OPEN ACCESS

GAVIN PUBLISHERS

Current Trends in Oceanography and Marine Science

Blair A. Curr Trends Oceanogr Mar Sci 2: 109.
DOI: 10.29011/CTOMS-109.100009

Research Article

Climate Variability and Change in The Caribbean and The South Pacific: Learning from Farmers' Perceptions and Responses in Antigua and Efate

Adelle Blair[1], Salim Momtaz[2]

[1]University of Newcastle, Australia

[2]University of Newcastle, Australia

Corresponding author: Adelle Blair,University of Newcastle, Australia. Tel: 268 4645198; Email: aacblair@gmail.com; Adelle.Blair@uon.edu.au

Citation: Blair A, Momtaz S (2019) Climate Variability and Change in The Caribbean and The South Pacific: Learning from Farmers' Perceptions and Responses in Antigua and Efate. Curr Trends Oceanogr Mar Sci 2: 109. DOI: 10.29011/CTOMS-109.100009

Received Date: 02 April, 2019; **Accepted Date:** 17 April, 2019; **Published Date:** 26 April, 2019

Abstract

Generally, the research sets out answer the following questions: (1) what is the level of perception of climate change and its impacts among key stakeholders who rely on the coastal environment for their livelihoods? (2) what climate change adaptation plans and measures have been implemented within these livelihoods? The purpose of this paper is to assess the responses of farmers to the impacts of climate variability and change in two small islands. Agricultural production in the Caribbean and the South Pacific is rain-fed thus vulnerable to the negative impacts of climate variability and change which include precipitation changes. Very little to no information is available on climate change perception in small islands hence a study which examines farmers' perception of climate change, how they match meteorological data and their adaptation strategies. This study uses a survey questionnaire to gather data on perception, adaptation measures, demographic and other factors from eighty farmers on two islands, Antigua and Efate. Farmers perceived changes in precipitation, temperature and wind speed. For both islands, the farmers' perception did not always coincide with the meteorological data signalling the need for further work to determine the underlying reasons which may include distance of farms from data collection stations. All implemented crop, water and land management techniques as well as income diversification measures either to adapt to changes in their climate or as routine practices. We conclude that more information and support from government extension and meteorological departments, could help farmers to better understand and respond to climate variability and change.

Keywords: Adaptation; Antigua; Climate Change; Efate; Farmers; Perception

Introduction

Some studies provide evidence that globally, temperatures have increased over the last 1,500 years by as much as 0.19 ˚C per decade since 1980, corresponding with increases in carbon dioxide emissions, associated with the burning of fossil fuels [1-3]. More recent studies such as [4]. reported that between 1998 - 2012, the warming rate was higher than indicated by the Intergovernmental Panel on Climate Change [5]. Further, changes in rainfall patterns are predicted to cause flooding and drought in some regions and sea level rise is also predicted to cause coastal flooding [6]. Climate change is also expected to affect crops, increase pests, pathogens and weeds as well as reduce the number of pollinators [7].

The Caribbean and the Pacific have been described as regions seriously affected by climate change, threatening many livelihoods including commercial agriculture [8-10]. For the Caribbean, it is likely that agriculture will be affected by increases in temperature and an annual reduction in rainfall by around 12% [11]. In the Pacific, climate change will also affect agriculture as a result of higher temperatures and extremes in rainfall events with possible increases by up to 2% in some places. Considering these projections, it is important to assess adaptation within farming as it plays an integral role in the socio-economic development of these countries.

Climate change adaptation is a process which involves perceiving and learning through observation of climatic impacts and the adoption of response measures to lessen these impacts or to benefit from opportunities which may become available [12-13]. A study of how farmers have adapted to climate variability and change begins with an understanding of their perception of climate change, which may be direct, learning visually from the environment, or indirect, through the means of internal processes such as memories [14-16].

Whilst the number of perception studies in developing countries which specifically focus on farmers and their responses to climate change and variability have increased over the past few years, studies on small islands are severely limited [17]. Such studies highlight that farmers are aware of aberrations in the climate and their responses have been mainly spontaneous, that is, at the individual level [18-19]. Elsewhere, studies have been conducted on farmers' perception of soil erosion and land degradation and the level of investment in solving these problems. The results have been mixed. Some studies found that although the farmers were highly knowledgeable about soil erosion and conservation, they did not utilize the known control and conservation techniques [20-22]. However, positive associations between soil erosion and land degradation and the implementation of a wide range of management practices exist [23-25]. An understanding of how farmers perceive climate variability and change helps to improve social communication and assist in the development of relevant adaptation strategies and policies [26]. With this backdrop, this study aims to examine the farmers' perception of climate change as well as their implemented adaptation strategies.

