Flood displacement risk

Assessment for Fiji and Vanuatu in current and future climate scenarios

iDMC internal displacement monitoring centre

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With funding from the European Union, the Internal Displacement Monitoring Centre (IDMC) is collaborating with the International Organization for Migration (IOM) and the Platform on Disaster Displacement (PDD) to generate new evidence to help governments better understand, plan for, prevent and respond to disaster displacement in the Pacific region. The project will contribute to better policy responses, planning and operational tools.

IDMC's report was made possible thanks to the generous contribution of the EU.

This study benefited from the support, advice and substantive input of CIMA Research Foundation.

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Cover photo: Ba, Western Divison, Fiji © OCHA/ROP, January 2012.

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Key findings

1

The number of people expected to be displaced as result of riverine flood events was evaluated considering potential loss of housing and livelihoods, and with the latter income.

2

In Fiji, a flooding event with a 100-year return period could displace 9,000 people, or almost one per cent of the country's population. A similar event in Vanuatu could displace 500.

3

Optimistic climate scenarios suggest that average annual displacement for flood events will double in both countries by 2060.

4

Pessimistic scenarios suggest that devastating rare events, which now happen once every 250 years on average, are likely to occur every 5 to 25 years at the end of the century.

After Cyclone Pam, Efate island, Vanuatu.

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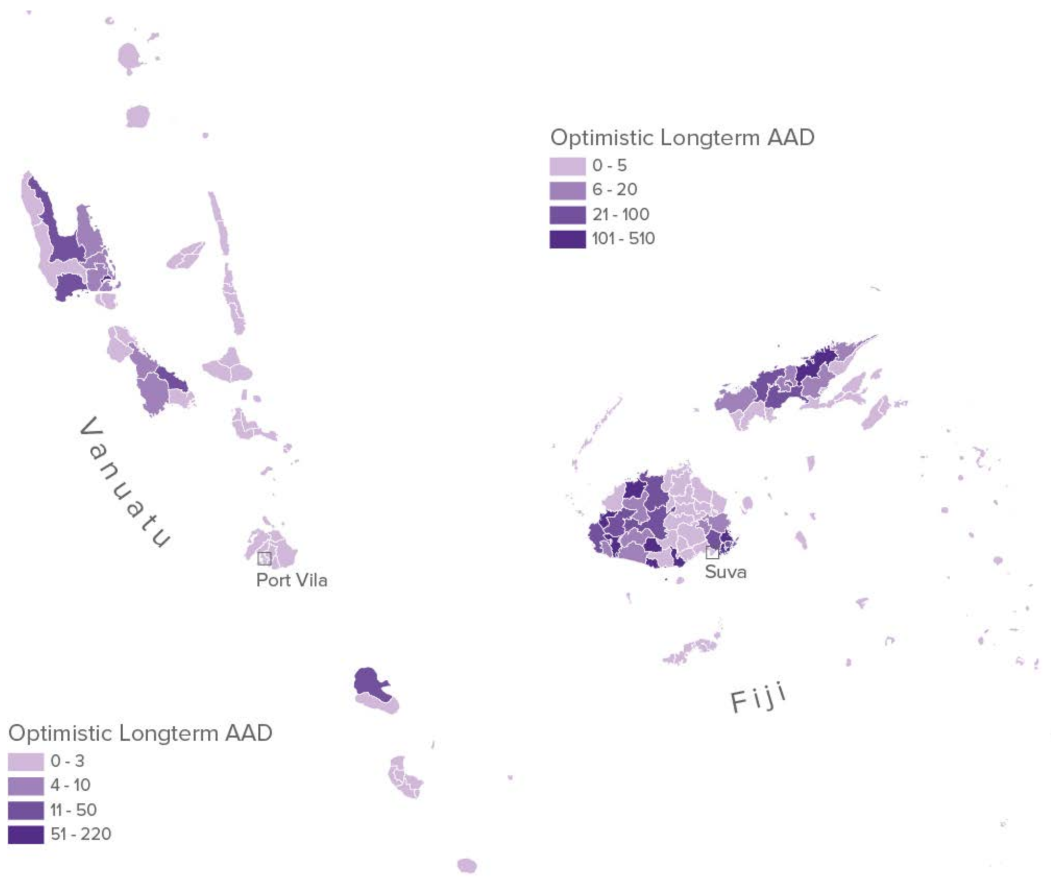
At a glance

