Climate hazard-based impact assessments for Vanuatu:

A step-by-step guide on climate change related impact assessments for sectors

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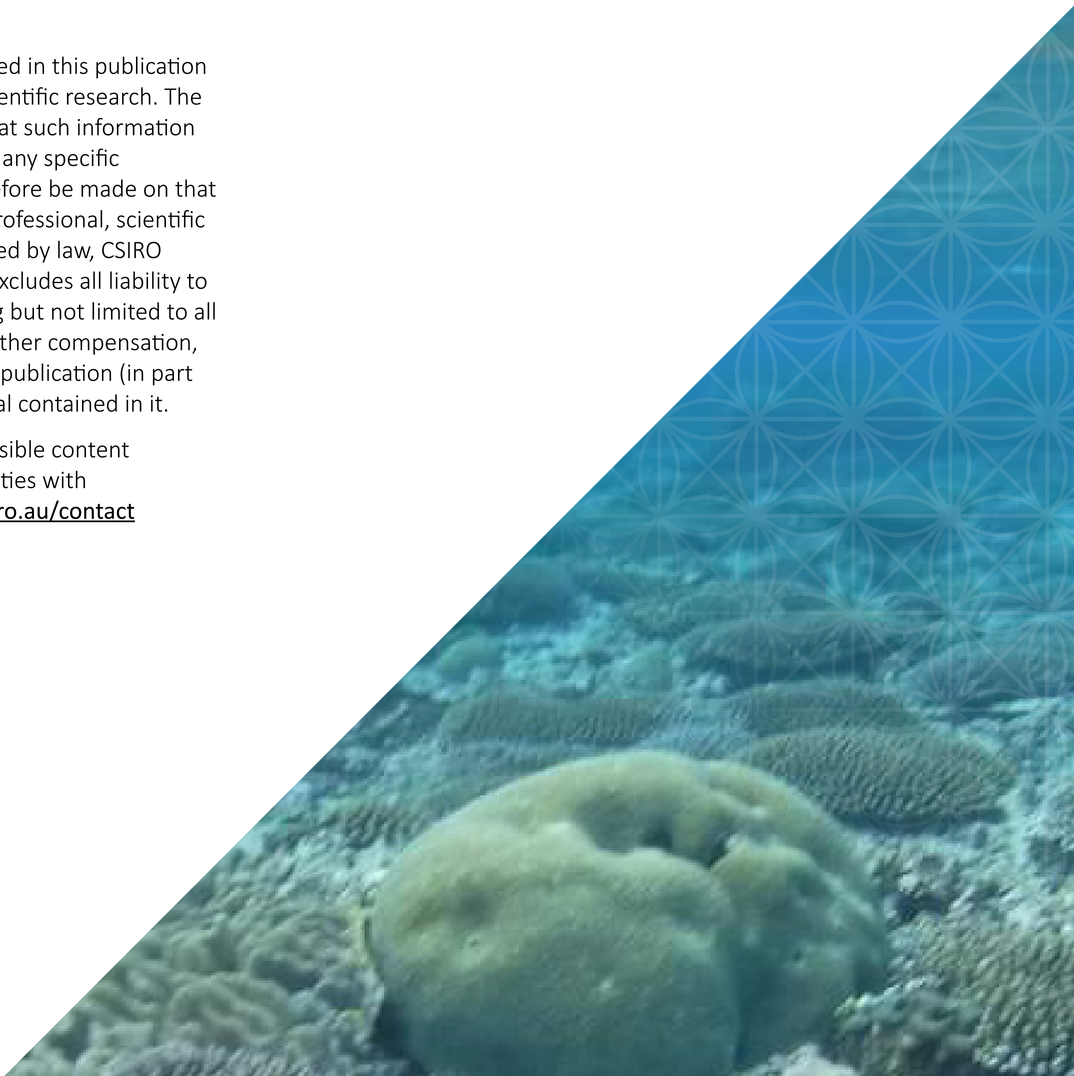

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Introduction

The series of eight steps listed below guide users of science-based Climate Information Services (CIS) through the process of undertaking a climate hazard-based impact assessment. These steps have been followed when producing sectoral case studies (reported as infobytes) for Vanuatu. Undertaking such assessments is often the first step in undertaking a more comprehensive climate change risk assessment, the outputs of which are typically used as evidence to inform policy development and adaptation planning, implementation and associated decision-making. For information on how this guidance fits into a broader risk assessment framework, see the Climate risk factsheet.

It is important to note that communication, consultation, monitoring, evaluation and review are included at every step. This is part of an underpinning co-design and co-production approach to climate action between climate science and service providers, sectoral end-users, local communities, non-governmental organisations (NGOs) and other climate actors where appropriate. Such an approach is intended to achieve tangible on-ground outcomes and thereby build climate resilience at the local level. In practice, this process aims to deliver data and information that is fit-for-purpose, credible and relevant, meets user needs, and aligns with previously developed guidance material produced for the Pacific [1, 2].