Study Sites

The study was conducted on two islands: Antigua, within the twin-island nation of Antigua & Barbuda in the Caribbean Sea/ Atlantic Ocean and Efate, an island within the Shefa Province of the Republic of Vanuatu in the South Pacific Ocean. For Antigua, the study area extended from the southwest in the Parish of St. Mary, eastwards to St. Paul and St. Philip parishes and northward through the parishes of St. Peter and St. George. This means that all parishes on the island were covered except St. John, the main urban centre, which has no significant agricultural holdings. The study area on Efate extended from Erakor in the southwest and northward to Mele, Part Havanah and eastward to Onesua, Epao, ending in the southeast in the Eton area. Overall, the study areas looped around both islands, covering all significant agricultural holdings.

Antigua

The island of Antigua is the larger of the two inhabited islands of the country of Antigua & Barbuda (Redonda, the third, is uninhabited) and contains the main urban centre. This island has an area of 281 km2 and the highest elevation 402 m. The population in 2013 was approximately 90,000 [27]. It has a tropical climate and is usually warm and dry with average daily temperature is approximately 28 °C. The average annual rainfall is 1143 mm and the island is drought-prone. In Antigua & Barbuda, tourism is the mainstay of the economy. The agricultural sector contributes 2% to the Gross Domestic Product (GDP) and provides employment for 21% of the labour force [28]. Production is mainly for the domestic market (tomatoes, carrots, mangoes, livestock) but sea island cotton is exported.

Efate

Vanuatu is an archipelago consisting of approximately 80 islands with approximately 65 being inhabited. Efate is the main urban centre of Vanuatu. It is the third largest island in the country with a population in 2009 of approximately 66,000 [29]. It is 900 km^2 in size and consists of a mountainous rainforest interior and sandy bays and lagoons along the coast and many rivers. The highest elevation reaches 647 m and the island receives an annual average rainfall of 2128 mm. In the Republic of Vanuatu, there has been a focus on developing tourism which is the main contributor to the country's GDP. Agriculture accounts for 28% of GDP and provides employment for 65% of the labour force. The main agricultural products include copra, coconuts and timber, some of which are exported to places like Thailand and Japan.

Materials and Methods

This work is part of a PhD thesis which looks at climate change impacts and responses in SIDS. This paper describes some of the results from one of three livelihoods explored in the research. It focuses on perceptions of farmers and their responses to climate variability and change.

The questionnaire

A structured questionnaire survey was used to interview a random sample of 40 arable farmers from each island. Field visits were conducted in Antigua during June and July 2014 and in Efate during October and November 2014. The questionnaire was pre-tested in Antigua on a pilot group of 30 which included 2 farmers and 5 Agricultural Officers to enhance the design and content where necessary. A sample size of 30 was used for the main survey as this falls within the range established in qualitative research literature [30-31]. To account for possible non-response, the sample size was increased by 20% [32]. The 40 farmers from each island represent 3.3% and 2.1% of crop farmers from Antigua (2007 Agricultural Census) [33]. and Efate (2009 Census) [34]. respectively.

Farmers were selected who were registered with the local authorities with 10 or more years of experience within the livelihood. In instances where participants did not meet the criteria, a convenience sampling technique was used to obtain the remainder. In this case, 4 of Efate's 40 questionnaires were completed through convenience sampling by farmers with 5-8 years' experience. These farmers were invited to participate whilst the other interviews were being conducted at the main market in Port Vila where they rented stalls to sell their produce. The registered farmers were contacted either via the telephone or face-to-face and the place and time of interviews were established (usually on the farms). All were given information statements to read and sign before the interviews were conducted mainly by the researcher. However, in instances where there were several farmers together especially at the main market in Port Vila, Efate, interviews were also conducted by the researcher's assistant and in others, the questionnaires were self-completed. The questions were in English.

The questionnaire consisted of three parts. Part A addressed the demographic characteristics of the respondents and included questions pertaining to number of years in farming, land tenure, income sources and number in their employ. Part B looked at the meaning of climate change as well as perception and impacts on the livelihood and adaptation measures. In this Part and the next, Likert Scales were used in addition to tick-the-box questions. For the Likert Scale questions, there were five options ranging from strongly agree to strongly disagree. Part C dealt with climate change and the farming industry, addressing inter alia changes in flowering times, growing seasons and yields and water concerns. Changes to the business were also explored as well as the impacts of extreme weather events such as heavy rainfall on their operations. This section also looked at future expected impacts and barriers to adaptation. Farmers were also asked about the need for information and training and were invited to give further comment on climate change and their businesses. All interviews were conducted during the day. The questionnaires were completed anonymously and took approximately 20 minutes to complete. The questions they were easily understood by the respondents. The scope of the study was limited to commercial farmers because of the importance of the agriculture to the economies of small islands.