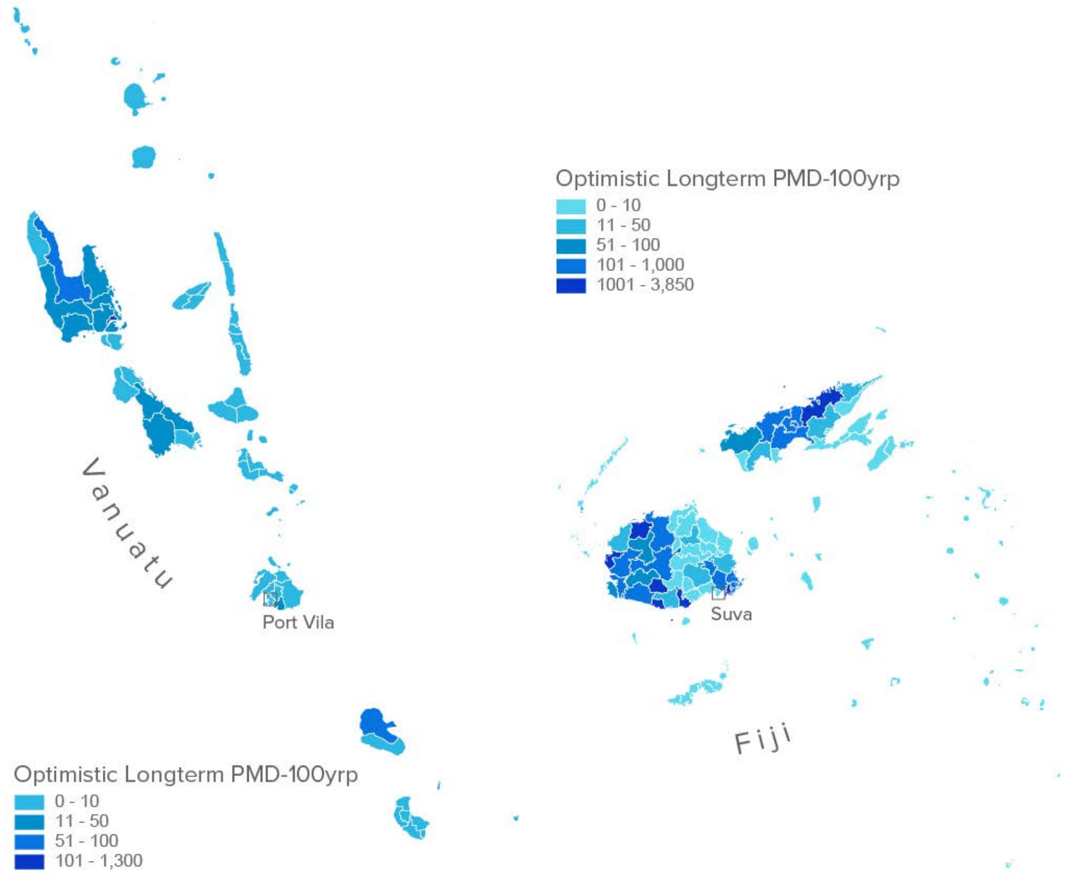
AAD

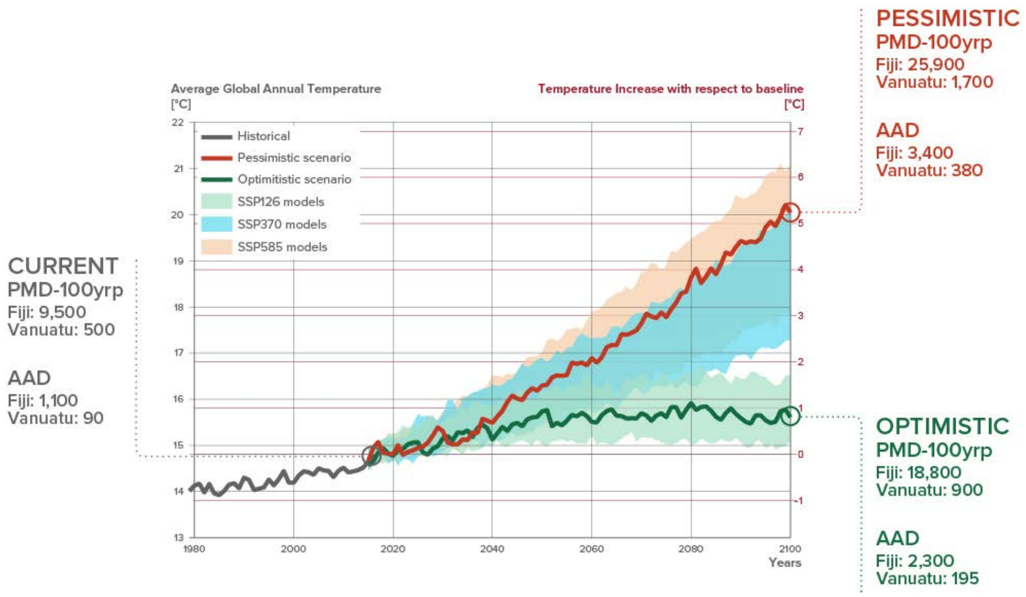
Average Annual Displacement (AAD) is a compact metric that represents the annualised accumulated effect of small to medium and extreme events and predicts the likely displacement associated with them on a yearly basis.