STEPS FOR CONDUCTING CLIMATE HAZARD-BASED IMPACT ASSESSMENTS

STEP 1	Understand the context and scope
STEP 2	Organise meeting of potential stakeholders to discuss project
STEP 3	Explore relevant background information and historic climate data
STEP 4	Collect information about future climate scenarios
STEP 5	Analyse climate-related impacts under 'best-case' and 'worse-case' scenarios
STEP 6	Evaluate all other climate and relevant non-climate factors
STEP 7	Plan future adaptation measures and treatments
STEP 8	Communicate findings

Brief sectoral infobytes produced for the Van-KIRAP project provide examples showing how climate information can be used in hazard-based impact assessments for priority sectors and key climate variables (Table 1). For each infobyte the analysis depends on the climate variable most relevant to the (impact) topic in question. The climate variables include average and extreme air temperature, average and extreme rainfall, droughts, tropical cyclones, sea level and ocean temperature and chemistry. Where appropriate, relevant Van-KIRAP CIS products are identified and used to demonstrate practical applications of science-based evidence to inform decision-making.

Table 1 Infobytes prepared for five sectors in Vanuatu where the eight-step process described in this guidance material has been followed. The assessments explore current and future climate/climate change conditions.

Infrastructure Sector
Coastal inundation affecting roads and bridges
Impact of extreme rainfall on airports
Impact of extreme heat on electricity production
Tourism Sector
Impact of coastal inundation on tourist bungalows
Tropical cyclones affecting design of tourist bungalows
Water Sector
Extreme rainfall affecting Port Vila flood exposure
Extreme rainfall affecting Sarakata river flood exposure
Impact of drought and rainfall on water security
Fisheries Sector
Impact of marine heatwaves on coral bleaching
Impacts to coral reefs from changes to ocean chemistry
Impacts of marine heat waves on seagrass
Sea level variability affecting mangroves
Sand temperature at turtle nesting sites
Wind speed affecting safe operation of fishing vessels
Agriculture Sector
Temperature suitability for coffee production
Temperature and rainfall suitability for cocoa production
Temperature suitability for root-crop production
Tropical cyclones affecting coconut, kava, and banana

STEP 1

Understand the context and scope

To undertake a climate hazard-based impact assessment, the first step is to clearly define the context and scope of the assessment. This is to ensure the assessment will deliver relevant and actionable outputs to address prioritised stakeholder needs. Given changing climate conditions and interdependencies [3], many sectoral systems will be affected in a multitude of ways (e.g. Figure 1). Exploring the issues requires clear definition of both the current and potential future climate impacts to be explored in depth using data and information provided in Step 2.

Figure 1 Damage from TC Kevin (top left). Major flooding at Bauerfield International Airport, Port Vila from a passing low-pressure system driven by Tropical Cyclone Gina (top right). Turtle protection (middle left). Cyclone-resilient beach bungalow, Port Resolution, Tanna (middle right). Water tanks in Tanna supplied by the Government of Vanuatu (bottom left). Coffee plantation, Tanna (bottom right). Photo Credit: Leanne Webb, Jeffrey Maynard, Geoff Gooley and Ellian Bangtor.

Undertaking a climate hazard-based impact assessment can be approached using different levels of detail [4]. In practice an initial 'first pass' scan of current and future climate impacts may be enough to guide strategic planning and inform useful decision-making processes, including whether a broader or more detailed (and perhaps more time consuming and/or expensive) assessment of climate impacts is required. The latter is often required when preparing policy and technical specification documents, and more detailed national or sectoral adaptation plans and climate finance investment proposals.

It is useful to also think more broadly about the context of the assessment: aside from climate change, what are the political, economic, social, technological, environmental and legal (PESTEL) drivers to consider? For example, is your context influenced by population growth, urbanisation or displacement, socio-economic well-being, technical innovation, local or regional geo-political circumstances, land ownership/tenure considerations? What underlying development issues (e.g. poverty, gender inequality, environmental degradation) will your assessment address? To guide the assessment of the 'big picture' (integrated econcomic, environmental and social systems thinking) and problem identification for the assessment, a series of contextualised climate change case studies have been developed by CSIRO [5].

STEP 2 Organise meeting of potential stakeholders to discuss project

Identifying, engaging, and meeting with stakeholders can help clarify the context and scope for the assessment including key climate hazards, decision-making processes, resources, and specific objectives. This step is critical to the success of the impact assessment.

Who might these stakeholders be?

- Farmers, fishers, engineers, tourism operators etc.
- Traditional knowledge specialists and other knowledge brokers.
- Chambers of commerce, industry groups, other private sector investors etc.
- NGOs and community-based groups like cooperatives, women's committees, school groups and faith-based organisations etc.
- Researchers, national universities, consultants, and other technical experts.
- Policymakers, climate and meteorological officers and focal points, sectoral extension and resource management officers, and adaptation planning experts at national and sub-national levels.
- Regional organisations involved in planning, coordinating and implementing climate action, including donor-funded programs and projects, capacity development.

The development and implementation of a stakeholder engagement plan is an important aspect of each of the subsequent steps in this process, including to:

- Organise meetings to communicate, discuss and identify needs, data, methods, results, etc.
- Organise site visits if required.
- Prepare, distribute and assess questionnaires to survey and identify user needs.

