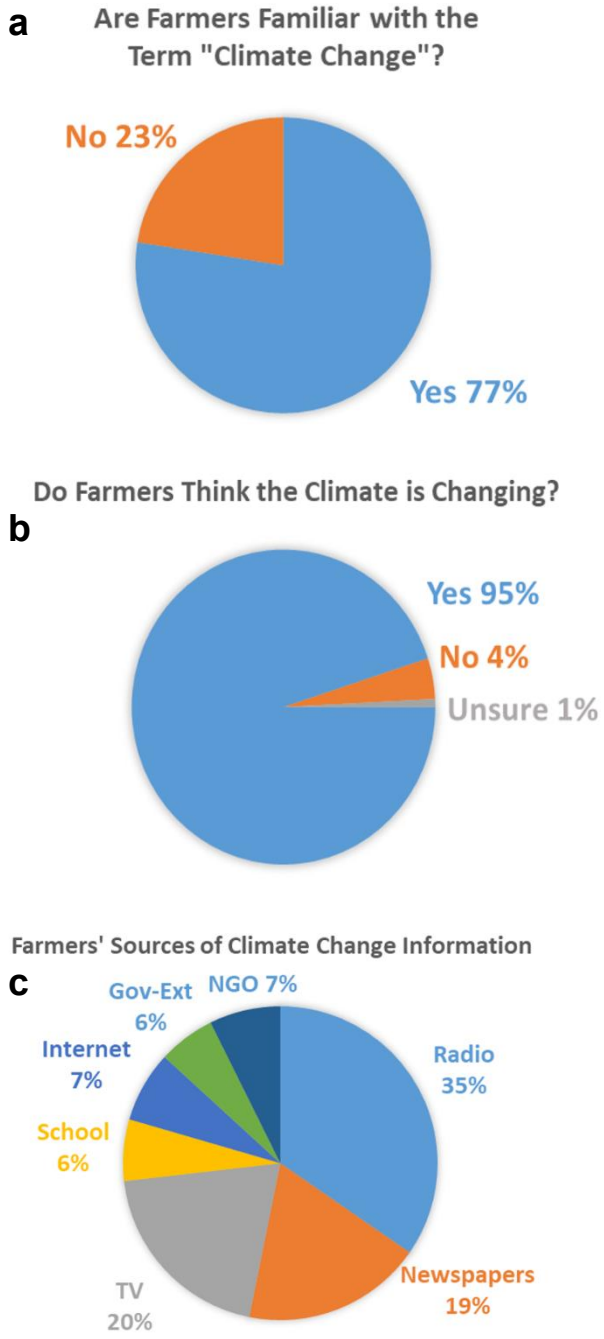

Fig. 14: a) Chart showing the proportion of farmers who have heard the term "climate change" before. b) Farmers' opinions on if the climate is changing. c) The information source that provided previous climate change exposure.

Participants were asked if they had heard of the term "climate change" before, if they thought their climate was changing and where, if anywhere, they had heard the term before. The results are summarised in **Fig. 14a-c**. A majority (77%) of respondents had heard of climate change, and over 95% of respondents believed their climate was changing. Access to climate information was primarily though radio, newspapers and TV. Other sources included through school, the internet, government extension and NGOs.

Previous knowledge of climate change is presented per village in **Table 4**.

A chi-squared test was performed to compare between villages and was converging on significance (χ^2=10.7, p=0.056, df=5) however the number of cells with sample size smaller than 5 indicates this test alone is not sufficient to draw conclusions.

Table 4: Previous knowledge of climate change in each village visited.

	Bukuya	Draubuta	Nasauvakarua	Nukuilau	Rewasau	Wema
Yes	4	3	10	3	4	3
No	16	17	10	17	16	17