PMD

Probable Maximum Displacement metric shows the likelihood of a certain scenario producing an estimated amount of displacements. PMD at 100-year return period (100-yrp) expresses the number of displacements that can be exceeded in a disastrous event occurring on average once every 100 years







CURRENT
PMD-100yrp
Fiji: 9,500
Vanuatu: 500

AAD
Fiji: 1,100
Vanuatu: 90

PESSIMISTIC
PMD-100yrp
Fiji: 25,900
Vanuatu: 1,700

AAD
Fiji: 3,400
Vanuatu: 380

OPTIMISTIC
PMD-100yrp
Fiji: 18,800
Vanuatu: 900

AAD
Fiji: 2,300
Vanuatu: 195

Applying different climate scenarios

To investigate how climate change may alter the future frequency and intensity of extreme events, two different scenarios are explored as reference:

- OPTIMISTIC - the scenario closest to the 20th percentile, corresponding to an average temperature rise of about +1°C by 2100
- PESSIMISTIC - the scenario closest to the 80th percentile, corresponding to an average temperature rise of over +5°C by 2100

Introduction

Floods have triggered about 166 million displacements globally since IDMC started collecting data in 2008. This figure represents more than half of the total disaster displacement reported for all hazards.

With so many people already affected by climate change and extreme weather events that are predicted to become more frequent and severe in many parts of the world, it is vital to establish the magnitude of future flood displacement risk so that adequate prevention and preparedness measures can be put in place.

IDMC began a unique probabilistic modelling exercise for global disaster displacement in 2017, which assesses the likelihood of such population movements in the future. We built on a risk analysis developed by the UN Office for Disaster Risk Reduction (UNDRR), based on the consideration of a wide range of hazard scenarios, their likelihood and their potential to cause housing damage, the latter serving as a proxy for displacement. The model used a state-of-the-art probabilistic approach similar to that applied by catastrophe modellers and the insurance industry over recent decades. At the time it covered only the physical aspect by looking at the extent of damage and destruction that hazards of different intensities were likely to cause.

Given that people's level of vulnerability and exposure to hazards does much to determine the severity of their impacts, however, it is important to assess how these aspects may change over space and time, and to unpack the economic, social and environmental factors that affect disaster risk.

To do so, IDMC has worked closely with partners to obtain improved data on risk exposure and rethink how to assess vulnerability in the displacement risk equation. Given that "riskscapes" evolve constantly, we need to understand population and socioeconomic patterns, and fluctuations in the frequency and intensity of hazards linked to climate change.

This report presents a first attempt to fill this information gap by estimating future riverine flood displacement risk at the national and sub-national level for two small island developing states (SIDSs). It proposes a new methodology that provides a more comprehensive assessment of vulnerability in the context of disaster displacement risk.

It reveals the magnitude of displacement risk, and by comparing present climate conditions with various future scenarios, it shows how they are likely to differ. As in many SIDSs, exposure to flood hazards in Fiji and Vanuatu is driven by the growing concentration of people and assets in low-lying urban coastal areas. Disasters affect ever more people in these areas, causing increasing harm to employment, housing and basic services such as education and healthcare.

With funding from the European Union (EU), we collaborate with the International Center for Environmental Monitoring (CIMA Research Foundation) on the Pacific Response to Disaster Displacement (PRDD) project. Together we have developed the first flood displacement risk model at building scale under two different climate scenarios - optimistic and pessimistic – in the medium and long term, and applied it to identify disaster displacement risk hotspots in the two countries.

Floods in Sigatoka, Fiji
© OCHA/ROP, January 2012

Displacement risk concepts

Disaster risk and vulnerability

UNDRR defines a disaster risk as “the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity”.[1] It is important to consider the social and economic in which disaster risks occur and understand that people do not necessarily share the same perceptions of risk or underlying risk factors.

Vulnerability is defined as the conditions determined by physical, social, economic and environmental factors or processes that increase the susceptibility of individuals, communities, assets or systems to the impacts of hazards.[2] Human vulnerability depends on a range of economic, social, cultural, environmental, institutional, political and psychological factors that shape people’s lives and their environment. Income, education and access to medical services, for example, affect people’s level of vulnerability. Vulnerability is dynamic and evolves over time. It is composed of various dimensions, all of which need to be considered in a holistic assessment.

Vulnerability levels tend not to be the same across a community or a population. They are likely to vary depending on people’s income, education, social class, age and ethnic origin. The higher the level of vulnerability, the greater the probability of being negatively affected by a disaster.

Disaster displacement risk

The term disaster displacement refers to a situation in which people are forced to flee their homes or places of habitual residence by a disaster or to avoid the impact of an impending natural hazard. Forced displacements generally result from the fact that affected persons are exposed to a natural hazard in situations where they are too vulnerable and lack the capacity to face its impacts. [3]

Similarly to disaster risk, disaster displacement risk is linked to the nature and magnitude of a given hazard, and to people’s exposure and vulnerability. It is used to estimate the likelihood of future disasters triggering displacement. The assessment of vulnerability levels in particular is useful in understanding why extreme events do not always generate extreme impacts on people and territories, while less extreme events can have extreme impacts. It explains why two hazards of similar intensity and duration could have very different impacts in terms of damage and the number of people affected and displaced.