What do we want to find out? This may include actions to:

- Scan stakeholders for their concerns and information needs around the topic.
- Identify stakeholder capability/capacity strengths and gaps/needs.
- Clarify available resources that may affect the scope e.g. staff, time, finance etc.
- Seek more information about current climate impacts, from both traditional knowledge and digital records (see Step 3).
- Subject to the scope of the assessment, identify exposure and vulnerability of people, resources, and assets where appropriate.
- Identify relevant strategies, policies, and implementation plans.
- Determine if there are any stakeholders with special data/information needs in relation to climate change impacts, such as gender specific issues and/or issues for aged or disabled people or those from cultural minorities etc.

Determine meeting outcomes, including:

- An agreed scope, purpose, and method for the impact assessment.
- Available data, information, staff and financial resources.
- Associated gaps, needs and opportunities, including awareness raising and capacity development, for key stakeholders (e.g. Figure 2).
- Links to climate adaptation/resilience and related sustainable development strategies and policies and other related climate actions (other assessment and/or adaptation programs, projects and related initiatives) where appropriate (including opportunities for alignment, leveraging and other forms of coordination and/or collaboration).

An important topic that will be explored at the meeting is to understand how historical and current weather and climate information, including observational (station) data where relevant and available, is included in decisions now, and what other non-climate information is relevant to inform your assessment

Figure 2 Recent Van-KIRAP stakeholder engagement and site visit at Port Resolution in Tanna, February 2023.

STEP 3 Explore relevant background information and historic climate data

Existing knowledge, both climate and non-climate related, provides valuable context, and in some cases useful baselines in the form of observed data sets, for impact assessments. This includes what was discussed with key stakeholders in Step 2. An important focus is to understand how historical and current weather and climate information is already included in decisions (or not, as the case may be), and what other non-climate information (e.g. to inform exposure and vulnerability) is relevant to your assessment (see Step 6).

A useful way to determine whether an historical relationship exists between observed climate and impacts is to conduct a literature review and/or environmental scan of available information, including traditional knowledge and digital records to establish a baseline for then comparing to future climate impacts (see Step 4). Technical information including but not limited to:

- Existing CIS relevant to observed weather to short-term seasonal forecasting timescales and early warning systems etc., can be sourced from national meteorological and hydrological services, along with station-based observational data and associated technical reports, communication collateral (fact sheets, bulletins etc.) and other decision-support tools.
- Sectoral agencies can often provide related technical support, data and information including summary census data, engineering specifications, management and/or adaptation plans and related databases (e.g. spatially and temporally explicit survey data of environmental and/or hard infrastructure assets etc).
- A google-scholar search or a university library gives access to scientific literature and supplementary data resources.

Sectoral specialists, extension officers and knowledge brokers within government, universities, regional organisations and NGOs can often readily access relevant information if they are involved or otherwise able to assist the assessment.

If statistical historical/current climate-impact relationships already exist, check whether they need to be updated with the latest climate and impact information e.g. the impact of recent cyclones on infrastructure, communities, natural resources, sectors etc. If statistical climate-impact relationships don't already exist, you will need to find relevant climate and impact data to derive a causal or at least correlative relationship where appropriate. Climate scientists, data analysts and knowledge brokers can help with this task.

Historical climate data

The [Vanuatu Meteorology and Geo-hazard Department](#) (VMGD) provides station-based observed weather and climate data, multi-day weather forecasts, seasonal climate forecasts, early warnings and other CIS to a wide range of user audiences. Historical weather and climate data (over at least 10 years) required for a climate hazard-based impact assessment typically include:

- rainfall, temperature, wind and humidity (daily, monthly and annual) observations and trends from multiple weather stations
- extreme events such as tropical cyclones, floods, droughts, heatwaves, ENSO events (El Niños and La Niñas), high sea levels and coral bleaching alerts
- radar and satellite images, and cyclone tracking maps (also available from [Fiji Meteorological Service](#)).

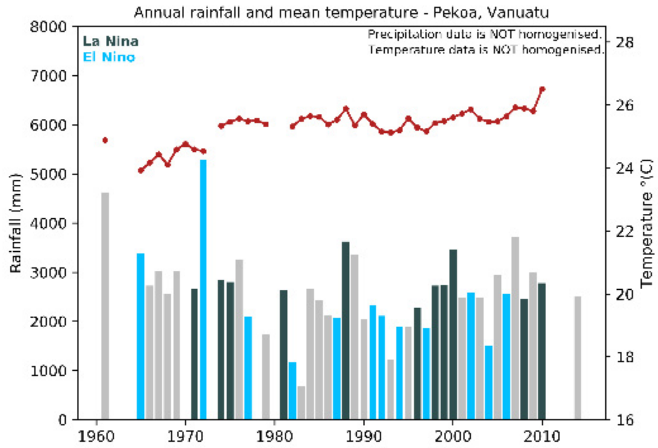


Figure 3 Annual mean temperature (red line with markers) and rainfall (bar) in Santo-Pekoa, Sanma Province, for the period 1960–2017. Light blue, dark blue and grey bars denote El Niño, La Niña, and neutral years, respectively. Data source: Pacific Climate Change Data Portal (2018) (top). VMGD staff delivering CIS material to the Tafea Province climate change headquarters in Isangel (bottom).

