CURRENT AND FUTURE INFLUENCE OF TROPICAL CYCLONES ON AGRICULTURAL PRODUCTION IN VANUATU

AGRICULTURE


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This case study describes tropical cyclone impacts on agricultural production in Vanuatu, using a step-by-step approach. Guidance around conducting this type of step-by-step assessment is provided in more detail on the Van-KIRAP web portal, along with other climate impact related case studies (also termed infobytes), factsheets, visualisation tools and technical resources. This case study can be used as an example for undertaking similar climate hazard-based impact assessments.

STEP 1 Understand the context and scope

Vanuatu is located in one of the most cyclone-prone parts of the south-west Pacific, with agricultural production being highly vulnerable [1], as evidenced in recent severe tropical cyclone events [2-4]. While the overall frequency of tropical cyclones (TCs) affecting Vanuatu has declined, the severity (i.e. mean TC wind speed intensities) of TCs passing in the vicinity of Vanuatu has increased [5, 6]. Ongoing increases in greenhouse gas emissions will lead to decreases in the average number of cyclones in the Vanuatu region (low-medium confidence) [5-9], however average cyclone wind speed intensity for severe cyclones (categories 3–5) is projected to increase slightly (medium confidence) [5].

Better understanding of the changing frequency and intensity of cyclones due to global increases in greenhouse gases may inform current planning decisions. **Here we explore TC wind speed as it affects coconut, kava, and banana production in Vanuatu under current and future climate conditions.** For information on how this climate hazard-based impact fits into a broader risk framework, see the Van-KIRAP Climate-risk factsheet.

Figure 1 Coconut, kava, and banana plants affected by tropical cyclone winds in Vanuatu. Photos courtesy Pakoa Leo.

STEP 2 Engage and meet with stakeholders

Van-KIRAP agriculture sector personnel, Vanuatu Meteorological Geo-hazards Department (VMGD) staff and CSIRO scientists visited some coconut, kava and banana production areas in February 2023 and July 2023 to discuss different production and management aspects for each of these commodities. Key published literature was also explored (see Tropical Cyclone explainer), as well as industry strategic planning reports from the Government of Vanuatu.

STEP 3 Explore background information and historic climate data

The average annual number of TCs passing within 500 km of Vanuatu has declined by 28 % across the period 1971–2021 [5] (Figure 2), with decreasing trends also for TCs passing within 250 km and 50 km of the country [5]. The proportion of severe TCs within 250 km of Vanuatu has increased from 40 % to 53 %, and from 45 % to 57 % within 500 km, with only a slight increase noted within 50 km (38 % to 39 %) [5].

Vanuatu is more susceptible to TCs during La Niña years than El Niño years: between the 1971 and 2021 seasons, TCs within 500 km of Vanuatu were more frequent during La Niña years (~13 cyclones per decade) than El Niño and ENSO neutral years (~9 cyclones per decade) (Figure 2).

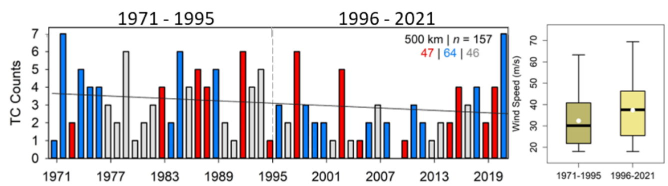

Figure 2 Observed number of cyclones categorised into El Niño (red), La Niña (blue) and ENSO-neutral (grey), that have occurred within 500 km of Vanuatu between the 1971 and 2021 TC seasons. The total number of TCs is represented by n, further broken down into El Niño (red text), La Niña (blue) and ENSO-neutral (grey) frequency. Vertical dotted line separates the first period (1971–1995) from the second period (1996–2021). The black line within the timeseries represents the linear trend, statistically significant at 90 %. Also presented (right panel) are relative wind speed distributions as boxplots for 1971–1995 and 1996–2021. The black line within the boxplot represents the median, the white dot represents the mean, the box is the 25–75th percentile range, and the whiskers represent the 5–95th percentile range.