Understanding the parameters that influence vulnerability is essential to inform effective policies and strategies that prevent and manage disaster displacement risk, and so reduce the number of people forced to flee.

Approaches to disaster displacement risk assessment have until now calculated, vulnerability levels by using likely housing destruction as a proxy for displacement, as in our report from 2017. By assuming that if a disaster renders a home inhabitable its occupants will be displaced at least temporarily, the likely scale of future displacement can be estimated.

The need for a broader approach

People’s vulnerability depends on several physical and social factors. People who live in concrete buildings are likely to be less vulnerable to some types of hazards than those living in adobe huts, but their vulnerability also depends on a range of other factors that need to be assessed. They may have different sources of livelihood, income and social conditions, including access to basic services such as health and education.

Such elements, however, are not yet included in standard risk models despite the fact that they help to determine whether people flee or not.

Consider, for example, a flood that leads to the death of 20 head of cattle. Its impact will not be the same on all farmers. A subsistence farmer who only owns 30 animals will suffer a major loss of livelihood, while a large-scale farmer who owns 3,000 animals will be much more able to withstand the loss. A similar scenario would apply to arable famers who suffer crop losses. In effect, people who depend on the primary sector – agriculture and livestock – and particularly if it is for subsistence, are at higher risk of being displaced when a disaster strikes.

Disaster risk models need to analyse such socioeconomic factors if they are to inform more effective policies and strategies to reduce the number of people vulnerable to disaster impacts and the number at risk of being displaced. Such policies and strategies would consider the geographical context and specific population groups, and would include not only structural interventions – those intended to mitigate disaster impacts through physical construction - but also social and economic measures.

It is also important to consider that being able to move implies having sufficient economic, logistical and social resources to do so. Those without them are unlikely to be unable to flee and may become trapped in the affected area. Such groups may include extremely poor people, those with disabilities or illnesses and those living in isolated parts of a country.

Using a probabilistic risk assessment

The added value of a probabilistic risk assessment (PRA) is often misinterpreted, because audiences tend to view it as a highly technical approach that is difficult to apply or understand. These difficulties represent a challenge for communicating results. A probabilistic disaster displacement risk profile should be seen as a diagnostic instrument, because it provides indications of possible hazard events and their impact.

Such profiles cover all possible risk scenarios in a certain geographical area. Both low-frequency, high-impact events and high-frequency, lower-impact events are considered. Included is their probability of occurrence, all elements of the risk equation - risk = hazard X exposure X vulnerability - their variability and uncertainty ranges.

Events that have never been recorded but might occur under climate projections are also considered. This feature is particularly useful given that climate change is dramatically increasing uncertainty about future hazard patterns. Societies need to calculate their worst possible impacts in order to be prepared. Viewed through this lens, there is no valid alternative to a probabilistic analysis to address such uncertainty in a usable, quantitative way.

Displacement risk information - expressed in annual average displacement (AAD) and probable maximum displacement (PMD) - is calculated at the national scale and disaggregated by sector and region, allowing for a geographic and quantitative comparison both within and between countries. These analyses and comparison exercises are an important step in risk awareness processes and key to pushing for risk reduction, adaptation and management mechanisms to be put in place.

PMD curve show the likelihood of a certain scenario producing an estimated number of displacements. This likelihood is usually measured in terms of return period, which is often misunderstood. A return period is the average time interval in years that separates two consecutive events equal to or exceeding the given magnitude. The most common misconception is that an event with a 100-year return period will only occur once a century. In fact, it means that it has an exceedance probability of 1/100, so events of the same or greater intensity happen once every 100 years on average. It does not preclude more than one event with a 100-year return period happening within a century or even the very small probability of back-to-back events one year after another. Nor does it rule out a century passing without such an event occurring.

Applying different climate scenarios

To investigate how climate change may alter the future frequency and intensity of extreme events, and with it exceedance probabilities and return periods, our assessment also considers different timescales:

- Under current climate conditions, with disaster risk assessed using observed conditions from 1979 to 2016
- Under medium-term projected conditions from 2021 to 2060
- Under long-term projected conditions from 2061 to 2100