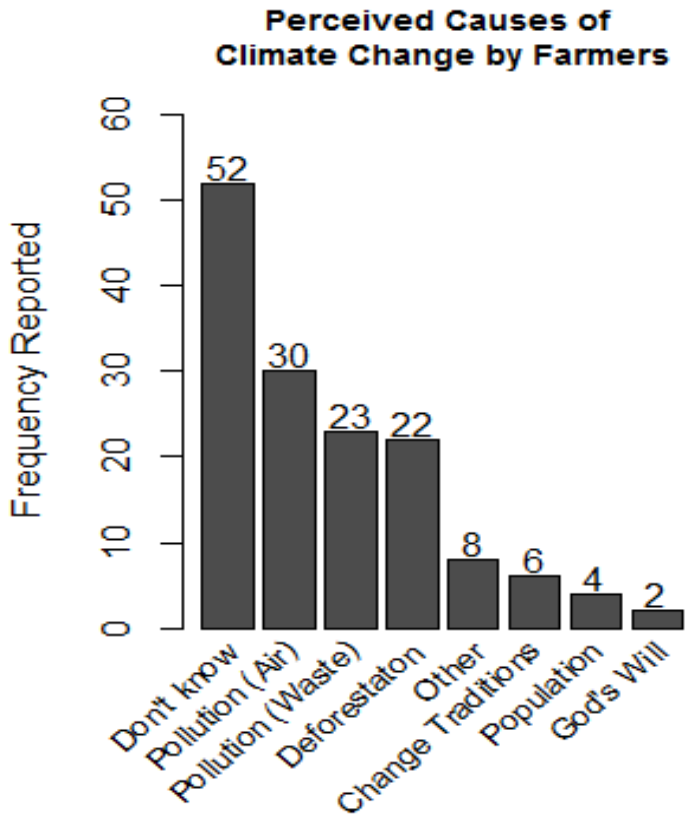

Fig. 15: Perceived causes of Climate Change by Highland Fijian Farmers.

What causes climate change was also explored and responses proved inconsistent and uncertain. The most common response was "don't know" (**Fig. 15**). Other responses included man-made causes such as pollution from air and waste and deforestation. Only 2 respondents mentioned God or divine intervention.

Section 4: Adaptations and Farming Practice

A total of 12 farming practices that could have climate interactions were explored. These practices included: tillage systems, agroforestry, irrigation, income diversification, cropping systems, fertiliser use and agrochemical applications. **Fig. 16a** shows the percentage of farmers using each of the adaptations mentioned and **Fig. 16b** shows the mean number of adaptive practices used in each village.

The most common practices included intercropping (85%), crop rotations (88.3%) and cover crops (85.8%). Other practices were not well adopted such as no-tillage systems (20%), irrigation systems (30.8%) and income diversification (43.3%).

An ANOVA was conducted on the mean number of adaptive practices reported in each village and was statistically significant (F-4.45, p=0.001, df=5). This suggests a statistically significant difference between adaptive practices between villages.

The total number of practices used was regressed upon log-age, log-experience, gender, education and household size. Only log-experience showed a result converging on significance at the 95% confidence level (F=3.7, p=0.06, df=118). All other results were insignificant.

