MODULE 1

INTRODUCTION TO THE IMPACT OF CLIMATE CHANGE ON AGRICULTURE IN FIJI AND THE PACIFIC ISLANDS

CLIMATICALLY, ENVIRONMENTALLY AND ECONOMICALLY SMART FARMING PRACTICES

Australian Aid

pacific farmer organisations

KSP KOKO SIGA PACIFIC

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CONTENTS

1 THE MAIN FACTORS EFFECTING CLIMATE IN THE PACIFIC ISLANDS

1.1 The ENSO cycle

The El Niño – Southern Oscillation (ENSO) has been influencing climate in Fiji and other Pacific Islands for centuries, and to this day remains a major source of climate variability[1].

The main climate effects of the ENSO cycle are:

- Changes in rainfall seasonality
- Occurrence of localized droughts and floods
- Changes in the frequency, strength and location of tropical cyclones
- Extreme high tides that result in saltwater intrusion which damages crops in low lying areas
- Widespread frosts at higher altitudes in PNG

El Niño and La Niña are opposite extremes of the ENSO, referring to very different environmental conditions. The impact of El Niño and La Niña on islands in the Pacific will vary depending on their location. In Suva, Fiji, for example, El Niño events tend to bring dry seasons that are drier and cooler than normal, while La Niña events usually bring wetter than normal conditions (river flooding can occur during the dry season with La Niña events). Recent severe droughts associated with El Niño events occurred in 1987, 1992, 1997-98, 2003 and 2010[2]. Currently, drought incidences and severity are greater during El Niño events in Fiji, Samoa, Solomon Islands and Tonga, whereas drought is associated with La Niña events in Kiribati[3].

In Samoa, flooding associated with tropical cyclones and strong La Niña events has caused widespread damage, particularly in Apia. In early 2008 and 2011, for example, transportation infrastructure and water supplies were severely damaged[4] El Niño and La Niña events will continue to occur in the future. Recent studies on the impact of climate change on ENSO have suggested that extreme El Niño and La Niña events may increase in frequency from about one every 20 years to one every 10 years by the end of the 21st century under high emissions scenario[5].

To this long-standing source of climate variability the increasing influence of climate change has been added.

1 CSIRO/SPREP. 'NextGen' Projections for the Western Tropical Pacific: Current and Future Climate for Fiji (2021). https://publications.csiro.au/publications/publication/PIcsiro:EP2021-2149

2 Pacific Climate Change Science Program Fiji Country Report 2011: https://world.350.org/pacific/files/2014/01/1_PCCSP_Fiji_8pp.pdf

3 Chand et al., 2016 Projected increase in El Niño-driven tropical cyclone frequency in the Pacific, Nature Climate Change, DOI: 10.1038/NCLIMATE3181

4 Pacific Climate Change Science Program Samoa Country Report 2011 https://world.350.org/pacific/files/2014/01/3_PCCSP_Samoa_8pp.pdf

5 https://research.noaa.gov/article/ArtMID/587/ArticleID/2685/New-research-volume-explores-future-of-ENSO-under-influence-ofcli-mate-change

1.2 Climate variability: the ENSO cycle has been causing climate extremes in the Pacific for centuries and now is being combined with the impact of Climate Change

The earth's climate is changing rapidly. The primary cause of that change is the release of carbon dioxide from burning coal, oil and natural gas. Every few years the United Nations' Intergovernmental Panel on Climate Change (IPCC) summarizes how the climate has changed and its implications. The objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies. IPCC reports also provide a key input into international climate change negotiations.

To support policy development, the IPCC established emission scenarios – these represent different levels of Greenhouse Gas (GHG) emissions and their implications for the climate, and therefore for human society. These scenarios cover a wide range of GHG emissions from drastic reduction of GHG (low emissions) to business as usual (high emissions) with clear consequences for increased temperatures, sea level rise etc. The findings of the latest IPCC report[6] leave no excuse for delaying action on adaptation and mitigation. Without major action to reduce emissions, global temperature is on track to rise by 2.5 °C to 4.5 °C by 2100. And according to the latest estimates; Earth has already, essentially, reached the 1°C threshold

What are the main effects of climate change in the Pacific Islands?

- **Average air temperatures are increasing –** The Pacific Islands mean temperature over land has increased by 1.1°C since 1951; seven of the warmest eight years on record have occurred since 2007[7]. Across Fiji's two main islands, the number of cool nights has decreased and warmer days has increased since 1942[8], around +0.3 °C warming up to the 1986-2005 baseline and around +0.7 °C warming up to the 2010-2019 baseline. Increasing night time temperature is of particular relevance for many crops, for example, rice, fruit and vegetables. Average air temperature in Fiji is projected to increase by up to 1°C by 2030; 2°C by 2050 and 4°C by 2090 under the high emissions that we find today that is business as usual[9].