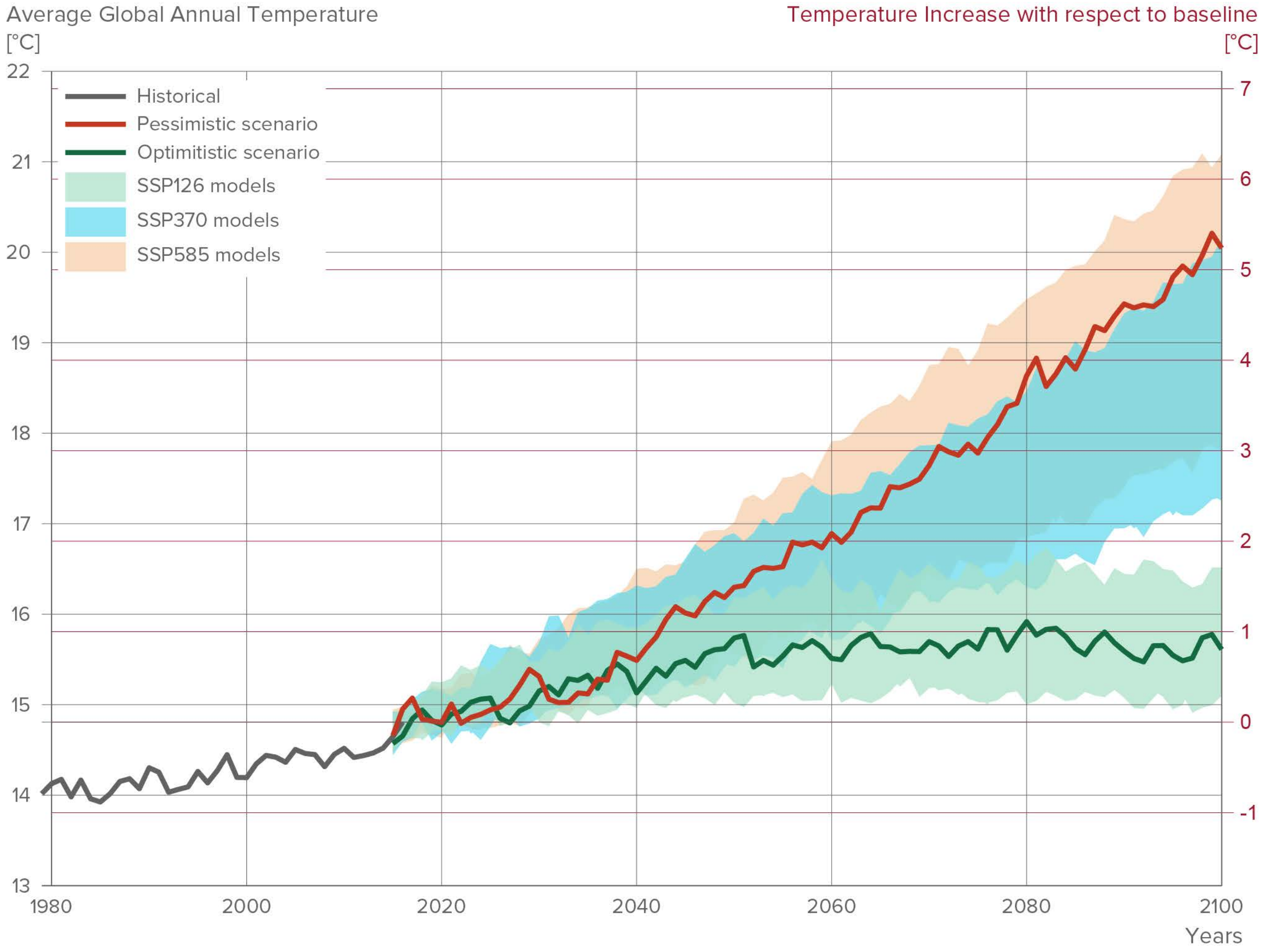


Figure 1: Model projections of future climate scenarios from ISIMIP3b.

To capture the spread of possible climate scenarios, we compared 15 models from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP3b) - which provides bias-corrected CMIP6 climate scenarios for pre-industrial, historical, SSP1-RCP2.6, SSP3-RCP7.0 and SSP5-RCP8.5 conditions - in terms of temperature and precipitation rise with respect to 2016. Temperature and precipitation trends proved to be highly correlated in the models considered, so we referred only to temperature trends to define representative scenarios, from which we selected two:

- "Optimistic" - the scenario closest to the 20th percentile, corresponding to an average temperature rise of about +1°C by 2100
- "Pessimistic" - the scenario closest to the 80th percentile, corresponding to an average temperature rise of over +5°C by 2100

We did not consider changes in exposure and vulnerability between current and future climate conditions, but it is worth noting that factors such as population growth and distribution – for example, the rapid urban sprawl that shrinks natural areas available to absorb floodwater - may greatly alter the future "riskscape".

Home inundated by flood water in Sigatoka, Fiji
© OCHA/ROP, March 2012

A new methodology

Our new methodology is designed to fill the gaps in current displacement risk models and provide a more comprehensive assessment of vulnerability to the risk associated with sudden-onset hazards. Assessing displacement risk for slow-onset event would require a different approach.

The methodology considers different but intrinsically linked components in assessing the impact of disasters that have already occurred:

Direct impact on houses

This element is included in traditional disaster displacement risk models, and accounts for the number of houses rendered inhabitable by a disaster. Many models, however, treat it in a simplified way. A threshold on the hazard intensity parameter is often used, which means they do not differentiate between the different vulnerabilities to hazards associated with different house types. The new methodology employs a complete physical vulnerability model to compute the impact on housing. Knowing this helps in estimating the probable number of people displaced because of severe damage to their homes.

Direct impact on livelihoods

This element, which goes beyond traditional models, measures the direct impact of a disaster on people's livelihoods, namely damage to crops, herds, shops, industries and services. Accounting for these additional factors provides a more comprehensive understanding of disaster-related impacts that may influence people's decisions to move.