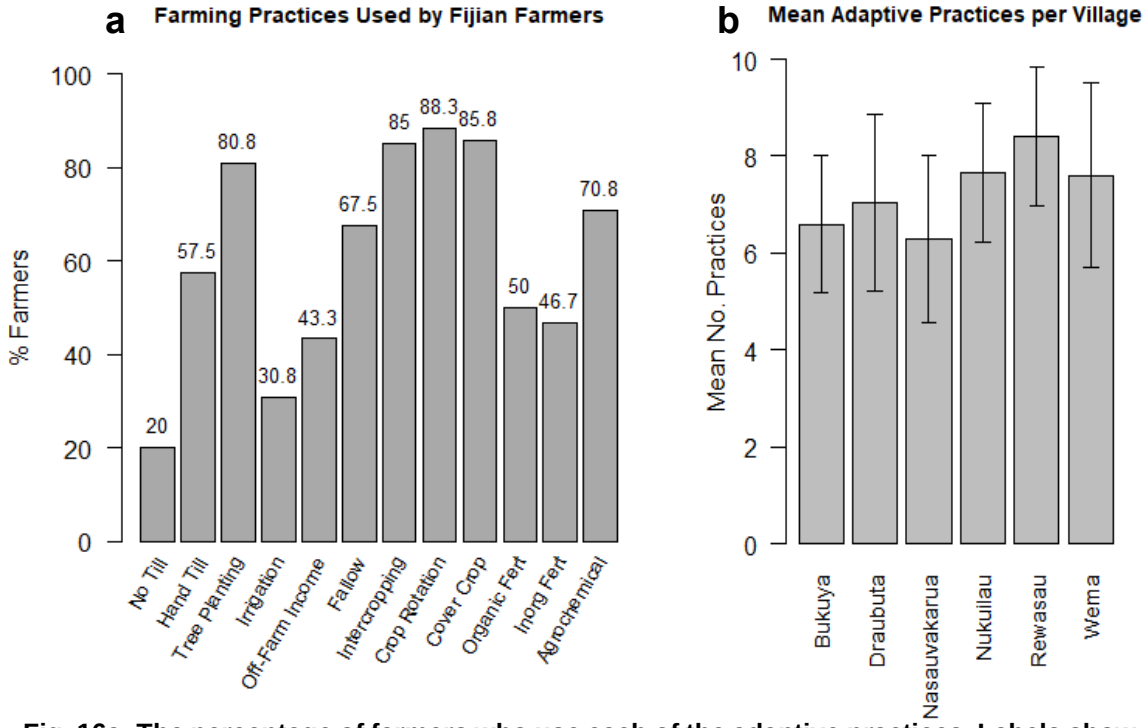

Fig. 16a: The percentage of farmers who use each of the adaptive practices. Labels show the % at the height of each bar. 13b: The mean number of adaptive practices used on farms in each village. Error bars represent one standard deviation.

To explore how perceived environmental impacts effect farming practice, a regression analysis was carried out as shown in **Fig. 17**. This linear regression compared the total number of climate impacts and the number of climate adaptive practices used. The result was statistically significant at the 95% confidence level, (F=7.1, p=0.008, df=118). This shows that the more negative climate related impacts are observed, the more climate adaptive practices are engaged in by farmers (See **Appendix C** for regression table).

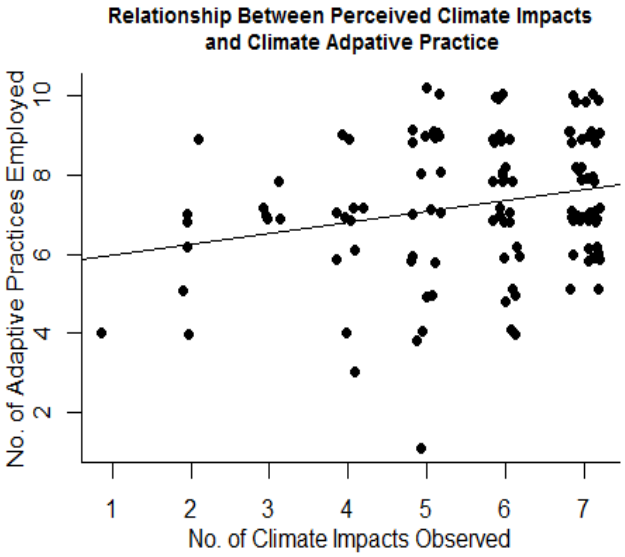

Fig. 17: Linear regression exploring the relationship between number of climate related impacts observed by farmers and the number of adaptive measures employed on their farms.

Section 5: Decision Making

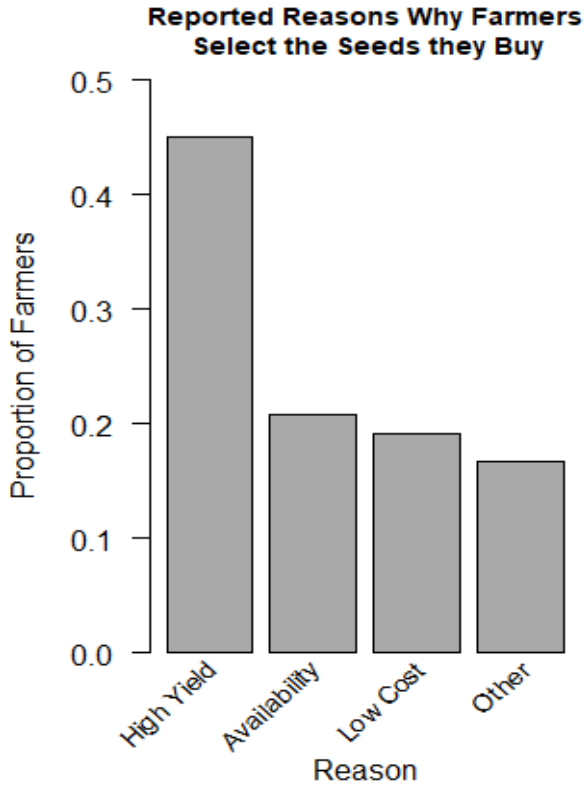

Fig. 18: Barchart showing what influences farmers when they purchase new seeds for their farms.

When asked if farmers felt able to adapt their livelihoods under a changing climate, over 90% responded positively indicating that they felt adaptation was viable. To explore the decision making process incvolved in farming, the incentives behind why certain seeds were selected by farmers was asked. The most common answer was farmers select the seeds they perceive as "best" (45%) which was clarified to mean the highest yield. Cost and availability were also implicated as involved in the decision making process.