- **Sea level rise.** Sea surface temperatures are increasing and will continue to increase, and along with the melting of glaciers are resulting in sea level rise (SLR). Sea level rise coupled with storm surges and waves exacerbate coastal inundation and increase the likelihood of saltwater flooding. Many PICs are less than 2 m above sea level with Kiribati and Tuvalu being two of the most vulnerable countries in the world to SLR. Low-lying islands and coastal areas of other Pacific Islands, such as Fiji, Palau, Samoa, Solomon Islands and Tonga are also highly exposed to SLR. Palau, for example, stands 9 m above sea level, but most of the high ground is hilly and thickly forested, unfavourable for human habitation and economic activity. See the plot of data below of the daily mean tidal data collected by the Hawaii Coral Reef Foundation for Palau (https://coralreefpalau.org/research/ The Global Mean Sea Level will rise between 0.29–0.59 m, (low emissions) and 0.61–1.10 m, (high emissions) by 2100 relative to 1986–2005[10].There are significant variations in sea level across the Pacific Island region.

6 https://www.ipcc.ch/ar6-syr/

7 https://www.pacificmet.net/sites/default/files/inline-files/documents/PICC%20Monitor_2021_FINALpp_0.pdf

8 https://cop23.com.fj/fiji-and-the-pacific/how-fiji-is-affected-by-climate-change/

9 CSIRO and SPREP 2021 NextGen' Projections for the Western Tropical Pacific: Current and Future Climate for Fiji. Final report to the Australia-Pacific Climate Partnership https://doi.org/10.25919/5gh8-qt86

10 https://www.ipcc.ch/srocc/chapter/chapter-4-sea-level-rise-and-implications-for-low-lying-islands-coasts-and-communities/

In the western part of the tropical Pacific Ocean, the rates of sea-level change are substantially higher than the global mean rise, mainly due to geographical variations in thermal expansion and the influence of ENSO[11]. By 2030 the SLR in Fiji is projected to be in the range of 0.09 - 0.18 m under all emission scenarios and 0.66 - 1.21 m by 2100 under a high emissions scenario. Recent data collected since the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) reports[12] indicate that the median value of sea level rise under high emissions is higher because the enhanced Antarctic contribution is expected to be strongest for the higher emission scenario[13]

- **Rainfall –** Annual total rainfall in the region shows large year-to-year variability, partly related to the ENSO, with no significant trends since 1960. In contrast to temperature, possible changes in mean rainfall will vary from increases to decreases[14], therefore farmers need to plan for the impacts of both wetter and drier conditions. Of importance is the projection that extreme rainfall days will occur more frequently and with greater intensity[15]. For example, over the last 20 years there has been a significant intensification of rainfall in Samoa. Such extreme rainfall can potentially cause dangerous flooding, which has already been observed in parts of Samoa in recent years[16].

- **Cyclones –** The total number of tropical cyclones may decrease over the century, but will increase in intensity, therefore strengthening the impacts through stronger winds, more intense rainfall and greater coastal inundation. In Fiji, severe Tropical Cyclone (TC) Winston (category 5) in 2016 impacted approximately 62 per cent of the country's total population and destroyed crops on a large scale. The estimated effect of TC Winston was equivalent to FJD2.0 billion[17]. Since 2016, Fiji has experienced 12 cyclones, three of them categorized as severe. TC Sarai (2019) followed by TC Ana (2021) caused a huge amount of human and material losses in Fiji, particularly on Vanua Levu, despite the fact that it did not make full landfall[18] Cyclone Gita was the most impactful tropical cyclone to hit Tonga in recorded history; and despite the projections for reduced frequency of cyclones and increased severity the total number of cyclones that have crossed in to Tonga waters and those categorized as severe have both increased[19].

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11 https://public.wmo.int/en/media/press-release/climate-change-increases-threats-south-west-pacific

12 https://www.pacificclimatechangescience.org/publications/country-brochures/

13 CSIRO and SPREP 2021, NextGen' Projections for the Western Tropical Pacific: Current and Future Climate for Fiji. Final report to the Australia-Pacific Climate Partnership https://doi.org/10.25919/5gh8-qt86

14 https://www.met.gov.fj/aifs_prods/Climate_Products/Country%20Report%20Fiji.pdf

15 Pacific Climate Change Science Program Fiji Country Report 2011 https://world.350.org/pacific/files/2014/01/1_PCCSP_Fiji_8pp.pdf

16 Samoa's 2nd National Communication to the UNFCCC https://unfccc.int/resource/docs/natc/samnc2.pdf

17 Government of Fiji 2018 Climate Vulnerability Assessment https://cop23.com.fj/wp-content/uploads/2018/02/Fiji-Climate-Vulnerability- Assessment-.pdf

18 https://www.e-ir.info/2020/01/09/climate-change-and-the-sinking-island-states-in-the-pacific/

19 Government of Tonga, 2018 Post disaster rapid assessment

Table 1, provides more detail regarding the observed and projected changes in climate by 2050 and 2070 for Fiji.