Regarding agricultural impacts, coconut, kava, and banana are affected in different ways (Table 1), with some crops being more vulnerable to high winds. For example, after Cyclone Ofa in Samoa (1991), 100 % of banana plants were destroyed compared to around 5 % of coconut trees [1], mostly due to the differences in sensitivity to wind speed of the different crops.

Table 1 Coconut, kava and banana production importance in Vanuatu, and different levels of impacts caused by tropical cyclone winds.

	Coconut	Kava	Banana
Importance of the crop	As well as providing a staple food source [1], coconut has been an important export crop for Vanuatu since 1870. Copra, which is dried coconut extracted from inside the coconut kernel is used as a food ingredient and as an oil by-product for cooking and electricity generation [10]. It has grown to one of Vanuatu's highest commodity exports [11, 12].	Kava is an important social and ceremonial drink [1, 13] contributing to local economies as a cash crop, with the number of households involved in planting kava increasing over more recent years [13]. In 2020, kava accounted for ~50 % of all exports from Vanuatu (774 tonnes) [14].	Banana is the second most important staple food crop in the Pacific in terms of total calories supplied [1]. In Vanuatu there is widespread cultivation of many varieties across a range of intercropping environments [1, 15]. Local gardens also contribute to local economies as a cash crop.
Vulnerability to TCs	Cyclonic winds strip fronds, causing premature nut-fall, and damage to young inflorescences, delaying (although not stopping) future nut production [1]. Younger and older palms are most vulnerable to being uprooted or broken during severe cyclone events. Introduced hybrid coconut varieties are less cyclone-tolerant, being shorter and less elastic than the taller varieties that have naturally evolved in the region.	From 12–18 months of age kava becomes susceptible to wind damage. "If the tops break and the roots are shaken, the plant will die" [1]. The roots of older damaged plants can be salvaged if they are processed immediately post-cyclone [1]. After Cyclone Pam it was reported that up to a third of the country's kava crop was destroyed, reducing both cash and export income for local communities.	Steady winds will cause banana leaf shredding, leaf drying, distortion of the crown and, if the winds are extreme, complete or partial toppling of the plant will occur [1]. Often bananas are the first crops to be destroyed during cyclones. A strong cyclone can wipe out nearly all bananas in an area, and severely affect the food security of thousands of people [1, 16] before replanting and new production can occur.

STEP 4 Collect information about future climate scenarios

Ongoing increases in greenhouse gas emissions will lead to decreases in the average number of cyclones in the Vanuatu region [5-9] (low to medium confidence). A reduction of up to one cyclone per decade has been projected by the end of the century for Vanuatu, with higher reductions in the northern region (Figure 3) [6] (see also Tropical cyclone explainer).

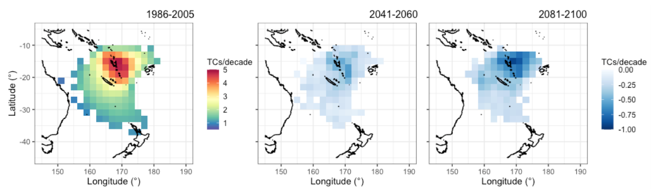

Figure 3 Average number of tropical cyclones (TCs) for the historical period (1986–2005 left panel), and the projected change in the number of cyclones for the mid-century (2041–2060 central panel) and late-century (2081–2100 right panel) under RCP8.5 (see Emission pathways factsheet). These data are based on the MIT synthetic cyclone tracks model driven by a set of eight CMIP5 global climate models. Note the cyclone trend per decade scale is negative [6].

Projections indicate an increase in the mean intensity of future cyclones (i.e. 2070–2100 relative to 1970–2000 periods) across all six provinces of Vanuatu (Figure 4) [5]. Malampa, which is centrally located within Vanuatu, exhibits the maximum projected change of 3.2 %, followed by Shefa (2.4 %), Penama (1.7 %), Torba (1.4 %), Tafea (1.2 %) and Sanma with the lowest change of 0.4 % [5].