When asked why certain adaptive practices were not already being used, the most common response was a lack of knowledge of alternative farming practices. Economic cost and resource constraints were also implicated by some farmers (**Table 5**).

Table 5: Limitations to implementing new agricultural practice

	Limitation					
	Knowledge	Cost	Resources	Time	Traditions	Unsure
Frequency	94	12	9	4	6	9
% of Respondents	78	10	7.5	3	6	7.5

Discussion

Demography

The total 120 questionnaires completed provided a suitable sample size for this study. Age, gender, education and experience were found to be statistically insignificant across the six villages indicating that the sample population was random across the FAPP project area. Age and experience varied greatly indicating that farming is not a livelihood limited to just one social group, reiterating the importance of agriculture for Fijian livelihoods. Education showed a highly peaked distribution with most farmers responding that they completed secondary education (11 years of schooling in total) and did not progress further although outliers were present.

While community meetings and extension services were primarily attended by men, a greater than expected number of female farmers also attended allowing for gender analysis. When comparing male and female farmers, no significant difference was detected in age, experience or education which is contrary to other development literature that suggests women are excluded from formal education systems.[32,48,49]

When examining age and education, a significant negative correlation was observed that did not differ by gender. This shows that older farmers received fewer formal years of education and may benefit more from future education outreach in these rural communities. This is consistent with previous agriculture literature.[39]

Years of experience in the village was examined to see if communities are highly mobile or if farmers spend long periods of time in once place. When compared against age and gender, a statistically significant ANCOVA regression was generated. Overall, older members of the community have spent more years in the village as expected. However, this relationship is shallower for women compared to men indicating that young men are more mobile than young women whereas older men are more likely to have remained in their village for many years. It should be noted that the sample size for female respondents was smaller than that of men and would benefit from further investigation.

Financial services

Financial services were examined to explore any financial limitations or opportunities for FAPP recipients. The question explored access to financial services but failed to capture if respondents *used* financial services which future studies would benefit from exploring. Despite this limitation, over half of respondents reported access to banking and finance which did not

differ based on gender or village indicating equal access between location and gender. This also contradicts previous studies that suggest women or older people are excluded from formal financial institutions[33,48,50,51].

Crop Selection and Diversity

Traditional agriculture in the FAPP area includes a focus on kava, cassava and dalo which is consistent with the three most grown crops reported in this sample.[45] FAPP focuses on a transition from subsistence agriculture towards agriculture as a business which includes increasing crop variety and high-value products e.g. ginger, chile. Respondents reported growing a variety of vegetables (cabbage, capsicum, lettuce, aubergine) but in low frequency. When comparing the crop diversity across villages, no significant difference was detected. This suggests that while the crops grown across the project area vary, the overall diversity does not, especially in relation to kava and dalo. An overreliance on these crops limits resilience and creates vulnerability, especially as kava requires 3-4 years before it becomes a viable crop.

Climate Perceptions and Environmental Impacts

The first research question for this study was focused on the climate perceptions of farmers.

a) Temperature

Meteorological data show a clear trend of warming in Fiji, but this was less clear in farmer perceptions with only 55% in agreement and 32% responding that temperatures had decreased. The survey was conducted in the coldest months and recent/current cold nights may have biased respondents towards recent cold events rather than yearlong trends.

b) Rainfall

Rainfall models are uncertain for Fiji but suggest the amount of rain will remain the same, but the intensity will increase.[6] Responses from farmers showed little consensus when discussing rainfall. Less rainfall was the most common response despite little meteorological support for this.[5,6] The lack of consensus can be interpreted as large variation or no obvious trend. The frequency of rainfall response showed even less consensus despite 73% of respondents reporting increased drought conditions. It is possible this question was simply misinterpreted or that overall, farmers are unsure.

c) Cyclones

The greatest agreement was found when farmers were asked about the change in cyclone severity with over ¾ agreement for an increase. This is consistent with climate predictions for the future although historic data is inconclusive at this stage.[5,6] Cyclone frequency is reported to be decreasing but this survey showed more farmers felt they were increasing. This is possibly due to the recent Cyclone Winston 2016, the most devastating cyclone to hit Fiji, being fresh on people's minds as rebuilding is still going on.[1,12]

Climate Impacts

All seven climate impacts explored in this study were reported as already occurring in rural villages in Fiji. Climate changes are not the only cause for these environmental changes but may contribute towards them. However, regardless of their origin, the presence of these environmental changes will have significant interaction within future climate change. The government publications from which these impacts were initially taken from are accurate in identifying key challenges for rural highland areas as they are already present.