Table 1: Observed and projected changes (2030, 2050) for Fiji[20]

<table>
<tr><th>Country</th><th>Observed changes 1942</th><th>Projected changes by 2050</th><th>Projected changes by 2070</th></tr>
<tr><td rowspan="2">Fiji (Nadi and Suva)</td><td rowspan="2">Increase in maximum temperature at Suva is 0.15°C per decade & increase in minimum temperature is 0.26°C. At Nadi increase in maximum temperature is 0.04°C per decade & increase in minimum temperature is 0.13°C. Decline in annual cool nights is greater at Suva & similarly the increase in annual warm days is greater at Suva.
Data show no clear trends in annual or seasonal rainfall however substantial variation in rainfall has been recorded from year to year; moderate to strong El Niño events can reduce rainfall by as much as 20-50%.
Cyclones: in the period 1969-2010 an average of 28 per decade but with variation from year to year; overall the proportion of more severe tropical cyclones has increased
Satellite date indicate a sea level rise (SLR) of about 6mm per year since 1993 - larger than the global average of 2.8–3.6 mm per year. Higher rate of rise maybe partly related to natural fluctuations that take place year to year or decade to decade caused by phenomena such as the El Niño-Southern Oscillation.</td><td>Annual average air & sea surface temperature increases will vary from 0.5-1.0°C at very low emissions to 0.8-2.0°C at very high emissions
SLR (low emissions) will be 0.13-0.29m; at high emissions 0.16-0.33m.
An increase of 47-103mm (24hr) of rainfall with 1-in-20 year event</td><td>Annual average air & sea surface temperature increases will vary from 0.4-1.1°C (low emissions) to 1.4-2.9°C (high emissions).
SLR (low emissions) is projected to be 0.18-0.43m; at high emissions 0.26-0.56m.</td></tr>
<tr><td colspan="2">Models generally suggest greater increase in wet season rainfall. Extreme rainfall days are likely to occur more often and be more intense. The proportion of time in drought will decrease slightly.</td></tr>
</table>

20 FMS 2016. Climate Change Science and Projections for Fiji. Fiji Meteorological Service, Government of Fiji.

2 CLIMATE CHANGE POSES A SIGNIFICANT THREAT TO THE WORLD'S STAPLES: RICE AND WHEAT

Climate change impacts will undermine food security both through the local availability of food and the ability of people to purchase food. Agricultural productivity is being, and will be affected by climate variability and change, with extreme weather events most likely to have the greatest impact in the short to medium term timescale (2030–2050) compared with changes in mean temperature where significant impacts are not expected before 2050. High night temperatures are of significance for many crops, for example, fruit and vegetables. Hot night temperatures (nights above 24 °C) will lead to greater cell respiration which limits the amount of sugars and other storage products that can go into fruits and developing seeds. Because of this increased respiration the plant expends stored photosynthates, therefore they do not contribute to yield[21].

Drought presents problems to agriculture everywhere in the Pacific Islands, particularly given the lack of irrigation. The 2015–16 drought which followed TC Pam destroyed vegetation across Vanuatu, and the lack of foliage worsened the impacts of the drought on soils and crops, reducing food security. The 2015-16 drought also affected food security in Papua New Guinea and the Republic of the Marshall Islands[22].

The increased probability of extreme rainfall (both frequency and intensity) will greatly test the skills of farmers in those countries where rainfall is already high, for example, Solomon Islands, especially for crops sensitive to waterlogging, such as sweet potato. Flooding is more of an issue on the larger islands of Fiji, Samoa, Solomon Islands and Vanuatu with severe local impacts, often exacerbated by uncontrolled clearing of forests in steep, erosion-prone, water catchments; the increased risk of flooding in river catchments also threatens food production. Fiji has experienced, on average, more than one flood each year for the past 40 years, with particularly devastating floods in 2004, 2009, 2012 (two events), and 2014[23].

The impacts of SLR on low-lying atolls will be direct, with progressive inundation over the coming decades. There will also be significant SLR impacts in the larger islands of Fiji, Samoa, Solomon Islands and Tonga, where many communities are located in highly exposed coastal locations, For coastal communities, the effects of erosion, increased contamination of groundwater and estuaries by saltwater incursion, cyclones and storm surges, heat stress and drought may individually or in combination undermine food production. One study estimated that most previous extreme water levels recorded at Suva and Lautoka (Fiji) had been due to **small and moderate** storm surges (< 30 cm in height) coinciding with **high** astronomical tides[24].

Extreme events clearly are the greatest challenge but it is the combination of all climate change impacts, coupled with, in many cases, land degradation problems, that poses a major risk to the future food and nutrition security of the Pacific Islands.

