CLIMATE CHANGE IMPACTS ON COFFEE IN VANUATU

AGRICULTURE

This case study examines climate change impacts on coffee production in Vanuatu using a step-by-step approach. Guidance around conducting this type of assessment is provided in more detail on the Vanuatu Climate Futures Portal, along with other case studies (called 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

The climate has been changing in Vanuatu [1, 2], and these changes are projected to continue [3]. Vanuatu has warmed by 0.7 °C since the pre-industrial period (1850–1900) [3], however there has been little change in annual average rainfall. In the coming decades, annual average temperature is projected to increase further, and while little change in annual average rainfall is projected, extreme daily rainfall is expected to increase [1, 3].

Coffee (*Coffea arabica*) is one of the major cash crops of Vanuatu, along with others such as kava, coconut and cocoa [4]. Aligning agricultural production to the climate is an important factor for producers to consider. **Here we explore the temperature suitability for coffee production in Tanna under current and future climate conditions.** For information on how this climate related impact assessment fits into a broader risk framework, see the Climate risk factsheet.



Figure 1 Tanna coffee farmer and coffee bean sorting, drying and roasting facility in Tanna (Photos: © CSIRO)

STEP 2 Engage and meet with stakeholders

Van-KIRAP agriculture sector personnel, Vanuatu Meteorology and Geo-hazards Department (VMGD) staff and CSIRO scientists visited coffee processing facilities and farms in Tanna in February 2023 to discuss different aspects of coffee growing. From these discussions important climate variables affecting coffee production were identified, as well as gaining a better understanding of how and where coffee is typically grown. In preparation of this report, key literature was also drawn upon e.g. [5, 6], as well as industry planning reports [4].

STEP 3 Explore relevant background information and historic climate data

Arabica Coffee was first introduced to Vanuatu in 1852 and the industry expanded until 1909, when coffee leaf rust (CLR) sent the industry into steep decline. Since then, various attempts have been made to revive the industry. Established in 1982, the Tanna Coffee Development Company has introduced improved management practices and a new rust resistant coffee variety 'Catimor' which has stabilised coffee production [4, 7]. The industry, currently expanding (Figure 2), employs many small-holder farmers with income generated for around 1,000 people on Tanna Island alone. Coffee is also grown in Santo, Erromango, Epi, Malo and Efate to a lesser degree [4].

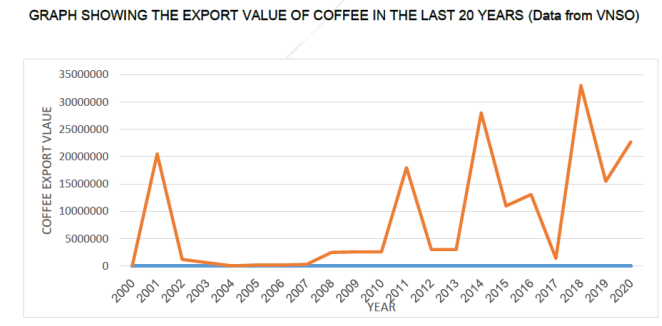




Figure 2 Export value (Vatu) of Vanuatu coffee (orange line) [4] (top). Farmers discussing coffee production in Tanna (bottom) Photo: © CSIRO.

The climate of Vanuatu has a wet season (November to April) and a dry season (May to October), with the north tending to be hotter and wetter than the south [8]. For White Grass Airport weather station, located on the coast in Tanna (Figure 3), the monthly temperatures range from about 21–26 °C, and the annual hottest days for the period 1986–2005 range from 31.4–34.0 °C [1]. Coffee is grown in elevated sites on Tanna and therefore would experience cooler conditions than those at the weather station.

Coffee production is affected by temperature, rainfall, drought, and tropical cyclones [5, 6, 9, 10]. Annual average temperature ranging between 17–24 °C is optimal for coffee production [6, 10-12]. In general, coffee needs an annual rainfall of 1800–5000 mm [6, 9]. Both drought and extreme rainfall can negatively impact coffee production (see Step 7).

Areas in Vanuatu, and Tanna (inset), with a climate suitable for coffee production (1970–2000) are indicated in light green shading in Figure 3.