Tailoring historical climate information and data

An understanding of historical impacts related to climate will help inform what types of climate data are needed to derive relevant climate-impact relationships for the assessment (Table 2). In most cases only one climate variable will be needed, but other cases may be more complex, particularly where compounding or cascading effects of certain climate hazards are apparent. Impacts are often related to the intensity, frequency and duration of extreme weather/climate events, so it may be necessary to access weather/climate timeseries data for specific locations or broader geographic areas.

Table 2 Climate information and relationships with historical impacts for informing hazard-based impact assessments for future climate.

Historical climate information
• Climate variable, e.g. temperature, rainfall, sea level, tropical cyclone, drought
• Annual, seasonal, monthly, daily
• Averages*
• Regional or site-specific data
• Timeseries showing variability, extremes and trends
• Phases of the El Niño Southern Oscillation
• Intensity, frequency and duration data
• Baseline period
Examples of climate-impact relationships
• Crop suitability based on seasonal temperature and/or rainfall ranges
• Infrastructure impacts based on cyclone wind speed intensity, frequency, duration (IFD)
• Coral bleaching impacts based on marine heatwave IFD
• Flood impacts based on extreme rainfall IFD
• Water security based on drought IFD
• Electricity demand based on extremely high temperatures

*The classical period for averaging is 30 years, as defined by the World Meteorological Organization.

In Figure 4 for example, when assessing impacts on seagrass in Vanuatu, relationships with sea surface temperature (SST) [6] can be explored for regional averages (top left), marine heatwave frequency and intensity (top right), or timeseries showing daily variability and extremes (bottom).

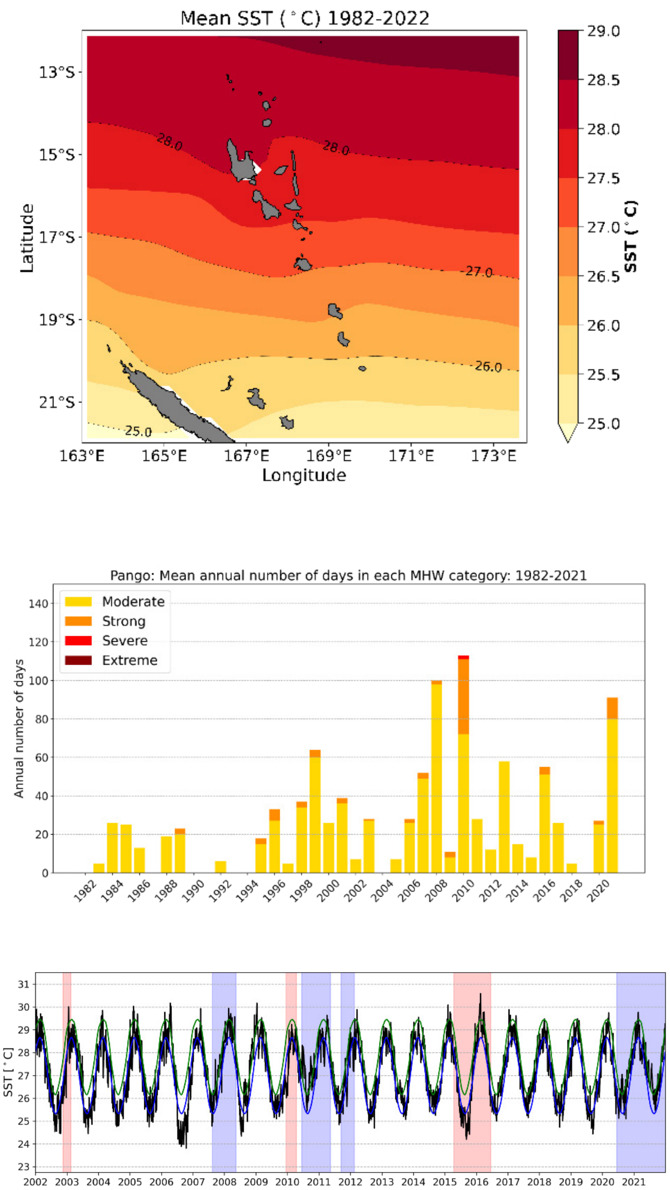


Figure 4 Vanuatu mean SST (°C) (1982–2022) (top); annual number of days in each marine heatwave category over the period 1982–2021 (middle); SST (°C) timeseries from 2002–2021 for Pango region (bottom) showing the observed SST (black line), the seasonal average (blue line; based on 30-year baseline, 2002–2015), and the 90th percentile threshold (green line). Pink and blue bars denote strong El Niño and La Niña events respectively.