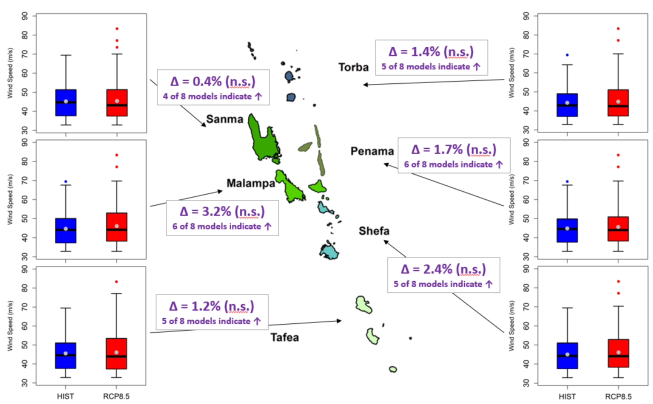

Figure 4 Historical (1970–2000) and projected (2070–2100; high emissions RCP8.5) severe cyclone wind speed (m/s) for six Vanuatu provinces [5]. Severe cyclones are defined as category 3-5. Boxplots indicate the range of maximum cyclone wind speed. For each province, the average per cent change in wind speed is noted, as well as climate model consensus information, with 'n.s.' indicating a change that is not statistically significant. Historical data are from climate model output. Projections are derived from eight climate models following Chand et al. (2017) and Bell et al. (2019) [8, 17].

STEP 5 Analyse climate-related impacts

In Vanuatu increasing cyclone wind speed is the climate factor likely to have the greatest impact on coconuts, kava and (arguably) banana [1]. Management of the crops to minimise impact will remain important, noting the overall effect of tropical cyclones is expected to increase with further warming through higher rainfall rates due to warmer sea and air temperatures, together with increased coastal inundation impacting some production areas located immediately adjacent to the coast associated that will experience storm surges on top of a higher sea level [18]. Further work quantitatively assessing impacts for a given cyclone category, for example, would be instructive for the agriculture sector in Vanuatu.

STEP 6

Evaluate other climate and non-climate factors

It is important to note that only tropical cyclone wind speed conditions are assessed in Steps 4 and 5. Other climate and non-climate factors are listed below that may also influence production of these three agricultural commodities. Further analysis around any or all of these may be prudent.

	Coconut	Kava	Banana
Climate Factors			
Temperature	The ideal mean temperature for growing is 28 °C, a maximum of not more than 33 °C and minimum of not less than 22 °C [19].	A 1.2 °C increase in mean annual temperature (projected for 2050 under RCP8.5) for Vanuatu is unlikely to have an adverse impact on kava site suitability in Vanuatu [6].	Higher temperatures in excess of 35 °C are likely to affect flowering and bunch filling [1].
Drought	Coconuts can survive drought conditions, hence their ability to grow in atoll conditions. However, prolonged drought significantly delays nut production [1].	Kava is susceptible to drought. A kava plant of less than one year of age can tolerate only one month of less than 40 mm of rainfall. Stressed plants are more susceptible to kava dieback [1].	Drought is detrimental to bananas, though some varieties can still produce a crop. (Lebot pers. comm.) [1].
Extreme rainfall	In Pacific Ocean basins, TC-induced rainfall rate is projected to increase (high confidence) [9, 20]. Both banana (some varieties are more resilient) and kava are intolerant to waterlogging, while coconut is more tolerant [1]. Extreme rainfall can also impact physically and damage plants during some growth phases e.g. flowering, fruit set.		
Sea level rise	Sea level rise and an increase in extreme sea level events are projected for Vanuatu, which may exacerbate TC impacts from coastal inundation [5, 9, 21, 22], potentially affecting agricultural sites. Coastal coconut palms are already affected, and this will be exacerbated with further sea level rise [1]. Banana species are tolerant of salt spray, but considered susceptible to salt intrusion and salinity.		
Climate Drivers			
Climate drivers	The **El Niño Southern Oscillation (ENSO)** is a large-scale driver of natural climate variability in the Pacific, affecting many climate hazards including extreme rainfall and drought [23]. In El Niño years the South Pacific Convergence Zone (SPCZ) moves north-east (drier conditions). While overall TC frequency is projected to decrease for the south-west Pacific region including Vanuatu, more cyclones are projected in future during El Niño conditions compared with present-climate El Niño conditions. Fewer cyclones are projected during future La Niña conditions compared with present-climate La Niña conditions (medium confidence) [17]. Overall, extreme La Niña and El Niño events are projected to increase in future [24, 25].		
Non-climate Factors			
Pests and diseases	Both coconut rhinoceros beetle and coconut leaf beetle are important pest species whose impact could be explored under future climate change [1].	Kava dieback is primarily caused by cucumber mosaic virus [26], with impact from projected climate change unknown [1].	Black leaf streak disease (BLSD), *Radopholus similis*, banana weevil borer and *Banana bunchy top virus* impacts may increase in some areas with climate change [1].
	Crop hygiene reduces disease pressure e.g. BLSD release fungal spores in post-cyclone environments which may exacerbate fungal diseases [1].		
Socio-economic factors	Worker productivity, soil properties and a range of other relevant socio-economic factors affect the management practices, livelihoods and wellbeing of smallholder crop production.		
Transport infrastructure	The level of damage to critical transport/logistics infrastructure is important for the agriculture sector, such as roads for accessing markets and related distribution networks. Such impacts will also depend on the pre-cyclone status of that infrastructure and how well it has been maintained or otherwise designed to be climate resilient [1].		