Data analysis

Quantitative survey responses were collated by island on spread sheets using Microsoft Excel (2010). The information was then analysed using the SPSS (version 23) to produce summary statistics and frequency tables to compare the socio-demographic characteristics of the participants. Fisher's Exact Test, a non-parametric test, was used to determine statistical significance within frequency tables as well as whether non-random associations were present between data from both islands.

Climate data were collected from the meteorological departments in both Antigua & Barbuda and Vanuatu for the 43 years from 1971-2014. In the case of Antigua, although the southern and south-western regions (the agricultural belt) receive more rainfall than the north-eastern region where the meteorological department is located, the rainfall data collection was inconsistent during the period 1957-2013, with several months' data missing [35]. Similarly, all climate data for Efate were obtained from the national meteorological department for ease of comparison and to ensure data reliability.

The data were analysed using the Mann-Kendall (MK) trend test by means of the Addinsoft XLSTAT 2016.06.36773 for Microsoft Excel. The MK method is used to detect linear trends mainly in rainfall and temperature time series and has been endorsed by the World Meteorological Organisation and was used in many recent studies [36-37]. The MK test is used to determine statistical significance within the data at a p-value=0.01. The MK statistic (S) indicates the existence of a positive or negative trend in the data (ITRC, 2013). In XLSTAT 2016, the MK statistic (S) used for the test and its variance are given by

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} Sgn(x_j - x_i) \quad (1)$$

$$Var(S) = \frac{n(n-1)(2n+5)}{18} \quad (2)$$

in which n represents the number of observations and x_i (I=1…n) are the independent observations.

The Sen's slope estimator tells the magnitude of the slope in the trend [38]. Based on [39]. the slopes (T_i) of all data pairs are first obtained using

$$T_i = \frac{x_j - x_k}{j-k} \quad \text{for } i = 1, 2, \ldots, N, \quad (3)$$

in which x_j and x_k are data values at time j and k ($j > k$) respectively. The median of these N values of T_i is Sen's estimator of slope which is calculated as

$$\beta = \begin{cases} T_{\frac{N+1}{2}} & N \text{ is odd,} \\ \frac{1}{2}\left(T_{\frac{N}{2}} + T_{\frac{N+2}{2}}\right) & N \text{ is even.} \end{cases} \quad (4)$$

A positive β indicates an upward or increasing trend while a negative result indicates a downward or decreasing trend in the data. Both methods have now been used extensively to identify positive or negative trends in meteorological data as well as the resulting statistical significance determined by a p-value <0.05 [40].

Qualitative responses were organized and coded into themes based on the issues highlighted and their frequencies. Themes that emerged were concerns over the inadequacy of extension services and the need for more information on climate change.

Results and Discussion

Farmers' characteristics

(Table 1) presents a summary of the demographic characteristics of the farmers. The highest percentage of farmers from both islands were males and between the ages of 45-54 and had attained primary level of education. The highest percentage of Antiguans made over USD2000 in weekly income (data were standardized) while 97.5% of Efate's farmers made <USD 200. On average, the Antiguans had 12 more years of experience in farming than Efate's farmers. These variances in income and years of experience may be attributed to cultural differences, standard of living and activities undertaken by the farmers in both islands.

Factors		Antigua	Efate
Gender (%)	Male	85	50
	Female	15	50
Age Range (%)	18-24	2.5	12.5
	25-34	7.5	12.5
	35-44	10	20
	45-54	37.5	32.5
	55-64	35	15
	65-74	7.5	7.5
	75+	0	0
Marital Status (%)	Single	Visiting 20 Common-law 10	Visiting 12.5 Common-law 7.5
	Married	62.5	75
	Divorced	5	0
	Widowed	0	2.5
	Separated	2.5	2.5
Number of years as a Farmer		Range 10-40 Mean 26 Mode 17.5	Range 5-30 Mean 14 Mode 10

Factors		Antigua	Efate
Level of Education (%)	Primary	40	70
	Secondary	32.5	12.5
	Technical/Vocational	15	2.5
	College	10	0
	University	2.5	2.5
	No Formal Education	0	12.5
Weekly Income Range (in US $) (%)	1-199	2.5	97.5
	200-299	5	0
	300-399	17.5	0
	400-599	17.5	2.5
	600-799	10	0
	800-999	2.5	0
	1000-1249	12.5	0
	1250-1499	0	0
	1500-1999	2.5	0
	2000+	30	0
Number of Financial Dependents		Range 1-50 Mean 10 Mode 9	Range 1-10 Mean 5 Mode 4

Table 1: Farmer's Demographic Characteristics.

Farmers' awareness and perception of climate change

The findings revealed that farmers from the Caribbean and the South Pacific perceived that they are experiencing changes in their climates (Table 2). Most perceived that the weather pattern had changed, temperatures had increased, rainfall had become unpredictable, droughts were more frequent and winds were stronger. These perceived changes are critical to agricultural productivity and affect various crops differently. These impacts must therefore be addressed separately.