There was no significant difference between villages when examining overall number of impacts observed suggesting that no village can be isolated as particularly vulnerable or stressed. Future studies could examine climate change impacts in isolation to see if there is spatial variation at this finer scale but was beyond the scope of this initial exploratory study.

Farmers overwhelmingly agree that changes to climate will make their agricultural activities more difficult (86%), consistent with Ministry of Agriculture research and publications. Unless FAPP and other extension services can equip farmers to adapt alongside climate change, this increased difficulty will limit the success of any farmer attempting to transition from subsistence to farming as a business.

Climate Change Knowledge

Climate change permeates every aspect of top-down policy and reporting, domestically and internationally for Fiji. However, this study has revealed a knowledge gap in that 23% of respondents were unfamiliar with the term. While 77% familiarity would be considered high for other development settings, as a climate leader, it would be expected that Fijians are more familiar with the term. Despite the unfamiliarity, over 95% of respondents agreed that the climate in their local environment was changing. This result is concerning as it shows how climate change is already being experienced in Fiji at the local scale. This is not unexpected due to SIDS being the first predicted to experience climate departure.[52] As those most familiar

with their local environment, highland farmers are providing local level, bottom-up feedback that climate change is indeed progressing rapidly in Fiji.

Climate change information was predominantly accessed through radio, newspapers and TV. As these tend to be in English, the information within these reports may be inaccessible to many rural villages who are less confident with English and scientific language used. School, internet, government extension and NGOs were also mentioned indicating that there are other information streams that FAPP and MoA outreach can utilise. It is interesting to note the NGO response was almost entirely from one village and cited as a recent REDD+ extension service indicating that such extension services can be effective in conveying climate change information.

Almost half the respondents did not have any answer to what causes climate to change. However, several common responses did show the association of human activity with climate change such as pollution from air and waste, deforestation and population growth. In contrast to a previous study in Fiji river basins, God's Will was only mentioned by 2 respondents which is much lower than previous studies.[4] This may be due to the increased media attention climate change received in Fiji in recent years due to the Paris Agreement and COP23. Despite this, there is still a knowledge gap and misunderstanding that is present at the local level that is not present at the government and policy level.

Adaptations and Farming Practice

Twelve adaptive practices were investigated in this study and their adoption varied. The most common practices used by farmers form the core of traditional Fijian agricultural systems, intercropping, crop rotations and cover cropping. This suggests that traditional management remains widely practiced.[53] Financial, resource and labour intensive practices showed less uptake such as irrigation, alternative income sources, organic and inorganic fertiliser use.

This suggests social and economic capital are limitations to some degree for rural farmers to buy fertilisers, install irrigation systems and diversify incomes. As many farmers reported that a lack of knowledge regarding alternative management practices influenced their farming (78%), access to information and agricultural training could facilitate more adaptive practice uptake. Seed selection responses also mirror these limitations with 20% of farmers referencing access to seeds and economic costs respectively, as informing seed selection decision making.

There was a significant difference in adaptive practices between villages suggesting that agricultural management varies spatially across the FAPP area. This is consistent with the

fact that adaptation must always be context specific to the needs of the community.[54] Adaptation can be paradoxically maladaptive when applied incorrectly.[36] The confirmation that the agricultural system already shows spatial variation adds to the support that a one-size fits all model will not be appropriate across the entire FAPP region.

The relationship between climate related impacts and adaptive practice was explored using regression analysis in **Fig. 17**. The statistically significant, positive relationship indicates that those farmers who perceive greater environmental stress in their local environment are engaged in more climate adaptive practices. While consistent with the theory that those who depend on their environment for their livelihoods are more sensitive to any changes, it can't be assumed that this is a causal relationship. Many factors influence management practice and climate is only one strand of this decision-making process. However, this positive result does show correlation and suggests that as climate change progresses, farmers will engage in more adaptive practices. Caution should also be taken with this regression as there is a large spread and few data points at low impact values which could skew the relationship.

This regression result is consistent with the response that >90% of farmers felt adaptation to climate change was possible. Belief that adaptation is possible has been highlighted elsewhere as a pre-requisite for successful adaptation and is reassuring when considering future climate adaptation across Fijian highlands.[31]

Conclusions

Fiji is a climate leader when it comes to government policy and international presence within the climate arena. This study explored the gap between local level climate perceptions and adaptation, and the top-level policy. Highland, rural farmers within the FAPP area are experiencing climate change already but are not consistent in reporting those changes when compared to meteorological data. However, almost all farmers agree that the climate in their local environment is changing showing that climate change is already being felt by those most sensitive to their local environment. Previous government specified impacts of climate change are already present at the local level and being experienced by farmers. As climate change progresses, these impacts will become more severe.