Indirect impact on critical facilities, services and livelihoods

Indirect impacts, such as the prolonged absence of essential services, should also be considered. People's decisions to stay or move are often influenced by access to sufficient food and drinking water and education and health facilities, giving relevance to accounting for indirect damage to critical facilities, public infrastructure and services. This provides additional accuracy in estimating disaster displacement risk, because it considers the extent to which people's vulnerability is heightened and with it the likelihood of their being displaced.

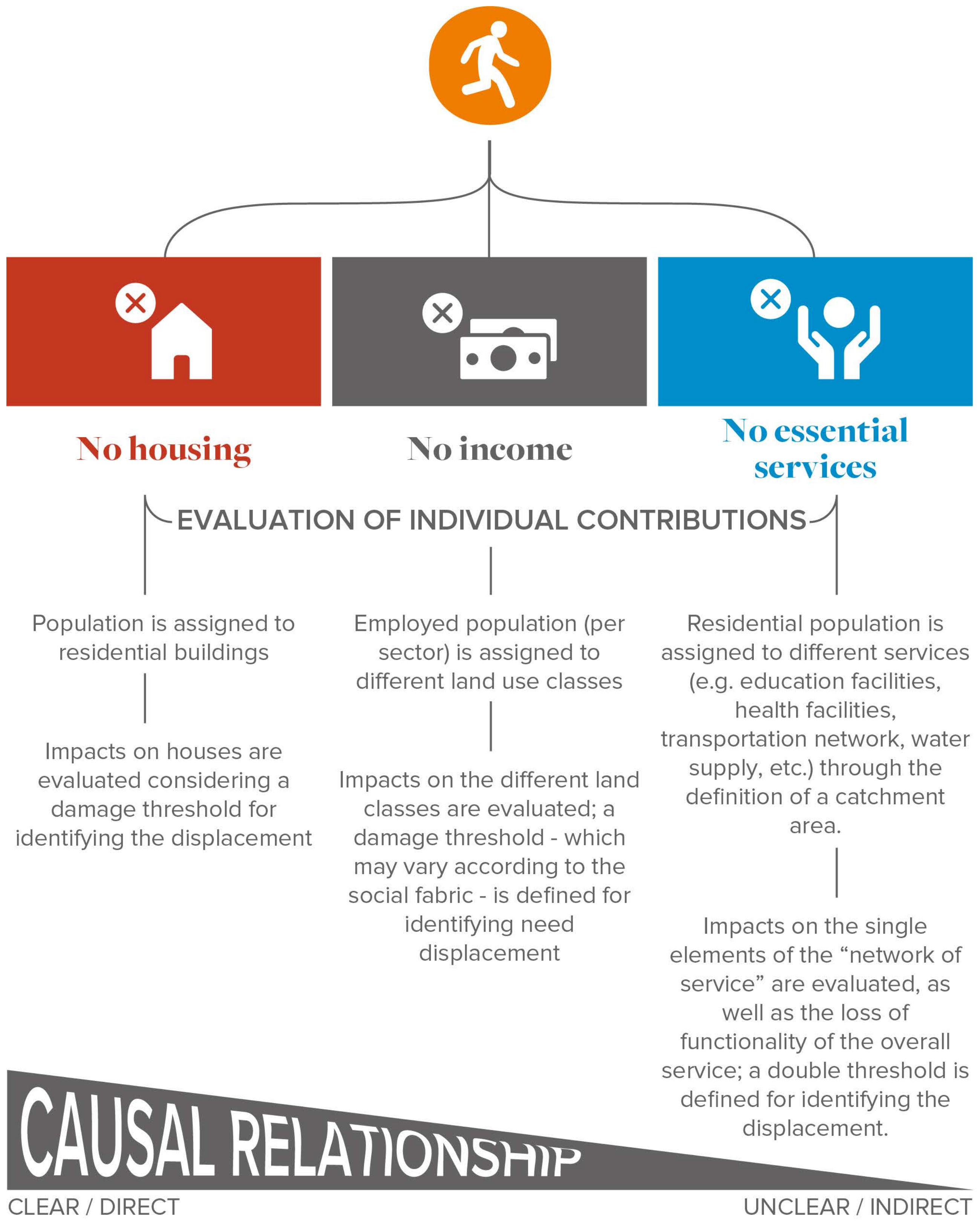
Taken together these elements provide a more accurate estimate of the number of people who may be displaced by the direct and indirect impacts of future sudden-onset disasters, such as floods, cyclones and geophysical hazards.

Incorporating analysis of them into disaster displacement risk assessments generates improved risk information to inform policymaking and the development of effective, localised and tailored strategies to reduce people's and communities' vulnerability to disaster impacts, and to address the protection needs of those compelled to move out of harm's way.

To evaluate flood risk specifically, it is necessary to adapt the classical approach to evaluate the three main components, namely hazard, exposure and physical vulnerability.