Variables	Agreed (%)		Disagreed (%)		Neutral (%)	
	Antigua	Efate	Antigua	Efate	Antigua	Efate
Increased flooding	26	76	68	3	6	21
Increased rainfall amount	18	79	70	0	12	21
Unpredictable rainfall pattern	88	76	5	0	7	24
Rainfall events have not become more intense	65	11	26	40	9	49
Lower temperatures	18	61	68	12	14	27
Stronger winds	55	70	20	6	25	24
More frequent droughts	88	67	5	3	7	30
Increased hurricanes/ cyclones/storms	43	61	35	3	22	36
Strange changes in the weather pattern	93	64	4	3	3	33

Warmer summers	86	73	3	3	11	24
Wetted winters	18	73	53	0	29	27
Higher temperatures	91	76	0	0	9	24
Decrease in heat extremes	8	6	80	54	12	40

Table 2: Farmers' Perception of climate change.

Perception of rainfall changes

For Antigua, 70% of the farmers believed that rainfall had decreased. Between 1972-2014, there had been considerable variability in the rainfall pattern but no statistically significant trend was found at the 95% confidence interval (Figure 1). However, the nature of the trend is negative as indicated by the values for Kendall's (S) and Sen's slope estimator (Table 3). Seventy-nine percent of Efate's farmers perceived that rainfall had increased. shows that the positive values of Kendall's (S) and Sen's slope estimator indicate an increasing trend though not statistically significant.

Figure 1: Annual Rainfall for Antigua and Efate (1972-2014).

Variables	Mann-Kendall Test								Sen's Slope Estimator			
	Kendall (S)		Trend Nature		*P*-Value		Trend Significance		Magnitude		Trend Nature	
	Antigua	Efate	Antigua	Efate	Antigua	Efate	Antigua	Efate	Antigua	Efate	Antigua	Efate
Annual Rainfall	-39	83	Negative	Positive	0.68*	0.38*	No	No	-1.403	5.491	Negative	Positive
Maximum Temperature	142	180	Positive	Positive	0.14*	0.00*	No	Yes	0.007	0.053	Positive	Positive
Minimum Temperature	0.274	76	Positive	Positive	0.01*	0.14*	Yes	No	0.011	0.025	Positive	Positive
Wind Speed	-268	40	Negative	Positive	0.00*	0.40*	Yes	No	-0.050	0.000	Negative	Positive
* Two-tailed test at significance level: α 0.05.												

Table 3: Results of trend analyses for selected climatic variables, Antigua and Efate.

In both cases, variability was detected in the rainfall data but it did not support the perception that rainfall had decreased for Antigua and increased for Efate. However, as also found by [41]. the direction of Kendall's (S) and Sen's slope were usually compatible with the farmers' perceptions as found in this research. Previous studies have also reported that farmers' perception about rainfall changes did not match with meteorological data and recommended more education on climate variability and change [42]. Still the farmers implemented adaptation strategies that were related to their perception, many of which may also be attributed to improving their yields and soil quality.

Perception of temperature increase

Ninety-one per cent of the Antiguan farmers perceived that there was an increase in temperature. The MK test indicates the trend for maximum temperature was close to being statistically significant (*p*=0.14). This increase was substantiated by the positive trend of Sen's slope. However, the minimum temperature was found to be increasing with a statistically significant trend (Figure 2). Seventy-six per cent of Efate's farmers perceived that temperatures had increased. A statistically significant trend (*p*=0.00) was observed in the maximum temperature data at the 95% confidence level. Regarding the minimum temperature, the MK test indicates that the trend was close to being statistically significant (*p*=0.14).

Based on the results of the MK tests, temperatures (both maximum and minimum) have increasing trends in both islands. Therefore, the farmers' perceptions matched the meteorological data. Previous studies have reported that farmers' perception of increased temperatures were corroborated by meteorological data [43] With specific reference to maximum and minimum temperatures found that the minimum temperature variable yielded a larger warming trend than the maximum temperature as found in Antigua. Other studies have found that daytime temperatures have greater increasing trends than night-time temperatures as found in Efate [44]. These increases will negatively impact the farmers as extremes in temperature affect plant development and growth, pollination, soil water balance and ultimately crop yield.