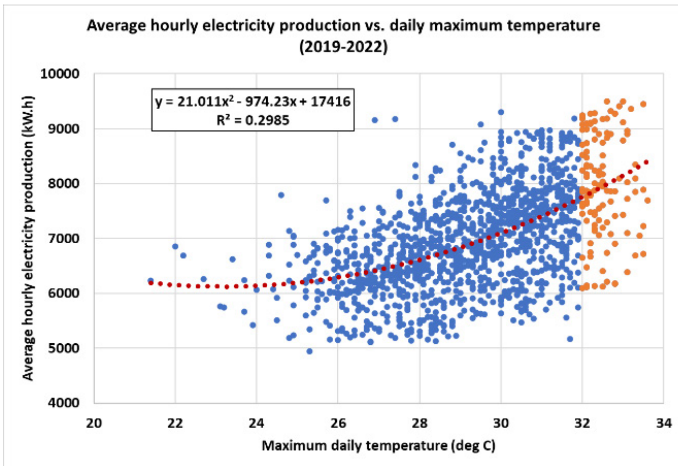
The current or 'baseline' climate conditions need to be defined to enable a comparison with future climate and thereby in part to quantify impacts. There are various definitions for 'baseline' climates, but they usually encompass a 20-year (e.g. 1986–2005) or 30-year period (e.g. 1960–1990, 1980–2010 or 1990–2020) (see Appendix B for a discussion of baselines in: Climate projections for use in impact assessments explainer). Ideally, for comparative purposes the impact data should have the same or at least very similar 'baseline' period, but this is not always feasible due to limited data availability. Therefore, a pragmatic approach requires matching the climate and impact data baselines as closely as possible, even though this may mean using less than 10 years of comparable data in practice for the assessment. In such cases, data limitations should be clearly communicated in the assessment findings so that users are aware and assessment results are applied appropriately within the known limitations of the data.

The VMGD has historical station-based daily temperature and rainfall data over varying time periods available for different locations in Vanuatu (see details Appendix A: Climate projections for use in impact assessments factsheet, and the Regional summaries). The Van-KIRAP project has recently expanded the climate monitoring capability of the VMGD to include coastal monitoring of various marine climate variables such as wave height and SST via a network of 'Sofar spotter buoys' containing sensors linked via satellite to deliver real-time data (see Ocean monitoring factsheet). Historical temperature and rainfall data are also available globally (including Vanuatu) for a 1 km gridded surface (e.g. WorldClim2; [7]), multiple climate variables are available on a 30 km global grid from ERA5; [8], and historical cyclone tracks are also available (SPEArTC; [9]). For ocean variables, sea level data from University of Colorado Sea Level Explorer [10, 11], and global gridded SST data can be accessed using the OISST V2 data set [6], or for ocean chemistry via the OceanSODA-ETHZ [12]. It is always advisable to verify the global gridded data against observed data, where available, to ensure consistency.

Pacific communities have a long history of dealing with natural climate variability including extreme events by reading the signs in their natural environment. Traditional knowledge is a valuable and critical resource that can complement current scientific understanding of physical climate processes and change, and thereby enhance adaptation strategies to build climate resilience in local communities [13].

Historical impact data

Historical impact data can be sourced from published reports, government agencies or private companies, with appropriate approval and acknowledgement. Such information is often also readily available from local and international news and social media, as well as via anecdotal information from face-to-face engagement with local communities. The impact data should be relevant to the purpose of the assessment e.g. coffee production, flood risk management, coastal inundation, coral reef conservation, water security, energy security, road design etc. Historical impact data over at least 10 years, where possible should include daily, monthly, or yearly variability that may be climate-related (e.g. Figure 5, also see Electricity demand infobyte), monthly water usage, annual crop yield etc.



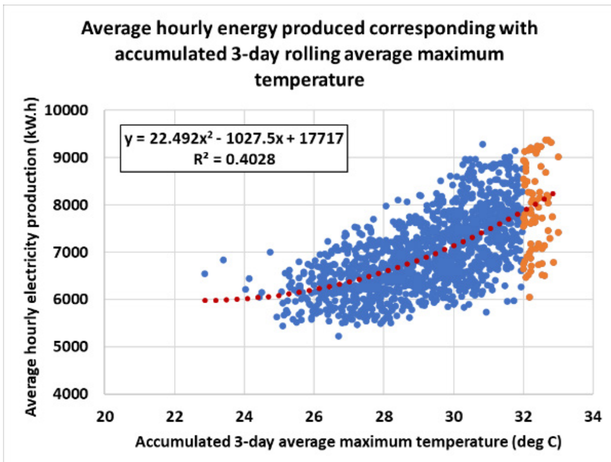


Figure 5 Average hourly energy production (kW.hr) compared to daily maximum temperature (top) and total 3-day electricity produced compared to accumulated 3-day-average maximum temperature (bottom). Non-linear regression lines (dashed) are statistically significant. Days with maximum temperature 32 °C and above are coloured orange. Electricity production data courtesy of UNELCO. Temperature data procured from VMGD for Bauerfield, Port Vila.

Non-climatic factors that affect existing exposure and vulnerability should also be noted e.g. use of fertiliser, flood mitigation measures, insurance, evacuation procedures, development in floodplains, construction of seawalls etc. (see Step 6).