21 https://sites.udel.edu/weeklycropupdate/?p=15224

22 Iese et al., 2021 Historical and future drought impacts in the Pacific islands and atolls Climatic Change 166, 19 https://doi. org/10.1007/s10584-021-03112-1

23 Government of Fiji 2018 Climate Vulnerability Assessment https://cop23.com.fj/wp-content/uploads/2018/02/Fiji-Climate-Vulnerability- Assessment-.pdf

24 25 Haigh, I 2017 An analysis of Mean and Extreme Sea levels for Fiji

2.1 Climate change and its impact on rice and wheat production

Temperature regimes greatly influence not only the growth duration, but also the growth pattern and productivity of rice and wheat crops. A study published by FAO in 2010 forewarned of the impact that rising temperatures, especially night temperatures, would have on rice yields resulting in losses of 10 – 20 per cent harvests in some countries. Extreme temperatures – whether low or high – cause injury to the rice plant. The most damaging effect is on grain sterility[25]; just 1 or 2 hours of high temperature at anthesis (about 9 days before heading and at heading) result in a large percentage of grain sterility . Water stress is a major source of yield and economic loss in rice production - drought has been shown to reduce rice yields by about 30 per cent[26].

Similarly wheat, another major staple, is also affected by climate change. For example, the Indo-Gangetic Plain (IGP) is one of the main wheat-production regions in India and the world. A recent study has indicated that the direct impact of climate change, via changes in temperature and precipitation, leads to wheat yield losses between −1 per cent and −8 per cent depending on the location examined in the IGP. The indirect impact of climate change resulting from a decrease in water availability leading to a decrease in irrigation results in much higher yield losses of −4 per cent to −36 per cent depending on the location examined and the irrigation regime[27].

Extremes of weather that coincide with key stages in wheat cultivation and production, such as planting, can also have a major impact on productivity. Currently (May, 2022) in Canada, one of the world's largest wheat exporters, excess rain is preventing planting of the wheat crop in some regions, whereas other regions are too dry to support germination[28].

To try and maintain production and yields, farmers are having to increase their inputs, thereby increasing production costs and putting upward pressure on the prices consumers have to pay. Wheat prices had risen by 60 per cent as a result of Russia's invasion of Ukraine but India's export ban[29] as a result of inclement weather added a further 6 per cent to wheat prices[30].

Import substitution by climate change resilient traditional crops such as breadfruit and cassava will be essential to ensure food and nutrition security in the Pacific Islands. See 'Green Pillars' video where Livai Tora and Andrew McGregor talk about breadfruit being "the crop of the future" due to climate change here and here

25 AO. (2010). "Climate Smart" Agriculture. Policies, Practices and Financing of Food Security, Adaptation and Mitigation. The Hague Conference on Agriculture, Food Security and Climate Change (Rome, Italy: Food and Agriculture Organization of the United Nations).

26 Zhang et al. 2018 Effect of Drought on Agronomic Traits of Rice and Wheat: A Meta-Analysis Int J Environ Res Public Health. 2018 May; 15(5): 839. doi: 10.3390/ijerph15050839

27 Daloz et al. 2021 Direct and indirect impacts of climate change on wheat yield in the Indo-Gangetic plain in India ScienceDirect Volume 4, https://doi.org/10.1016/j.jafr.2021.100132

28 https://www.bloomberg.com/news/articles/2022-05-18/canada-crop-land-deteriorating-as-excess-rain-hinders-planting

29 https://www.nytimes.com/2022/06/10/business/asia-export-ban-chicken-wheat-oil.html

30 https://www.ft.com/content/226f3f09-33ff-40c8-b439-08a36c515aba

2.2 Implications of increasing grain prices for food security in the Pacific islands

Why is this a major problem for us in the Pacific Islands – we only grow small amounts of rice, and no wheat?

- **We are large importers of grain.** All Pacific Island countries import large quantities of wheat and rice. For example, Fiji imported an average of 119,400 tonnes of wheat and 36,400 tonnes of rice per year over the period 2016-2020[31]. Based on these import figures, Fijians were consuming approximately 180 kg of imported grain per head per year. The average landed value of this imported grain was over FJD 140 million per year or over FJD160 per head of population.

- **Rising prices of grains threaten our food security.** Food security does not just refer to our ability to grow our own food but also includes having sufficient income to buy food. Around 75 per cent of the world's rice is grown in tropical locations and most of this rice is consumed by the countries in which it is grown. It is estimated that only around 7 per cent of the rice grown globally is exported – the figure is somewhat higher for wheat (18 per cent) and maize (11 per cent) but still far less than the amount consumed in the countries that grow the grain[32]. Thus, there will be increasing pressure on the countries that grow the grain to maintain supply for their local consumers – this pressure can result in reduced exports or total bans. Thailand, the world's second largest rice exporter, cut its export target by 13 per cent in 2020 due to drought[33] and in May 2022 India banned wheat exports because extreme temperatures had resulted in reduced yields. .