Knowledge of climate change is not as pervasive at the local level as it is at the policy level. There are farmers in rural communities who have never heard of climate change and therefore it future extension services must not assume a pre-existing level of understanding. The causes of climate change are even less understood and represent another knowledge gap.

Traditional agriculture is widely used across the FAPP area and improves climate resilience. This will limit the scope for further adaptation uptake in the future as these systems already have inherent resilience. Other adaptive practices show limited adoption, often due to social or economic capital limitations which may allow for some future adaptation.

As farming in Fiji has always been subject to a variable and challenging climate system, inherent climate resilience is already present, and farmers feel confident in their ability to continue to adapt in the future. However, the rate of climate change will outpace the system's ability to adapt unless farmers are equipped to best respond to new environmental pressures. Incorporating climate smart responses into future extension services will contribute towards this climate resilience.

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Appendix A – Questionnaire

CLIMATE CHANGE, CLIMATE VARIABILITY AND ADAPTATION QUESTIONNAIRE

Date:_____ **District:**_____

ID# :_____ **Village:**_____

Start Time:_____ **Cluster:**_____

Finish Time:_____

CONSENT: Hello. My name is _____. I am conducting a survey with IFAD and the Ministry of Agriculture. This survey and research will help planning and monitoring project activities. Your participation is voluntary. You can choose not to answer any questions, and you can stop the interview at any time. All of your responses will be confidential. Would you like to ask me anything else about the survey? Do you agree to participate in this survey?

YES ☐ **NO** ☐

MODULE A: PERSONAL INFORMATION

1	Sex	MALE…….. 0 FEMALE……. 1	
2	How old are you?	*Number in years*	
3	What is your marital status?	SINGLE…….. 1 MARRIED…. 2 WIDOWED… 3 DIVORCED… 4	
4	How many years of school did you attend?	*Number in years*	
5	How many years have you lived in your village?	*Number in years*	
6	How many people live in your household?	*Number*	
7	Do you own a radio?	YES…… 1 NO…….. 2	
8	Do you own a mobile phone?	YES…… 1 NO…….. 2	
9	How many **sleeping** rooms are there in your house?	*Number*	
10	Is farming your main source of income?	YES…… 1 NO…….. 2	
11	Do you keep any livestock?	YES…… 1 NO…….. 2	
12	What are your primary crops produced?	*Enter crop name(s)*	
13	How do you compare the production crops within the past 5 years?	NO CHANGE…… 1 IMPROVED…… 2 REDUCED……...3 UNSURE ….4	
14	Do you have access to financial services? *(credit, lending, etc).*	YES…… 1 NO…….. 2 DON'T KNOW….3	

MODULE B: PERCEPTIONS OF CHANGES TO THE LOCAL CLIMATE

15	Since you were a teenager, has the temperature changed in this area?	INCREASED…… 1 DECREASED…….. 2 NO CHANGE…….. 3	
16	Since you were a teenager, has the amount of annual rainfall changed?	INCREASED…… 1 DECREASED…….. 2 NO CHANGE…….. 3	
17	Since you were a teenager, has the timing of rainfall become….	MORE PREDICTABLE.. 1 LESS PREDICTABLE…. 2 NO CHANGE…….. 3	
18	Since you were a teenager, has the frequency of cyclones changed?	MORE OFTEN…… 1 LESS OFTEN …….. 2 NO CHANGE …….. 3	
19	Since you were a teenager, has the severity of cyclones changed?	INCREASED…… 1 DECREASED…….. 2 NO CHANGE…….. 3	

20 Have you noticed any of the following changes in your local environment in recent (5-10) years?

	Yes	No	Don't Know
Soil erosion			
Decrease of soil fertility			
Declining crop yields			
New crop disease and pests			
Reduced water availability			
Change to timing of cropping season			
Loss or disappearance of non-agricultural, natural plants			

21 Tick the box that matches your perceptions of the following statements.

	Strongly Agree	Agree	Uncertain	Disagree	Strongly disagree
Flooding has become more common					
Drought has become more common					
Changing climate has led to rural-urban migration					
Farming has become more difficult due to changes in climate					