STEP 4

Collect information about future climate scenarios

For this step expert advice may be required. Interested parties in Vanuatu are encouraged to contact the Climate Section of the VMGD as a starting point, including accessing relevant data and information from the Van-KIRAP portal via the VMGD website. Other relevant data, information and expertise can be accessed from: Regional Climate Consortium for Asia and the Pacific, Pacific Islands Regional Climate Centre Network, Intergovernmental Panel on Climate Change (IPCC) Working Group 1 Interactive Atlas, Pacific Data Hub, Pacific Climate Change Centre, University of the South Pacific's Pacific Centre for Environment & Sustainable Development and Australia Pacific Climate Partnership, amongst various other open-source climate platforms, portals, forums and networks.

Determine the future time frame of interest

Determine which future time frame may be relevant, informed by your planning and decision-making focus and time horizon. For example, Figure 6 shows that, depending on the impact of interest, the planning time horizon can change substantively. It is also worth noting that it is hard to predict using climate modelling what will happen in the next 1–10 years due to the dominant effect of natural climate variability often masking the underlying impacts of climate change (see Climate variability explainer). For this reason, future climate scenarios for climate change impact assessments typically focus on the next 10–80 years, when the climate change signal becomes dominant and better resolved in the models.

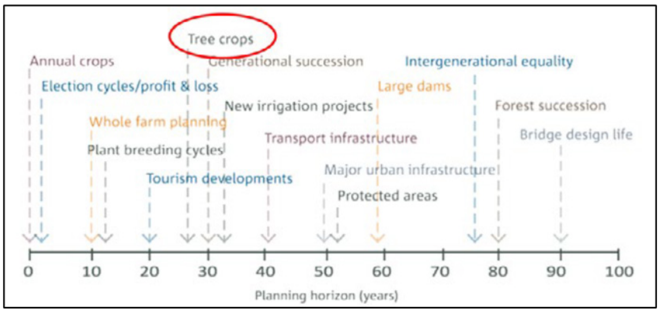


Figure 6 Typical climate adaptation planning time horizons (years to decades) across different sectors [14].

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Choose climate scenarios for impact assessment

Scenarios are descriptions of the future based on different assumptions around global greenhouse gas emissions (for more information, see IPCC). They should be plausible, distinctive, consistent, relevant, and challenging [15]. For impact assessments it is important to consider a range of possible future climate scenarios rather than just one scenario that might seem to be the 'best guess'. Future climates can be described using a storyline approach [16] and based on multiple lines of evidence (both quantitative and qualitative). For example: What would we do under a 'best case' or 'worst case' future climate scenario?

Uncertainty is inherent in all models used in climate scenarios due to (1) different greenhouse gas emissions pathways, (2) regional climate responses to each pathway simulated by different climate models, and (3) natural climate variability. By assessing climate change projections from selected climate models, driven by a range of future greenhouse gas emissions pathways, a range of potential impacts can be captured (also see Step 6) with varying levels of confidence. The following 'storyline' matrix (Figure 7) gives a guide to selecting scenarios informing impact assessments which capture the full range of uncertainty, and thereby assist with meaningful decision making.

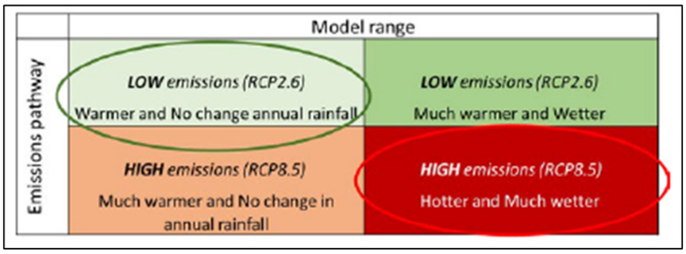

Figure 7 Four future climate scenarios are shown in this 'storyline' matrix: Rows: low (top row) to high (bottom row) emissions pathways. Columns: range of regional climate change for each emissions pathway, showing in this example a warmer future with no increase in average rainfall (left column) to hotter and wetter (right column) (CSIRO and SPREP 2021). Example 'best case' future scenario (green circle) and 'worst case' future scenario (red circle).

Typically, two or three emissions pathways are chosen to frame the impact assessment, including from: low (RCP2.6), medium (RCP4.5) and high (RCP8.5). There are over 40 climate models which simulate these scenarios, some of which have been 'downscaled' to provide finer spatial detail, so selecting appropriate climate models is technically challenging. Since stakeholders are often time/resource and/or otherwise technically constrained, it is pragmatic to choose a subset of climate models that (a) perform well in simulating the current climate and (b) represent a broad range of climate futures. Climate science experts can assist with this selection.

Confidence and limitations around climate data

When using data from climate models it is important to note the level of confidence associated with the data, as well as any limitations regarding the subsequent analysis:

Confidence

- There is greater scientific confidence in projections for some climate variables (e.g. temperature) than others (e.g. rainfall).
- Climate scientists usually provide confidence ratings based on the amount of evidence and the level of agreement between lines of evidence [17]. The ratings range from very low to very high. For example, if confidence is high, then the scenario can be used as a good guide to potential climate change; if confidence is low, then the results are plausible, but caution should be applied, and other possibilities should also be considered.