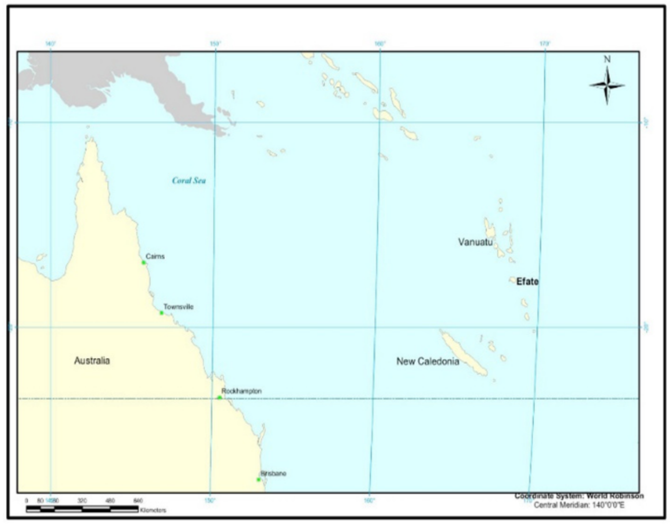

Figure 2: Trends in Maximum and Minimum Temperatures, Antigua and Efate (1971-2014).

Perception of stronger winds

Fifty-five per cent of the Antiguans perceived that winds were stronger. However, the MK test indicates that there is a statistically significant decreasing trend which is corroborated by Sen's slope estimator (Figure 3). For Efate, 70% of the farmers perceived that winds were stronger. Nevertheless, the meteorological records revealed no statistically significant trend and Sen's slope estimator indicates that there is no trend. However, the MK (S) suggests that the nature is upward, that is, it is increasing. A number of global studies have found that over the last 30-50 years, there have been a decreasing trend in seasonal and or annual mean wind speed in places such as the Caribbean [45]. Studies have also reported that in other places, there are either no trends or an increase in some oceanic regions as the Pacific, as found in Efate [46]. Nevertheless, the farmers' perceptions were not corroborated by the meteorological data. It must be stated, however, that this could be due to wind speed variations at both airports and farm locations.

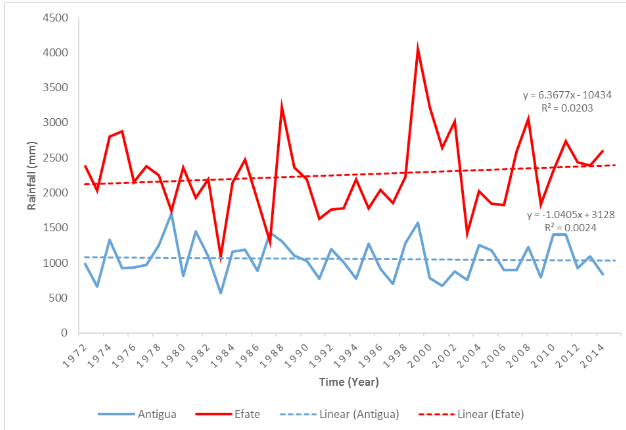

Figure 3: Wind Speed trends for Antigua and Efate (1971-2013).

Farmers' perception of climate change impacts on the farm

In addition to changes in the climate, the farmers perceived that several changes had occurred on their farms within the last decade (Table 4).

Changes	Agreed (%)		Disagreed (%)		Neutral (%)	
	Antigua	Efate	Antigua	Efate	Antigua	Efate
Freshwater shortages	96	58	0	15	4	27
Changes in Crop Seasonality	83	61	14	6	3	33
Reduced number of Pollinators	70	55	18	18	12	27
Increased incidences of Pests	90	52	3	12	7	36
Increased incidences of Diseases	83	58	5	6	12	36
Increased incidences of Weeds	55	67	28	3	17	30
Increased Crop Varieties	53	64	30	0	17	36
Increased incidences of Saline Intrusion	50	39	33	15	17	46
Changes in the growing season in my country	73	57	26	0	1	43
There has been an increase in new insects	98	17	0	37	2	46
Crop yield has decreased	88	32	11	11	1	57

Table 4: Perceived changes on the farm.

The main changes perceived in both islands were freshwater shortages, changes in crop seasonality and growing season and increased incidences of pests and diseases. Similar findings to this study were reported in rural Senegal where water scarcity was perceived as the main issue [47]. The perceived increase in new insects in Antigua was consistent with the findings of [49] who found this as the main barrier to production. Efate's farmers' perception that weeds had increased was also reported by [42] and responses included chemical and biological inputs to reduce the infestation. These results mean that farms are under threat from abiotic and biotic stresses which must be resolved often with costly measures.

Adaptation strategies

In response to the perceived changes in the climate and on the farms, all farmers implemented several strategies (Antigua: *n*=40, Efate: *n*=37). However, it must be noted that the implemented measures could also be considered as routine strategies by farmers to maximise profits, reduce the spread of plant/diseases while maintaining soil fertility.

Crop management

The main measures implemented in both islands were crop rotation, changes in crop varieties and planting of shade trees (Figure 4). Similar methods of modifying farming practices, crop types and varieties were reported in other studies [48]. Crop diversification and the breeding of new varieties with greater tolerance to local abiotic and biotic stresses such as drought and insects, respectively, have been found to lessen the impacts of climate change [48-49].