MODULE C: KNOWLEDGE OF CLIMATE CHANGE

22	Before this survey, had you heard of "climate change" before?	YES…… 1 NO…….. 2 >>24 DON'T KNOW....3	
23	Where did you access information about climate change?	*Circle:* Radio TV School Internet Newspapers Government Extension NGO Other:	
24	Do you think climate change is already happening?	YES…… 1 NO…….. 2 DON'T KNOW....3	

25 What do you think is the primary cause of climate change?

Increasing population		Change from traditions		Burning fossil fuels	
Deforestation		God's will		Pollution from waste	
Vehicle emissions		Other: (*specify)*			

26 What other causes do you think contribute to climate change?

Increasing population		Change from traditions		Burning fossil fuels	
Deforestation		God's will		Pollution from waste	
Vehicle emissions		Other: (*specify)*			

MODULE D: ADAPTATION TO CLIMATE CHANGE

27 Please indicate if you practice any of the following:
*Explain what each term means if necessary**

	Yes	No
No tillage		
Contour plowing		
Agroforestry		
Irrigation		
Water harvesting		
Non-agricultural income		
Leave field to fallow		
Intercropping		
Crop rotations		
Cover crops		
Apply mulches or manures		
Fertiliser application		
Pesticide/Herbicide application		

Read: "Adaptation means doing something new or different to what you or your community did in the past in order to adapt to climate change"

28	Do you think you can adapt to climate change?	YES…… 1 NO…….. 2 DON'T KNOW….. 3	
29	Do you think climate change will continue effect this area for generations to come?	YES…… 1 NO…….. 2 DON'T KNOW….. 3	

30 What is the main reason you select the seeds you plant?

High yields		Requires less water		Disease resistant	
Only seeds available		Cheap to buy		Pest resistant	
Other: (*specify):*					

31 What are the major hindrances to adapting to climate changes in this area?*

Financial Cost		Lack of improved seeds		Lack of labour supply	
Access to farming tools		Lack of knowledge of adaptation methods		There is no barrier to adaptation	
Adaptation is not necessary		Other: (*specify)*			

32	How often do you access weather forecasting?	DAILY…… 1 WEEKLY…….. 2 MONTHLY…….. 3 ONCE PER SEASON…….. 4 NEVER……..5>>36	
33	How do you access weather forecasting?	*Circle:* Radio TV SMS Internet Newspapers NGO Neighbours/Family Other	
34	Has the weather forecast been helpful in planning your farming activities?	YES…… 1 NO…….. 2 DON'T KNOW….. 3	

35 Is there anything else you wish to add about climate change issues in this region?

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Appendix B – Normality Testing