Different procedures and methodologies to determine risk are used worldwide through a variety of models and approaches. Their common aim is to understand the probability of different magnitudes of flood characteristics, such as depth, horizontal extent, velocity and duration, occurring over an extended period of time.

Estimates can be calculated both in current and projected climate conditions, also considering different emission scenarios, using consistent analysis of meteorological, geological, hydrological, hydraulic and topographical properties of watersheds, channels and floodplains to produce detailed hazard maps. This allows expected water depth for a certain location and/or individual pieces of infrastructure to be predicted for a set of return periods.



Population is assigned to residential buildings

Impacts on houses are evaluated considering a damage threshold for identifying the displacement

Employed population (per sector) is assigned to different land use classes

Impacts on the different land classes are evaluated; a damage threshold - which may vary according to the social fabric - is defined for identifying need displacement

Residential population is assigned to different services (e.g. education facilities, health facilities, transportation network, water supply, etc.) through the definition of a catchment area.

Impacts on the single elements of the "network of service" are evaluated, as well as the loss of functionality of the overall service; a double threshold is defined for identifying the displacement.

Figure 2: Identification of the main components that have the potential to trigger disaster displacement.

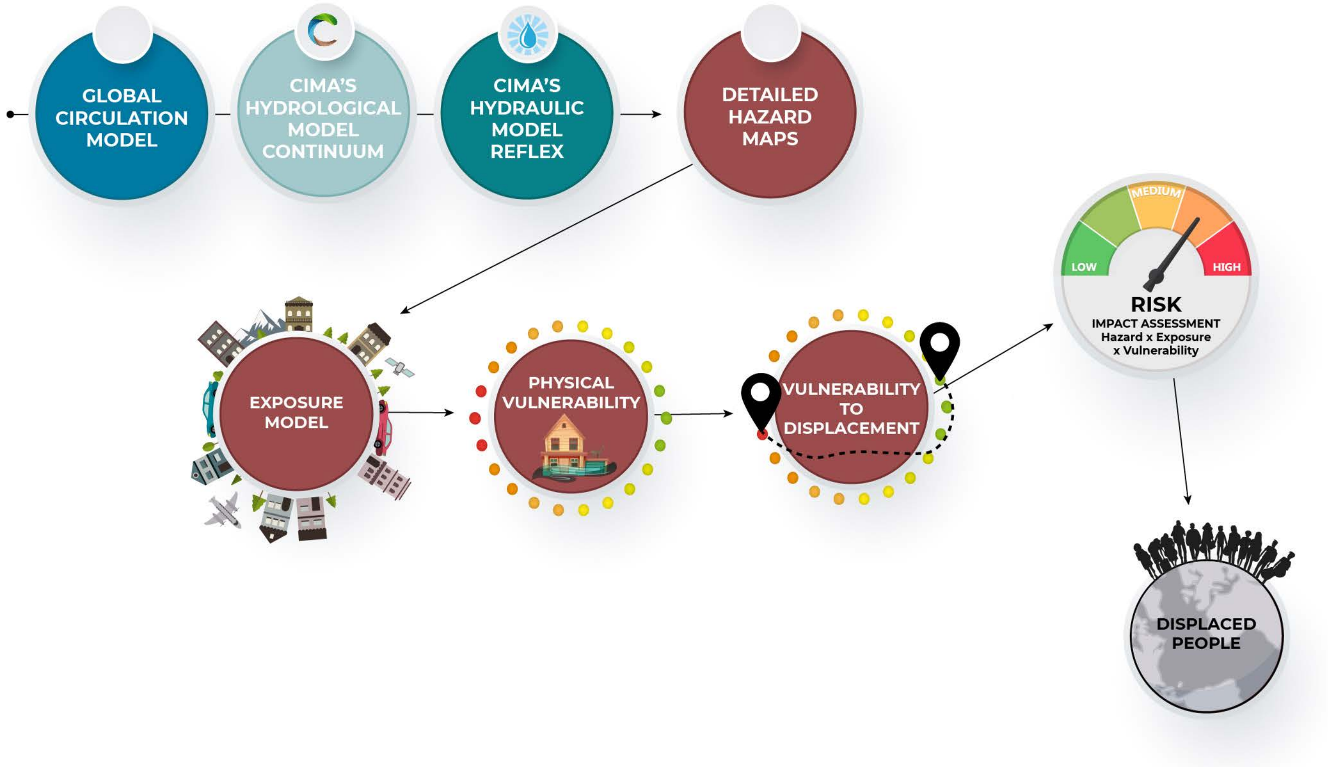


Figure 3: Representation of the overall process adopted for developing the assessment of flood displacement risk