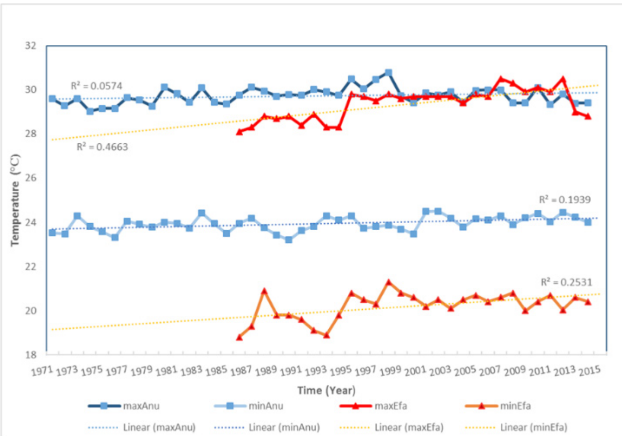

Figure 4: Trends in Maximum and Minimum Temperatures, Antigua and Efate (1971-2014).

Water management

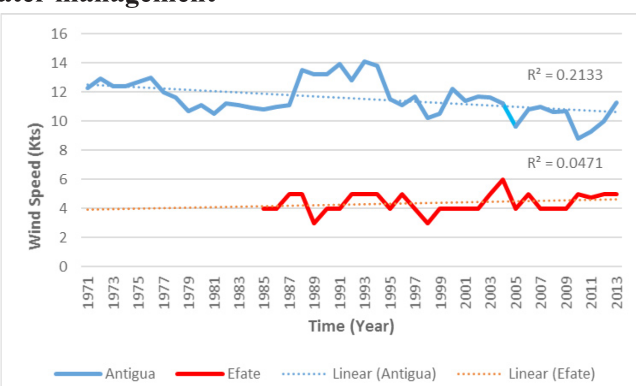

Figure 5: Wind Speed trends for Antigua and Efate (1971-2013).

Farmers from both islands were managing water mainly through rainwater harvesting and water conservation (Figure 5). Dam construction was also common to both islands. It was also found that dam construction, pond clearing and maintenance were important methods to address water scarcity [42]. Although irrigation was only used by the Antiguans, it was found to be one of the main adaptation strategies implemented elsewhere to provide water to the farms and allow planting in the off-season [50]. The only reported cases of irrigation usage on Efate were in areas related to horticulture and may be because of the high availability of ground water even during drought conditions.

Land management

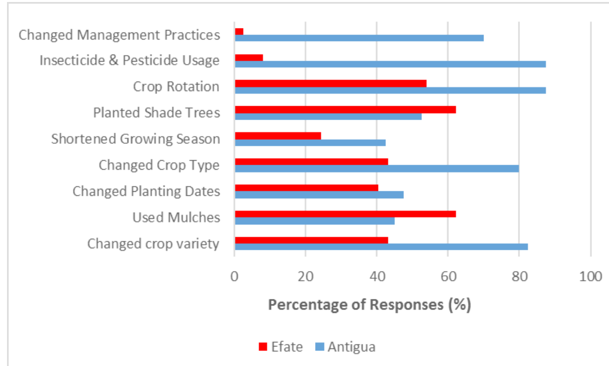

Figure 6: Crop Management Measures Recently Implemented.

The main method used by farmers from both islands was shifting cultivation and mirrors the finding of [19] (Figure 6 in the supplementary material). This method, while used to increase yield, is often used in conjunction with fertilizers and mulching to make up for loss of nutrients and soil moisture [51]. The main technique implemented by the Antiguans was reduced tillage which has been found to be beneficial to soil quality and improves crop production when combined with crop rotation [52].

Income diversification

Off-farm employment activities included taxi-driving, logging, charcoal production, fishing, weaving and a shift from crop to livestock production. Diversification into non-farming activities such as fishing and animal husbandry has been found to be a popular coping mechanism for farmers as it provides additional income and helps the farmers to manage their climate change risk [53-54].

Conclusion

The findings of this study suggest that the climate is changing in the Atlantic and the Pacific. Useful information has now become available that was absent on how these farmers are addressing climate variability and change. Notwithstanding the distance and the differences in socio-economic conditions. The farmers have many similar experiences in terms of climatic change and their resulting impacts within the industry. Although the farmers' knowledge cannot be equated to scientific data, the anecdotal information still provides an important baseline for future studies [55-56]. Because of the perceived changes, the farmers have taken steps to protect their livelihoods. However, they could benefit from targeted weather forecast and early warning systems which would help them to be more proactive in a changing climate. Crop rotation, rainwater harvesting and shifting cultivation are common adaptation strategies used in both islands. These strategies were combined with various off-farm activities to diversify and increase income. Agricultural productivity can be improved with various crop, water and land management practices but farmers lack funds and technical support. Collaboration between farmers, agricultural extension and meteorological services is crucial in successfully managing the impacts of climate variability and change in Antigua & Barbuda and Vanuatu.