Over the next few decades, we can expect that the price we pay for our imported grains will increase substantially[34].

Given the high dependency of PICs on imported grain, these potential declines in supply and increases in cost have major food security implications. **Growing more rice in the Pacific islands is not the answer.** They are tropical countries and rice will become increasingly more expensive and more challenging to grow due to climate change, much more so than our traditional food staples.

Andrew McGregor, in a Fiji TV "Green Pillars" episode, discusses the impact of climate change on our food security here and here

31 Min Agriculture Economic Planning and Statistics Division 2020 Key Statistics on Fiji's Agricultural Sector p, 37

32 http://siteresources.worldbank.org/INTAFRICA/Resources/Rice-Profile.pdf.

33 https://www.bloomberg.com/news/articles/2020-07-22/thai-rice-exports-dropping-to-6-5-million-tons-least-since-2000#xj4y7vzkg

34 International Food Policy Research Institute. Food Policy Rpt. Climate Change and Impact on Agriculture https://ebrary.ifpri. org/utils/ getfile/ collection/p15738coll2/id/130648/filename/130821.pdf

3 CLIMATE CHANGE IS NOT ALL BAD NEWS FOR PACIFIC ISLAND FARMERS

3.1 Most of our traditional Pacific island food staples are more climate change and climate variability resilient than grain crops

Why are our staples more resilient?

The Pacific Islands staple food crops, in varying degrees, are expected to be more resilient to climate change than imported grains due to their larger leaves (photosynthetic efficiency) [35]and underground organs (less demanding on external inputs). Throughout the tropical regions of the world root and tuber crops are grown because they are robust and can be depended upon to contribute to household food and nutritional security. They contribute to increased productivity of food systems through use of marginal spaces and reduced risk through their capacity to withstand weather extremes.

Cassava can produce deep rooting systems (more than 2m) to extract sub-soil water and can escape drought by going dormant, losing its leaves, and then reinitiating growth when there is fresh rainfall[36].

Sweet potato is an efficient crop producing higher quantities of energy per day per unit area than cereals. It is also a robust crop requiring few inputs and can escape drought through its deep rooting system and extensive vine network in dry spells[37].

Rice and other grain crops remove significant amounts of nutrients from the soil that must be replaced in order to maintain yields. In an effort to counteract declining yields due to climate change, farmers tend to increase inputs resulting in higher costs both to the producer and consumer. Research undertaken at the Vanuatu Agricultural Research and Technical Centre (VARTC) compared the nitrogen (N) extracted from soil by traditional root crops with the N extracted by rice. The research found that:

- Cassava extracted 28-36% less N than rice;
- Cocoyam (dalo ni tana) 70-90% less N than rice;
- Sweet potato (kumala) 70 to 90% less N than rice;
- Taro (dalo) 56-72% less N than rice)[38].

Such research is yet to be undertaken for other staple crops such as breadfruit and bananas although similar results are expected.

35 El-Sharkawy, 2014 Global warming: causes and impacts on agroecosystems productivity and food security with emphasis on cassava comparative advantage in the tropics/subtropics Photosynthetica 52 (2): 161-178, DOI: 10.1007/s11099-014-0028-7

36 Prain and Naziri, 2020 Food Resilience through Root and Tuber Crops in Upland and Coastal Communities of the Asia-Pacific (Food- START+)

37 Prain and Naziri, 2020 The role of root and tuber crops in strengthening agri-food system resilience in Asia

38 Lebot, V., Malapa, R., and Jung, M. (2013). Use of NIRS for the rapid prediction of total N, minerals, sugars and starch in tropical root and tuber crops. N. Z. J. Crop Hortic. Sci. 41 (3), 144–153 http://dx.doi.org/10.1080/01140671.2013.798335.

A study on the impact of climate change on the yield of tropical root and tuber crops vs. rice and potato in India showed that cassava, sweet potato, greater yam, elephant foot yam and taro can be considered as future crops based on their predicted yield variations and economics[39]. Similarly research in the Philippines highlighted how root crops – particularly sweet potato and cassava , helped vulnerable households cope with the destruction and recovery from super-typhoon Mangkhut in September 2018[40]. In Madagascar, in the face of increasingly unstable rice production, as the country becomes hotter and drier, the yam has become a source of hope for food security[41]

Climate projections and species distribution modeling approaches for eight key crops in the Asia-Pacific region have been used to identify areas where climate impacts will be very high, and where currently cultivated crops may need to be substituted with more resilient crops. The study indicated that cassava and sweet potato can play an important role in terms of food resilience in areas where climate change is likely to trigger transformational changes for crops such as rice and maize[42].

The importance of agricultural biodiversity in strengthening the resilience of our traditional food crops must not be forgotten. There is evidence that landraces often guarantee higher provisioning services (such as yield) under non-optimal farming conditions and can show high resilience under harsh environmental conditions. Regulating services such as resistance against pests and diseases often appear to become lost during breeding for high-yielding, modern varieties[43].