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STEP 7

Plan future adaptation

Adaptation can be incremental or transformative, with enablers and barriers, synergies and trade-offs, pathways and limits, costs and benefits. The process usually starts with consideration of adaptation options. A list of adaptation options to reduce impacts from cyclones that could be considered, tested, and verified in the community to improve resilience include:

COCONUT

Replanting to replace older palms which are more vulnerable to cyclones [1].

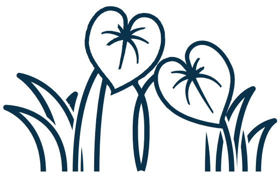
Selective breeding for resilience to cyclones using "Dwarf, Tall and Dwarf x Tall" combinations [27].

Plant trees in groups of three palms per hill (G3PH technique) produces a stable massive rooting system that strongly support the plants; the trees can resist cyclones or winds of 200 km/hr and are ideal for cyclone prone areas [28].

KAVA

Planting windbreaks can shelter larger kava plantings [1].

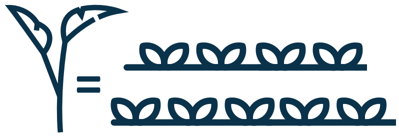
The single node technique is very useful to increasingly multiply kava planting materials after a disaster [28].



Reducing weeding in kava gardens during cyclone season helps protect kava from cyclone damage [28].

BANANA

Preserving bananas using the "Mara Technique" to reduce post-cyclone periods of food shortages [16].



The "Laufasi Technique": a propagation method to replant a whole new plantation with a single standing stem [16].

Cutting banana leaves, stem or supporting the stem with a stick before a cyclone helps to reduce cyclone impacts on the crop. The technique is very useful and works well during cyclones of category 1-2 [28].

Cross-cutting adaptation measures include developing more climate resilient transports and logistics infrastructure for accessing markets and distributing products. This includes ensuring critical coastal roads, bridges and drainage systems are designed according to engineering specifications informed by science-based Climate Information Services (see also Coastal Inundation factsheet and Roads and bridges infobyte).

Other options include potential relocation of existing production areas and/or development of new production areas that are more climatically suited to agricultural production. Diversification into production of new, more climatically suited products will potentially also offset the impacts of climate change on existing products and traditional production methods and locations.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STEP 8

Communicate findings

Communicating the assessment findings to key sector stakeholders is the final step of the climate hazard-based impact assessment. Multiple communication formats, co-designed and co-produced with target users in mind are more likely to support action and decision-making. The contents of this infobyte, together with other related resources shown below, can be disseminated and shared with key stakeholders to help them plan for and adapt to the changing climate.

Van-KIRAP Web Portal

Case Studies

Fact Sheets

Guidance Material

Videos

Click here for References

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