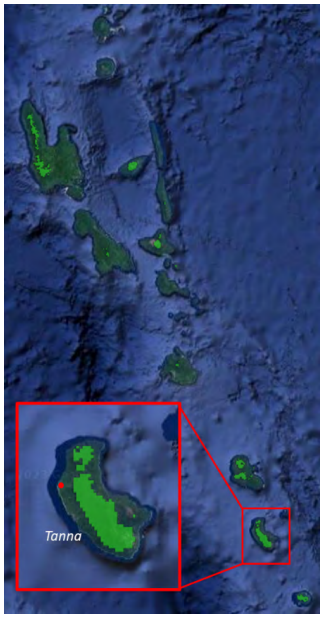


Figure 3 Areas with suitable mean annual temperature conditions (17–24 °C) for coffee production (1970–2000) (indicated by light green shading). Tanna is enlarged in the inset. Approximate location of White Grass Airport weather station indicated by red dot. NB: The term 'suitable' is used as a guide ONLY. Micro-climate, soil, and other management factors will all influence coffee productivity.

STEP 4 Collect information about future climate scenarios

Climate models indicate annual average temperatures will increase in Vanuatu by 0.7–1.3 °C by 2050, relative to 1986–2005 (Table 1). This warming will be associated with more heatwaves. It is unclear whether rainfall will increase or decrease by 2050 [1, 3] and while projected median changes in average rainfall by 2050 are small, ranges are large, with the amount of rainfall on the wettest days projected to increase [1].

Table 1 Projected changes in Vanuatu average annual temperature and rainfall for 20-year periods centred on 2030 and 2050 relative to 1986–2005. Median changes are given, with the 10th–90th percentile uncertainty range in brackets. For 2050, changes are shown for low emissions (RCP2.6: green) and high emissions (RCP8.5: red). In 2030, changes are similar for low and high emissions [3].

	2030	2050
Temperature from 1986–2005 (°C)	0.6 (0.3 to 1.0)	0.7 (0.5 to 1.1)
		1.3 (0.8 to 2.0)
Annual rainfall from 1986–2005 (%)	1 (-9 to 13)	1 (-6 to 9)
		0 (-12 to 14)

The projected ranges take account of uncertainty in greenhouse gas emissions scenarios [8], regional climate responses simulated by climate models for each emissions scenario, and natural climate variability (see also Step 5).

STEP 5 Analyse climate-related impacts

To assist with decision making, it is useful to frame the analysis around relevant questions, while ensuring the full range of projected climate outcomes are captured: What would we do under a 'least warming' or 'more warming' model under a range of emission scenarios? This is known as the 'storyline approach' [13]. The scenarios account for uncertainty in future greenhouse gas emissions, the regional climate responses to those emissions, and natural climate variability. By 2050, using this approach for coffee, the area suitable for production reduces (compared to historic suitability Figure 3) under a low warming scenario by 2050, however, under a higher warming scenario the area suitable for growing coffee in Vanuatu is markedly reduced (Figure 4).

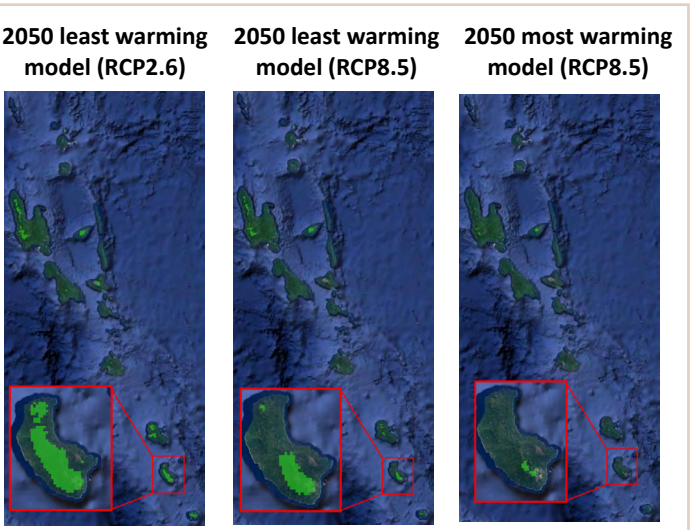


Figure 4 Tanna coffee suitability maps: (mean optimal temperature 17–24 °C = light green), for a 20-year period centred on 2050 under a 'least warming model with low emissions' (GISS-E2-R model, RCP2.6) (left), a 'least warming model with high emissions' (GISS-E2-R model, RCP8.5) (middle) and a 'most warming model with high emissions' (IPSL-CM5A-MR model, RCP8.5) (right). NB: 'Suitability' is used as a guide ONLY. Micro-climate, soil, and other management factors and other climate variables will all influence coffee productivity.