Sweet potato's genepool offers potential for identifying heat and drought tolerant varieties. A recent study has identified 132 heat tolerant accessions, and documented plant characteristics and responses to heat stress that can be used to predict whether a cultivar will produce good yields under high temperatures[44]. It must be noted however that local conditions can result in different responses to high temperatures – as such local evaluation is always essential before any extensive distribution of 'new' varieties is undertaken.

In the Pacific Islands significant work has gone into evaluation of agricultural biodiversity of traditional food crops by regional agencies, such as the Pacific Community, and national governments and CSOs. Varieties with climate resilience have been identified for most of the root and tuber crops however evaluation in farmers' fields has been limited thus holding back the potential value of these varieties to farmers. There is an urgent need for investment in getting these varieties into the hands of farmers to test in their own fields and to share amongst their community[45].

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39 Pushpalatha et al 2022 Impact of climate change on the yield of tropical root and tuber crops vs. rice and potato in India Food Security volume 14, 495–508 https://doi.org/10.1007/s12571-021-01226-z

40 https://cipotato.org/blog/weathering-storm-root-tuber-crops-boost-climate-resilience

41 https://www.theguardian.com/society/2021/dec/19/how-bringing-back-the-wild-yam-is-feeding-the-hungry-in-drought-hitmadagascar

42 Palao and Balanza, 2019 Food resilience through root and tuber crops in Upland and Coastal communities of the Asia-Pacific Technical Report https://www.researchgate.net/profile/Leo-Palao/publication/336303746_Food_Resilience_Through_ Root_and_Tuber_Crops_in_Upland_and_Coastal_Communities_of_the_Asia-Pacific_FoodSTART_Transformational_ adaptation_of_key_root_and_tuber_crops_in_Asia_using_species_distribution_/links/5d9aa80ba6fdccfd0e7ef8a0/ Food-Resilience-Through-Root-and-Tuber-Crops-in-Upland-and-Coastal-Communities-of-the-Asia-Pacific-FoodSTART-Transformational- adaptation-of-key-root-and-tuber-crops-in-Asia-using-species-distribution.pdf?origin=publication_detail

43 Ficiciyan et al 2018 More than Yield: Ecosystem Services of Traditional versus Modern Crop Varieties Revisited Sustainability, 10, 2834 doi:10.3390/su10082834

44 https://cipotato.org/blog/study-finds-untapped-climate-resilience-sweetpotato/

45 McGregor et. al. 2013, Assessing the social and economic value of germplasm and crop improvement as a climate change adaptation strategy: Samoa and Vanuatu case studies. International Union for the Conservation of Nature (IUCN)
https://www.agriculture.gov.au/sites/default/files/documents/iucn-value-germplasm-and-crop-improvement.pdf

Wild yams being grown on Tanna Vanuatu (photo Andrew McGregor)

A breadfruit orchard Lautoka Fiji (photo Livai Tora)

A traditional taro garden Malakula Vanuatu (photo Andrew McGregor)

The relative climate change resilience and photosynthetic efficiency (efficient solar energy converters) of traditional food staples provides Pacific Island farmers with a comparative advantage which will grow in a world with an increasing population, a growing scarcity of arable land and escalating fertilizer and energy costs.

The current global situation clearly illustrates the impact of escalating fertilizer and energy costs. The Ukraine crisis coupled with the exorbitant price of natural gas (used to make nitrogen fertilizer) has resulted in a huge increase in fertilizer prices – in many countries prices have trebled[46]. Russia and neighbouring Belarus, which has also been hit by sanctions, are key exporters of several critical fertilizing compounds, including urea and potash, but the curtailed exports of these products has caused prices to soar[47]. Sustainable production of traditional food crops can assist farmers in reducing their reliance on external inputs such as fertilizers and at the time same strengthen the climate resilience of Pacific Island food systems.

This comparative advantage of our traditional food staples is discussed by Andrew McGregor in a Fiji TV 'Green Pillars' episode here

46 https://www.npr.org/2022/04/12/1092251401/russia-ukraine-war-worsens-fertilizer-crunch-risking-food-supplies?t=1655639145048

47 https://fortune.com/2022/03/21/fertilizer-prices-record-high-food-crisis-middle-east-starvation/

The resilience of traditional food crops

As discussed, most Pacific Island traditional crops can expect to be more climate resilient than grain crops. However, some of these crops are expected to be more resilient than others, namely cassava, cocoyam (dalo ni tana), breadfruit (uto) and island cabbage (bele). Table 2 presents a summary of the observed and projected impacts of climate change and climate variability on the traditional staple food crops found in the Pacific Islands. These observations and projections are based on grower experience, expert opinion and some field trials of varieties grown in the Pacific Islands. The crops have been placed into four (4) broad categories: **most vulnerable; highly vulnerable; vulnerable; and least vulnerable.**