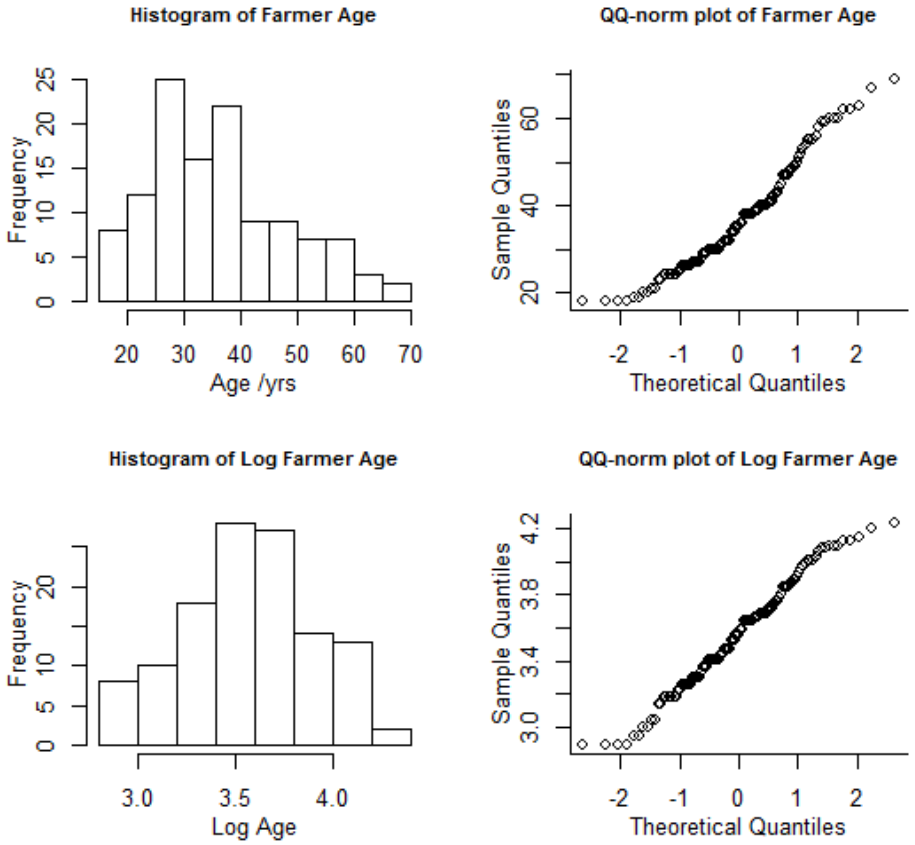

Fig. B1: Histogram and QQ-norm plots of age and lage of respondents

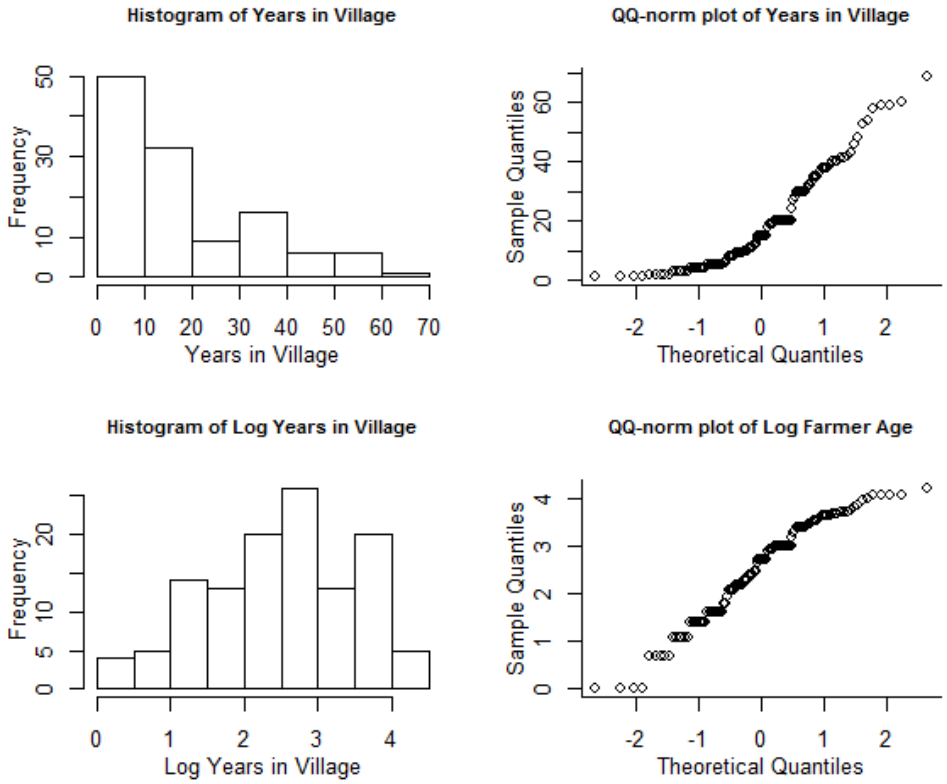

Fig. B2: Histogram and QQ-norm plots of experience and lexperience of respondents

Appendix C – Regression Tables

Table C1: Regression table showing ANCOVA model of log experience regressed upon log age * gender

	Dependent variable:
	Log-Experience
Log-Age	2.622***
	(0.255)
Gender	3.716**
	(1.527)
Age*Gender	-1.071**
	(0.426)
Constant	-6.764***
	(0.905)
Observations	120
R^2	0.522
Adjusted R^2	0.510
Residual Std. Error	0.733 (df = 116)
F Statistic	42.242*** (df = 3; 116)
Note:	*p**p***p<0.01

Table C2: Regression table showing ANCOVA model of education regressed upon log age * gender

	Dependent variable:
	Education
Log-age	-2.800***
	(0.970)
Gender	-9.445
	(5.821)
Age*Gender	2.745*
	(1.623)
Constant	20.692***
	(3.450)
Observations	120
R^2	0.069
Adjusted R^2	0.045
Residual Std. Error	2.796 (df = 116)
F Statistic	2.859** (df = 3; 116)
Note:	*p**p***p<0.01

Table C3: Regression table showing regression model of adaptive practices upon climate impacts.

	Dependent variable:
	Adaptive Practices
No. Climate Impacts	0.281***
	(0.105)
Constant	5.682***
	(0.615)
Observations	120
R^2	0.057
Adjusted R^2	0.049
Residual Std. Error	1.705 (df = 118)
F Statistic	7.102*** (df = 1; 118)
Note:	*p**p***p<0.01