Limitations

- There is greater scientific confidence in scenarios over large spatial scales and long time periods (e.g. global climate change over multiple decades) than for smaller spatial scales (e.g. regional and national projections) and shorter time periods (e.g. over periods of less than 10 years). Because of this, scenarios generated for smaller regions or provinces and/or for specific points in time should be used as a guide only. In this context, it is very important to understand the spatial, temporal, and associated methodological limitations in the scenarios.
    - While maps may look detailed, this should not be confused with precision. For example, the 1 km Worldclim historical climate dataset is based on model interpolations drawn from a limited observational network across the Pacific.
    - Data from Global Climate Models is typically at coarse resolution, e.g. around 150–200 km between data points on a global grid. Statistically or dynamically downscaled projections can be generated at a finer spatial scale, e.g. 5–50 km grid, but interpreting this information at a city-scale or farm-scale could be misleading (i.e. greater precision but less accuracy) unless scientifically validated.
    - Impacts data are often available for relatively short periods and few locations. This may limit the statistical significance of climate-impact relationships. Data need to be quality controlled and quality assured.

Helpful, non-technical guidance on understanding the limitations of the data for impact assessments is available in earlier reports [1].

STEP 5

Analyse climate-related impacts under ‘best-case’ and ‘worst-case’ scenarios

Information about future climate hazards and impacts can be explored through assessing the interdependencies under different scenario outcomes. The future climate scenarios (Step 4) are integrated with the historical climate-impact relationship (Step 3) to estimate future impacts, with the results used to inform decision-making. This may identify and clarify impacts that are more- or less-serious, with the former potentially requiring a more detailed risk assessment and adaptation-based mitigation, and the latter perhaps considered less important for further consideration/action.

Impacts can be analysed in terms of changes between the current and future climates, or actual values for the current and future climates. The changes can be seen by comparing maps, graphs, or tabulated values, noting limitations described in Step 6. In addition, the percent change in mapped areas can be calculated under different scenarios. Using ‘best case’ and ‘worst case’ scenarios in impact assessments are useful for informing the full range of potential adaptation decisions and related management practices to mitigate impacts and risks for stakeholders. For example, a plausible ‘best case’ (low emissions, lower warming, with decreased rainfall) and plausible ‘worst case’ (high emissions, higher warming, with increased rainfall) could translate to one to four weeks earlier maturity for taro by 2050 (Table 3).

Table 3 Projected average temperature change (°C) for a 20-year period centred on 2050 (relative to 1986–2005) under a ‘best case’ scenario (GISS-E2-R climate model) (left) and ‘worst case’ scenario (IPSL-CM5A-MR climate model) (right) for low (RCP2.6) and high (RCP8.5) emissions pathways. Changes to maturity timing for taro are estimated based on a climate-impact relationship.

	Projected temperature change (°C) by 2050 relative to 1986–2005 [18]		Approximate change in timing of maturity (Crimp, et al. [19])	
Emissions pathway	**‘Best case’**	**‘Worst case’**	**‘Best case’**	**‘Worst case’**
RCP2.6	0.4	0.8	1 week earlier	2 weeks earlier
RCP8.5	1.0	2.0	2 weeks earlier	4 weeks earlier

Highlighting the impacts for different emissions scenarios through the assessment should be policy relevant where possible. For example, compared to 2019–2022 electricity production in Port Vila (Figure 8; see Electricity demand infobyte):

- For low emissions (dashed lines; Figure 8), there is a 0 %–4.0 % increase on average to electricity production for a ‘less warming’ to ‘more warming’ model respectively by 2050 (larger changes in Nov-Feb and smaller changes in May-Aug).
- For high emissions (solid lines; Figure 8), there is around 1.6 %–6.6 % increase on average to electricity production for a ‘less warming’ to ‘more warming’ model respectively by 2050 (larger changes in Nov-Feb and smaller changes in May-Aug).

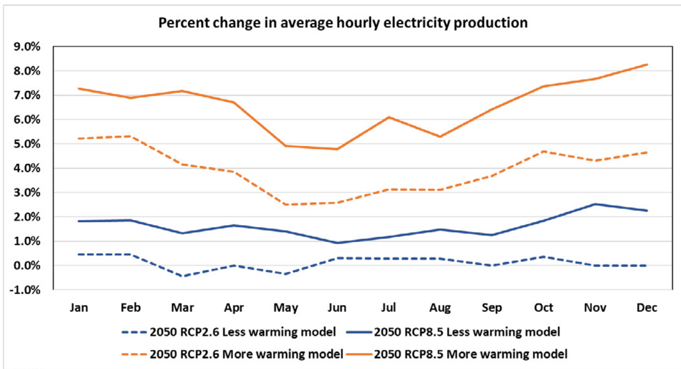

Figure 8 Percent change in average hourly energy production for Port Vila for a 20-year period centred on 2050 for a ‘less warming’ model (blue; GISS-E2-R) and ‘more warming’ model (orange; IPSL-CM5A-MR) under a low emissions pathway (RCP2.6; dashed line) and a high emissions pathway (RCP8.5; solid line). (See Electricity demand infobyte).