It appears that coffee production in Vanuatu is very sensitive to temperature increases, with potentially greatly reduced areas with suitable temperatures for growing coffee by 2050. By 2050, the area with a suitable climate for coffee is estimated to decline 44% for a 'least warming and low emissions' scenario and 93% for a 'most warming and high emissions' scenario. Under higher emissions scenarios, and the most warming model, coffee production may lose viability by 2050. It is noted, the term 'suitability' is used as a guide ONLY. Micro-climate, soil, other management factors and other climate variables will all influence coffee productivity. This assessment also assumes no adaptation practices are implemented throughout this period (see Step 7).

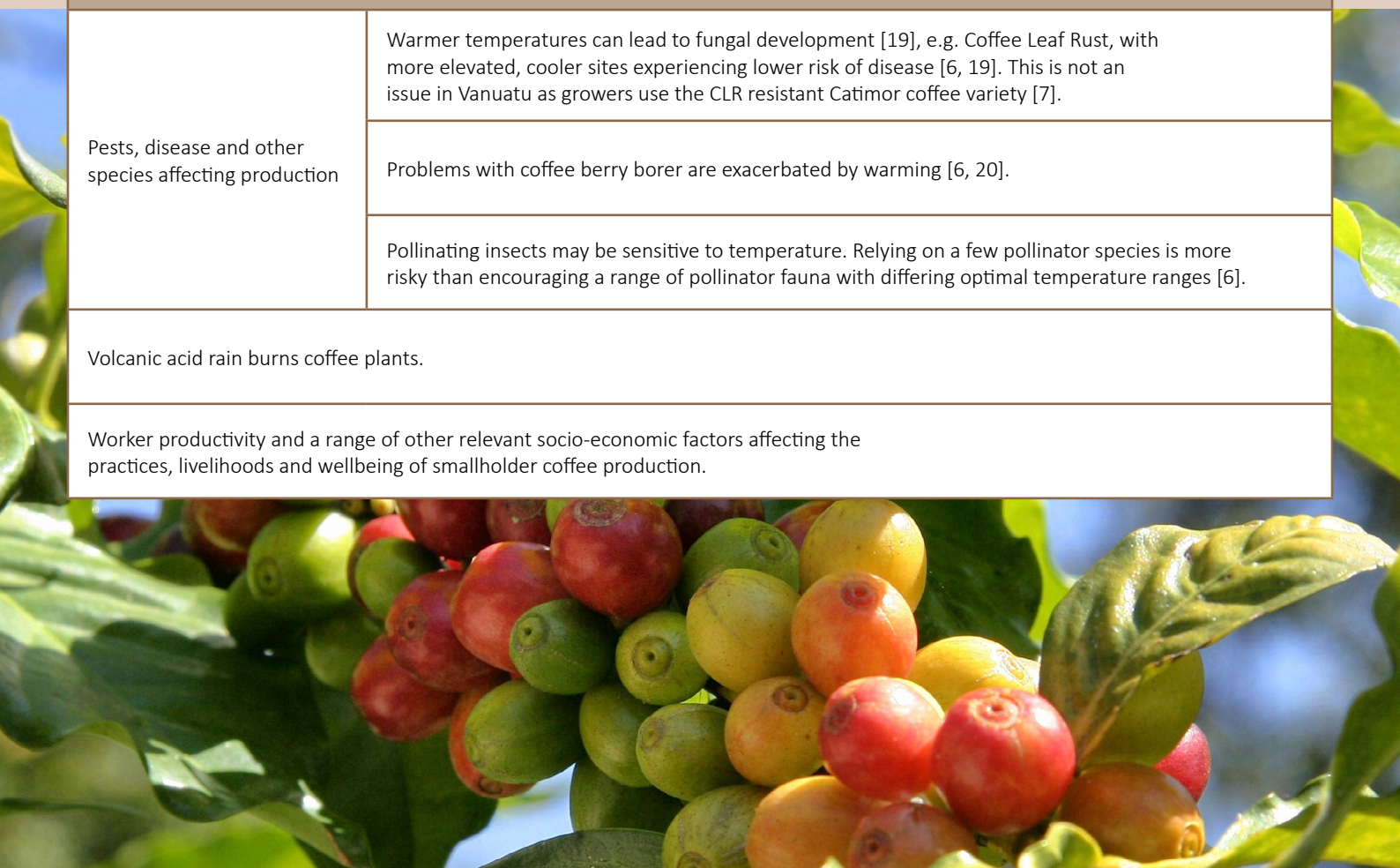
The Vanuatu Climate Futures Portal provides options to explore different future scenarios for coffee production (and other crops), and also the ability to interact with the climate variables separately to better understand the drivers of some of the production suitability shifts seen in Figure 4. Furthermore, future climate suitability for cocoa and root crops has also been undertaken and reported in separate infobytes. Collectively there appears a potential for a change in the prominence of some crops in some locations in Vanuatu. For example, while suitability for coffee production may decline in Tanna under some future warmer scenarios, opportunities for cocoa and taro production, for example, may improve.