Table 2. A summary of the observed and projected impact of climate change and climate variability on staple Pacific Island crops [48]

Crop	Climate change/ climate variability impact in recent decades	Projected climate impact to 2030	Projected climate impact to 2050
The most vulnerable			
Rice	Globally, rising temperatures, particularly at night, has caused yield losses 10-20%. No data for the Pacific – but expected to be at least as much	Increasing temperature expected to decrease overall rice production in tropical locations (75% of world rice production). Rice production in the PICs is likely to become even less viable in terms of productivity.	Severe global shortages in rice available to import. The high price of rice expected to enhance the comparative advantage of Pacific staple food crops
Swamp taro *(Via)*	Swamp taro pits which are found on atolls affected by saltwater intrusion.	Continued loss to sea level rise expected. Droughts will exacerbate salinity problems	Could disappear from atoll environments
Highly vulnerable			
Sweet potato *(Kumala)*	ENSO-induced droughts have had a major impact on production, particularly in PNG	Impact in countries where average temperature is currently around 32°C. As tuber yield is already vulnerable to high rainfall, it is difficult for growers to counter a significant rainfall increase	Increasing vulnerability to high rainfall. Impact on pests and diseases unclear — drought is likely to increase problems with weevil and viruses

48 Taylor et al. 2016, Vulnerability of Pacific Island agriculture and forestry to climate change, p 216 SPC/Australian Aid https://www.sprep.org/attachments/VirLib/Regional/vulnerability-pacific-island-agriculture-forestry- climate-change.pdf

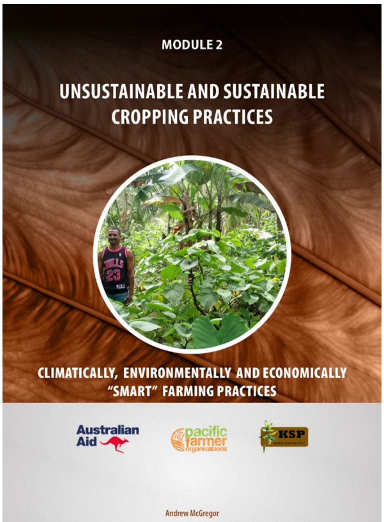
Vulnerable			
Taro (*Dalo*)	ENSO-induced droughts and cyclones adversely affected production. Taro leaf blight (TLB) in Samoa linked to increasing minimum night-time temperature	Overall wetter conditions could expand areas suitable for taro production. Cyclone damage with increased intensity. Likelihood of TLB spreading to countries where disease is currently absent (incld. Fiji). Increasing rainfall would increase incidence and spread of other pests and diseases. Possible yield benefits from increases in concentration of carbon dioxide (eCO_2) in the atmosphere	A continued spread and increase of TLB and other taro pests and diseases expected. Cyclone damage with increased intensity. Very high temperature increases (>2°C) could affect production. Possible yield benefits from increased eCO_2
Yams (*Uvi*)	Impact from ENSO induced droughts and cyclones. No clearly discernible direct impact on wild yams	Domesticated yam production more severely impacted by cyclones. No impact on wild yams expected. Increased rainfall will worsen problems with anthracnose.	Projected temperature rise could affect tuber bulking. Domesticated yam production increasingly affected by cyclones and wetter conditions (anthracnose). No impact on wild yams expected.
Bananas	Fruiting at higher altitudes with warmer temperatures – which is a positive development. Increased cyclone damage.	Will favour banana cultivation in areas that are currently sub-optimal being at higher altitudes. Higher temperatures could affect flowering in coastal locations. In these areas higher temperatures could increase pest (nematode and weevil) and disease damage (possibly Banana bunchy top virus). Higher rainfall likely to increase pest and diseases Increase in cyclone damage expected	Increased pest and disease pressure (Fusarium wilt, nematode and weevil). Heat stress effect on flowering and fruit filling. Increase in cyclone damage
Least vulnerable			
Cassava	No noticeable direct impact	Expected to be minimal — possible problems with waterlogging and susceptibility to high winds (> 55 km/hr). Possible yield benefits from eCO_2	Impact from waterlogging and susceptibility to high winds. Future climate pest and disease interactions unknown. Possible yield benefits from eCO_2
Cocoyam (*dalo ni tana*)	No noticeable direct impact	Expected to be minimal	No direct impact predicted, although future climate pest and disease interactions are unknown. Very high temperature increases (>2°C) could affect production

Breadfruit (*Uto*)	Some changes in fruiting patterns due to changes in rainfall	Expected to be minimal though cyclone damage likely to increase	Expected to be minimal though higher temperatures could reduce fruiting and fruit quality. Cyclone damage will worsen with increased intensity of cyclones.
Aibika (Island cabbage/ *Bele*)	No apparent impact from any change	Minimal impact likely from increasing temperature, but extremes of rainfall will increase pest and disease problems. Increase in frequency and intensity of drought will affect growth	More problems with pests and diseases from extremes of rainfall