STEP 6 Evaluate all other climate and relevant non-climate factors

As well as exploring the main climate hazards (Table 2), other climate variables and non-climate factors should also be considered as these may either exacerbate or ameliorate the impact (Table 4):

Table 4 Other climate and non-climate data and information that may be used to inform climate hazard-based impact assessments

Examples of other climate factors
Humidity
Fire weather
Evaporation
Soil moisture
Solar radiation
Ocean chemistry

Examples of non-climate factors
Pests and diseases
Management practices
Worker productivity
Socio-economic factors e.g. age, gender, education, financial security and associated special needs of certain key stakeholder groups
Access/transport
Fertiliser
Market/supply chain characteristics
Catchment/geographic characteristics
Flood mitigation measures
Land ownership/tenure
Insurance
Evacuation procedures and centres
Development in floodplains
Construction of seawalls
Existing/proposed adaptation plans, projects and initiatives (by Government, private sector, NGOs etc)

Some of these other climate and non-climate considerations may also be relevant in the next steps of the decision-making process in the event that the impact assessment identifies the need for a more detailed impact and/or risk assessment to inform adaptation planning and other forms of climate risk mitigation across different sectors.

STEP 7 Plan future adaptation measures and treatments

Adaptation planning decisions

There are several ways in which sectors can mitigate and adapt to the impacts of climate change, and thereby become more resilient to climate variability and change. As an example, for the agriculture sector, adaptation options include the introduction of new farm management practices, farming in new areas, changing to more heat/disease-tolerant varieties and diversifying the farming system to incorporate other crops or products.

In this step it is critical to reconnect with key stakeholders to discuss the main impacts, adaptation options, priorities and actions that could be implemented to ensure the impact assessment is providing useful and relevant results to inform next steps in the climate action decision pathway.

Near term climate variability and change

When considering near term planning (e.g. for the following 5 years), it is important to allow for significant natural climate variability which will potentially mask the underlying, longer-term climate change signal. As with the past climate, in future there will always be climate variability at all time scales, including daily, monthly, yearly, 10-yearly, and so on, mostly driven by large-scale climate processes such as the El Niño Southern Oscillation (ENSO) (see Climate variability explainer). In other words, there will be an underlying, long-term warming trend due to climate change, but different sequences of hot and cold years over shorter time periods will also be apparent in the climate system from time to time (Figure 9) [20]. It follows that adaptation to changes of multiple timeframes from short, weather to climate (seasonal) and longer-term, multi-decadal (climate change) timescales is required.

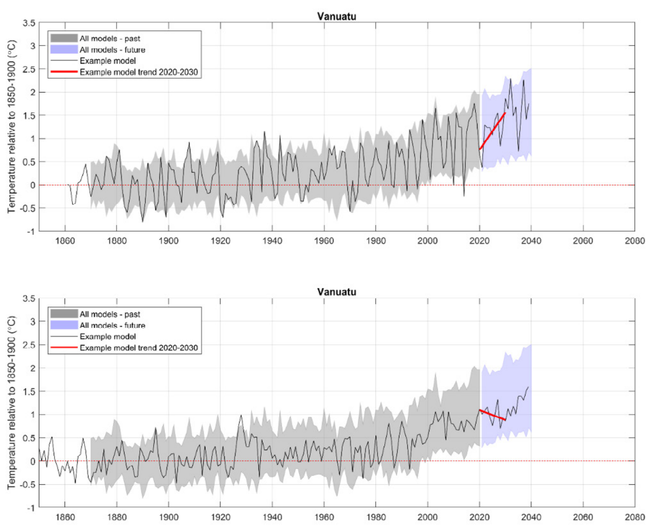

Figure 9 Average annual temperature (°C) in Vanuatu relative to 1850–1900 simulated in CMIP5 climate models, showing the range of all models (historic; grey band, future; blue band) and example model simulations (black line) with the linear trend for 2020–2030 marked (red line); top: an example with suppressed warming in 2020–2030 due to climate variability, bottom: an example where climate variability enhances the warming trend in 2020–2030 [20].

STEP 8

Communicate findings

Effective communication of a climate impact assessment requires an understanding of the objective(s) and the priority gaps and needs of the target 'users' audiences for the assessment findings. This step helps to convey information in a way that is understandable, relevant, and useful (and more likely to be acted upon). It also ensures the relevant data and information are produced in a range of formats that are readily accessible and understandable for application by users at different levels in the decision-making process (from government through to technical experts, private sector and local communities).

These results should therefore be presented in an appropriate format, in the language best understood by target users. Forms of communication, ideally co-designed and co-produced with stakeholders, include:

- briefings to decision-makers
- presentations at meetings and workshops
- technical reports
- brochures/factsheets/explainers and non-technical reports
- PowerPoint slides and infographics
- media releases, videos, and other forms of social media where appropriate
- web portals.

This communication would include the key findings of the impact assessment covering the eight steps in the Van-KIRAP Guidance, and address four key goals:

1. Raising awareness – alerting stakeholders to the climate impacts and elevating the level of general understanding on climate change science
2. Developing capacity to undertake climate impact assessments
3. Informing potential adaptation and mitigation planning pathways
4. Motivating adaptation and mitigation action.

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