STEP 6

Other climate and non-climate factors

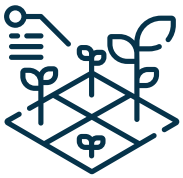
It is important to note that only average temperature conditions are assessed in Step 5. Other climate and non-climate factors are listed below that may also influence suitability for coffee production. Further analysis around any or all of these may be prudent.

Climate factors affecting coffee production	
Tropical cyclones (TCs)	TC Pam destroyed 90 % of the Tanna coffee trees in March 2015, leaving a total of 650 farmers without a source of income [7]. TC Judy and Kevin occurred just days apart in March 2023 impacting Tanna coffee production dramatically [14] (see Tropical cyclone factsheet for more information).
Droughts	Coffee production is adversely affected by drought affecting yield, with insufficient moisture also associated with biennial bearing [6]. There is agreement in the literature that a 2-month dry spell is important [5] (see Drought factsheet for more information).
Extreme rainfall	Extreme or heavy rainfall is related to waterlogging, and wet conditions can delay ripening [6]. Drainage is a critical component for selection of suitable sites for coffee farms [10]. Farm access can be a problem after extreme rainfall, as well as disease pressure increases (see Extreme rainfall explainer for more information).
Extreme temperature	Continuous exposure to temperatures as high as 30 °C leads to stress, which presents as depressed growth and abnormalities, such as the yellowing of leaves and growth of tumours on the stem, ultimately affecting yield [6].
Other climate factors	Coffee plants prefer some cloud cover, and higher humidity reducing sunlight intensity, with high wind speed being detrimental [11].
El Niño Southern Oscillation (ENSO)	ENSO is a large-scale driver of climate variability in the Pacific, affecting rainfall and drought [15]. In El Niño years, the South Pacific Convergence Zone (SPCZ) moves north-east, leading to drier conditions. In La Niña years, the SPCZ moves south-west, leading to wetter conditions. ENSO also affects tropical cyclone frequency [16]. La Niña and El Niño extremes are projected to increase in future [17, 18] (see Climate variability explainer).
Non-climate factors affecting coffee production	
Pests, disease and other species affecting production	Warmer temperatures can lead to fungal development [19], e.g. Coffee Leaf Rust, with more elevated, cooler sites experiencing lower risk of disease [6, 19]. This is not an issue in Vanuatu as growers use the CLR resistant Catimor coffee variety [7].
	Problems with coffee berry borer are exacerbated by warming [6, 20].
	Pollinating insects may be sensitive to temperature. Relying on a few pollinator species is more risky than encouraging a range of pollinator fauna with differing optimal temperature ranges [6].
Volcanic acid rain burns coffee plants.	
Worker productivity and a range of other relevant socio-economic factors affecting the practices, livelihoods and wellbeing of smallholder coffee production.	

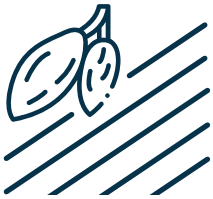


STEP 7 Plan future adaptation

There are several ways in which coffee producers can become more resilient to these climate challenges. Issues identified in Steps 1 to 6 provide valuable input to stakeholder discussions about actions that can build resilience. This is a complex participatory process. 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 potential adaptation options that could be considered, tested, and verified in the community to improve resilience includes:



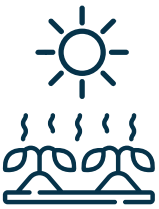
New farm management practices



Farming in new areas, in elevated locations



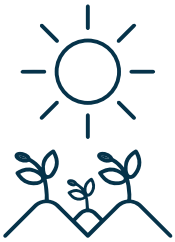
Diversify the farming system to include other crops



Change the aspect to reduce exposure to hot afternoon sun



Introduce more shade trees to reduce heat stress



Selectively breed more heat tolerant varieties



Mulch and prune to improve growing conditions



Plant cover crops where rainfall or moisture is adequate

STEP 8 Communicate findings

Communicating the assessment findings to key sector stakeholders is the final step of the climate related 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.

Vanuatu Climate Futures Portal

Case Studies

Fact Sheets

Guidance Material

Videos



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