Acknowledgments

This article was based on research work done as part of the first author's PhD programme at the University of Newcastle, Australia under the Australian Development Awards, funded by the Australian Agency for International Development.

References

1. Allison I, Bindoff N, Bindschadler R, Cox P, de Noblet N, et al. (2011) The Copenhagen diagnosis: updating the world on the latest climate science. Elsevier.

2. IPCC (2014a) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

3. Marcott SA, Shakun JD, Clark PU, Mix AC (2013) A Reconstruction of Regional and Global Temperature for the Past 11,300 Years. Science 6124: 1198-1201.

4. Simmons A, Berrisford P, Dee D, Hersbach H, Hirahara S, et al. (2016) Estimates of variations and trends of global surface temperature. Sheffield Park, Reading, Berkshire.

5. IPCC (2013) Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

6. Wheeler T, von Braun J (2013) Climate Change Impacts on Global Food Security. Science 341: 508-513.

7. Myers SS, Smith MR, Guth S, Golden CD, Vaitla B, et al. (2017) Climate Change and Global Food Systems: Potential Impacts on Food Security and Undernutrition. Annual Review of Public Health 38: 259-277.

8. Betzold C (2015) Adapting to climate change in small island developing states. Climatic Change 3: 481-489.

9. IPCC (2001) Climate Change 2001: Impacts, Adaptation, and Vulnerability - Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Retrieved from Cambridge.

10. IPCC (2014b) Climate Change 2014: Impacts, Adaptation and Vulnerability: Regional Aspects: Cambridge University Press.

11. Nurse LA, McLean RF, Agard J, Briguglio LP, Duvat-Magnan V, et al. (2014) Small islands. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. 1613-1654.

12. IPCC (2007) Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate.

13. Nguyen TPL, Seddaiu G, Virdis SGP, Tidore C, Pasqui M, et al. (2016) Perceiving to learn or learning to perceive? Understanding farmers' perceptions and adaptation to climate uncertainties. Agricultural Systems 143: 205-216.

14. Gibson JJ (1983) The senses considered as perceptual systems. Westport (Connecticut): Greenwood.

15. Gregory RL (1980) The intelligent eye. London: Weidenfeld & Nicolson.

16. Rock I (1985) The Logic of perception. Massachusetts: Massachusetts Institute of Technology.

17. Roco L, Engler A, Bravo-Ureta BE, Jara-Rojas R (2015) Farmers' perception of climate change in Mediterranean Chile. Regional Environmental Change 5: 867-879.

18. Loria N, Bhardwaj SK (2016) Farmers' Response and Adaptation Strategies to Climate Change in Low-Hills of Himachal Pradesh in India. Nature Environment and Pollution Technology 3: 895-901.

19. Vincent K, Cull T, Chanika D, Hamazakaza P, Joubert A, et al. (2013) Farmers' responses to climate variability and change in southern Africa - is it coping or adaptation? Climate and Development 3: 194-205.

20. Adimassu Z, Kessler A, Yirga C, Stroosnijder L (2013) Farmers' perceptions of land degradation and their investments in land management: A case study in the Central Rift Valley of Ethiopia. Environmental Management 5: 989-998.

21. Moges A, Holden N (2007) Farmers' perceptions of soil erosion and soil fertility loss in Southern Ethiopia. Land Degradation & Development 5: 543-554.

22. Yusuf M, Mustafa F, Salleh K (2017) Farmer perception of soil erosion and investment in soil conservation measures: emerging evidence from northern Taraba State, Nigeria. Soil Use and Management 1: 163-173.

23. Assefa E, Hans□Rudolf B (2016) Farmers' perception of land degradation and traditional knowledge in Southern Ethiopia-resilience and stability. Land Degradation & Development 6: 1552-1561.

24. Malongza BF (2013) Indigenous Perceptions of Soil Erosion, Adaptations and Livelihood Implications 58; The Case of Maize Farmers in The Zampe Community of Bole in The Northern Region of Ghana. Journal of Natural Resources and Development 3: 114-120.

25. Veihe A (2000) Sustainable farming practices: Ghanaian farmers' perception of erosion and their use of conservation measures. Environmental Management 4: 393-402.

26. Traore B, Van Wijk MT, Descheemaeker K, Corbeels M, Rufino MC, et al. (2015) Climate Variability and Change in Southern Mali: Learning from Farmer Perceptions and On-Farm Trials. Experimental Agriculture 4: 615-634.