4 HOW CAN FARMERS BENEFIT FROM THE COMPARATIVE ADVANTAGE OF TRADITIONAL STAPLE FOOD CROPS?

The experience of Pacific Island farmers and farmers elsewhere who cultivate the same crops as found in the Pacific Islands, highlight that these crops do offer some resilience to climate change and variability. Further there is also potential to strengthen that resilience through exploring and evaluating the genepool, for example, with sweet potato, and through adopting different farming practices. If farmers are to benefit from the comparative advantage of the traditional food crops, and provide sustainable livelihoods for their families, now and into the future, their crops must be grown in a climatically, environmentally and economically smart way. **It cannot be one or the other – it must be all three.**

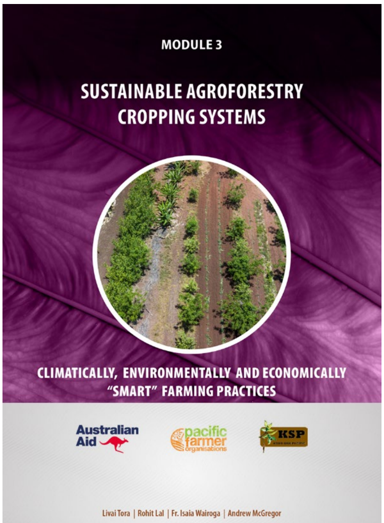
The seven farmer training modules that will follow explain how this can be achieved by farmers.



Topics Covered:

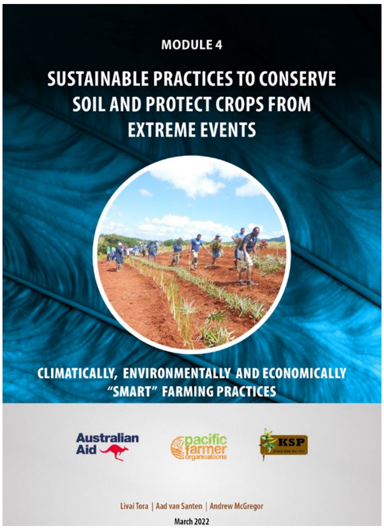
- *What are unsustainable and sustainable cropping practices for a farmer?*
- *The consequences of adopting unsustainable cropping practices and what can be done to avoid them*
  - → *The experience with dalo/yaqona/ ginger/ sugar*

Training modules that provide farmers with advice on farming practices that are climatically, environmentally and economically 'smart'.



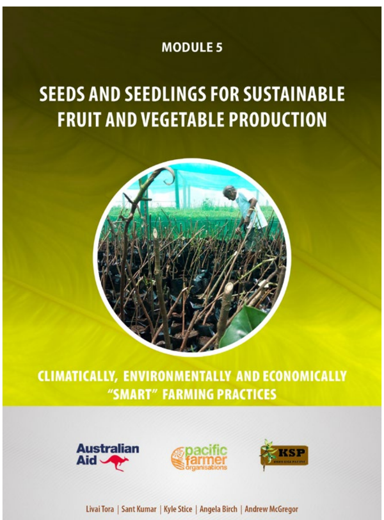
Topics Covered:

- *What are sustainable cropping systems that are climatically, environmentally and economically smart.*
- *Planting yaqona as part of an agroforestry cropping system: the experience of the Tutu Rural Training Centre*
- *A 'food forest' in the middle of degraded sugar cane land: a demonstration for farmers throughout western Viti Levu.*
- *Planting green manure cover crops – mucuna bean cropping systems for sustainable dalo and yaqona production on Taveuni.*



Topics Covered:

- *Sustainable cropping practices to stop soil erosion and enhance soil fertility and improve drainage*
- *The planting of vetiver grass along the contours*
- *Establishing drains to improve drainage and reduce soil erosion.*



Topics Covered:

- *Growing seedlings in a nursery: why and how.*
- *•Sourcing your vegetable seeds and seedlings.*
- *The Bula Agro 'Tel-A-Woman' (TAW) seeds and seedlings program.*
- *Off-season vegetable production.*

Topics Covered:

- *Why should I use compost – what are the benefits?*
- *Making your compost.*
- *Making compost tea*
- *Using compost that has been made*
- *Q & A about composting*

Topics Covered:

- *The resilience of coconuts to climate change.*
- *Why should I bother to replant my senile coconut palms?*
- *A rapidly growing market for Pacific Island coconut products.*
- *Replanting your senile palms.*

Topics Covered:

- *What are unsustainable and sustainable farming practices?*
- *The consequences of farmers adopting unsustainable cropping practices*
- *Identified sustainable farming practices that are climatically, environmentally and economically smart*
- *The economic returns to farmers from investing in sustainable agricultural practices*