27. FAO (2016) AQUASTAT website - Food and Agriculture Organization of the United Nations.

28. Index Mundi (2015) Country Statistics.

29. FAO (2010-2016) Fishery and Aquaculture Country Profiles the Republic of Vanuatu.

30. Bernard HR (2000) Social research methods: qualitative and quantitative approaches: Thousand Oaks, Calif.: Sage Publications.

31. Creswell JW (1998) Qualitative inquiry and research design choosing among five traditions. Thousand Oaks, Calif.: Sage Publications.
32. Bryman A (2012) Social Research Methods Oxford University Press.
33. Go A&B (2007) Antigua & Barbuda Census of Agriculture Final Report. Antigua.
34. Gov V (2009) National Population and Housing Census Basic Tables Report. Port Vila, Vanuatu: Vanuatu National Statistics Office.
35. Meade K (2018) Additional Meteorological Data.
36. Mulenga BP, Wineman A, Sitko NJ (2017) Climate Trends and Farmers' Perceptions of Climate Change in Zambia. Environmental Management 59: 291-306.
37. WMO (1988) Analyzing Long Time Series of Hydrological Data with Respect to Climate Variability and Change. Geneva, Switzerland.
38. ITRC (2013) Groundwater Statistics and Monitoring Compliance. Statistical Tools for the Project Life Cycle (GSMC-1).
39. Dhanya P, Ramachandran A (2016) Farmers' perceptions of climate change and the proposed agriculture adaptation strategies in a semi-arid region of south India. Journal of Integrative Environmental Sciences 13: 1-18.
40. Jain SK, Kumar V (2012) Trend analysis of rainfall and temperature data for India. Current Science (Bangalore) 1: 37-49.
41. Gocic M, Trajkovic S (2013) Analysis of changes in meteorological variables using Mann-Kendall and Sen's slope estimator statistical tests in Serbia. Global and Planetary Change 100: 172-182.
42. Swe LMM, Shrestha RP, Ebbers T, Jourdain D (2015) Farmers' perception of and adaptation to climate-change impacts in the Dry Zone of Myanmar. Climate and Development 7: 437-453.
43. Barrucand MG, Giraldo VC, Canziani PO (2016) Climate change and its impacts: perception and adaptation in rural areas of Manizales, Colombia. Climate and Development 9: 415-427.
44. Sujakhu NM, Ranjitkar S, Niraula RR, Pokharel BK, Schmidt-Vogt D (2016) Farmers' Perceptions of and Adaptations to Changing Climate in the Melamchi Valley of Nepal. Mountain Research and Development 1: 15-30.
45. Hatfield JL, Prueger JH (2015) Temperature extremes: Effect on plant growth and development. Weather and Climate Extremes 10: 4-10.
46. Zhao Z, Luo Y, Jiang Y (2011) Is Global Strong Wind Declining? Advances in Climate Change Research 4: 225-228.
47. McVicar TR, Roderick ML, Donohue RJ, Van Niel TG, Thomas A, et al. (2012) Global review and synthesis of trends in observed terrestrial near-surface wind speeds: Implications for evaporation. Journal of Hydrology 417: 182-205.
48. Dieye A, Roy D (2012) A Study of Rural Senegalese Attitudes and Perceptions of Their Behavior to Changes in the Climate. Environmental Management 5: 929-941.
49. Shukla G, Kumar A, Pala NA, Chakravarty S (2016) Farmers perception and awareness of climate change: a case study from Kanchandzonga Biosphere Reserve, India. Environment, Development and Sustainability 18: 1167-1176.
50. ACIAR (2013) Australian Centre for International Agricultural Research 2014-15 Annual Operational Plan.
51. Kattumuri R, Ravindranath D, Esteves T (2017) Local adaptation strategies in semi-arid regions: study of two villages in Karnataka, India. Climate and Development 9: 36-49.
52. Esham M, Garforth C (2013) Agricultural adaptation to climate change: insights from a farming community in Sri Lanka. Mitigation and Adaptation Strategies for Global Change 18: 535-549.
53. Powlson DS, Stirling CM, Jat ML, Gerard BG, Palm CA, et al. (2014) Limited potential of no-till agriculture for climate change mitigation. Nature Clim. Change 4: 678-683.
54. Baudoin MA, Sanchez A, Fandohan B (2014) Small scale farmers' vulnerability to climatic changes in southern Benin: the importance of farmers' perceptions of existing institutions. Mitigation and Adaptation Strategies for Global Change 19: 1195-1207.
55. Turvey ST, Barrett LA, Yujiang H, Lei Z, Xinqiao Z, et al. (2010) Rapidly shifting baselines in Yangtze fishing communities and local memory of extinct species. Conservation Biology 3: 778-787.
56. Lane A, Jarvis A (2007) Changes in Climate will modify the Geography of Crop Suitability: Agricultural Biodiversity can help with Adaptation. Journal of Semi-Arid Tropical Agricultural Research 4: 1-12.