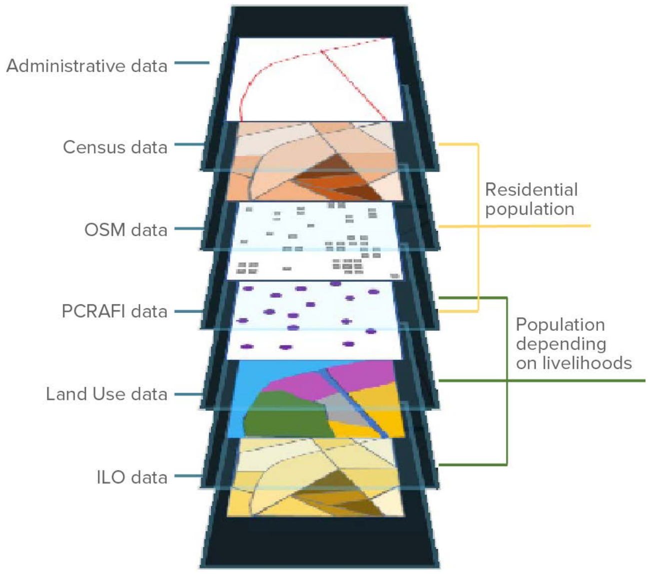


Figure 4: Development of population spatial distributions from different sources of data: administrative subdivision, census data, Open Street Map (OSM) data, Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) data, land use data and International Labor Office (ILO) data.

The damage assessment is converted into loss metrics through the computation of the annual average loss – in this case AAD, meaning the expected number of people displaced per year, averaged over many years – and the probable maximum loss – in this case PMD, a curve describing possible displaced with a certain probability range.

From vulnerability to vulnerabilities

Our new methodology's general approach to impact assessment is fairly standard, but it also includes some new and unusual elements to address the vulnerability component. Despite its general definition, use of the term depends strongly on the situation to which it refers. When addressing economic losses in a probabilistic flood risk assessment, for example, vulnerability is usually considered as the flood's potential physical impact on structures and infrastructure. Our new approach views it as a more complex element, describing people's susceptibility to being displaced.

This requires more factors to be considered, and specific physical vulnerability plays an important role in each of them. Their integration leads to a broader definition of the concept of vulnerability to displacement, in which potential interactions between the different factors must be taken into account.

The scale of displacement in a given area depends on the probability of people being displaced because their homes have been rendered inhabitable, plus the probability of their being displaced because of livelihood loss, minus the probability of their having lost both their home and livelihood.

This concept can be expressed in the following equation:

$$\overset{\text{Total number of displaced people}}{d_{tot}} = \underset{\text{Number of displaced due to loss of their house}}{d_h} + \overset{\text{Number of displaced due to loss of livelihoods}}{d_l} - d_h \cap d_l$$

Where dtot is the total number of people displaced, dh is the number displaced because of housing loss and dl is the number displaced because of livelihood loss.

The probability of people losing both their home and livelihood can be expressed as : the probability of people being displaced because their home has been made inhabitable conditioned to the fact that they have been displaced because of livelihood loss, transforming previous equation as follows:

$$d_{tot} = d_h + d_l\,(1 - \overbrace{P[d_h \,|\, d_l]}^{\text{Probability of having lost both house and livelihood}})$$

The probability of people being displaced because of livelihood loss is subdivided between those who depend on agriculture, pastoralism, services or industry.

The conditional probabilities are estimated separately for each sector based on the number of people who depend on that specific livelihood and the fraction of people being simultaneously exposed at work and at the working place.

The number of people who may lose access to basic services such as health and education, a factor that heightens vulnerability, is also quantified. As a first approximation this additional information is provided separately and not integrated in the displacement risk computation.

Exposure model

To evaluate the different components of the model, a spatial representation of the population in question subdivided by the various sectors is required. More specifically:

- To calculate the number of people displaced because of house damage, the population living in each building is needed.
- To calculate the number of people displaced because of livelihood loss, the distribution of employees in each sector, such as agriculture and industry, is needed. More practically, we need to know where people's workplaces are and how many work there.
- To calculate the number of people made more likely to be displaced for lack basic services, we need to know where each service is located and how many people depend on them.

The first two distributions are used directly to derive dh and dl, while the third is used as an aggravating element that increases the likelihood of people being displaced.

With all three, whenever we determine that an asset - a home, workplace or service point - is affected by an event, we can derive the number of people affected and identify them as susceptible to displacement.

To identify these distributions for Fiji and Vanuatu we collected, integrated and manipulated data from a number of sources as described below.

Residential population

To determine the number of people associated with each house, we derived building footprints from OpenStreetMap (OSM) updated to 2020 and additional information from an exposure layer generated by the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), which ran from 2012 to 2017.[4] This was used to characterise each building in terms of economic value, construction type, occupancy type, number of floors and floor area. Attributes such as occupancy from the PCRAFI point layer were associated to the more recent OSM polygonal layer according to a proximity criterion. Some extrapolations were performed where PCRAFI points were missing to account for urbanisation since 2017.

Population figures come from censuses, available at administrative level three or tikina for Fiji, and administrative level two or province for Vanuatu. Fiji's most recent census was conducted in 2017 and Vanuatu's in 2020.[5] Fiji's total population was 984,887 and Vanuatu's 300,019 (see figure 5).

Within each administrative unit, we assigned the corresponding population to buildings by weighting based on number of floors and floor area.

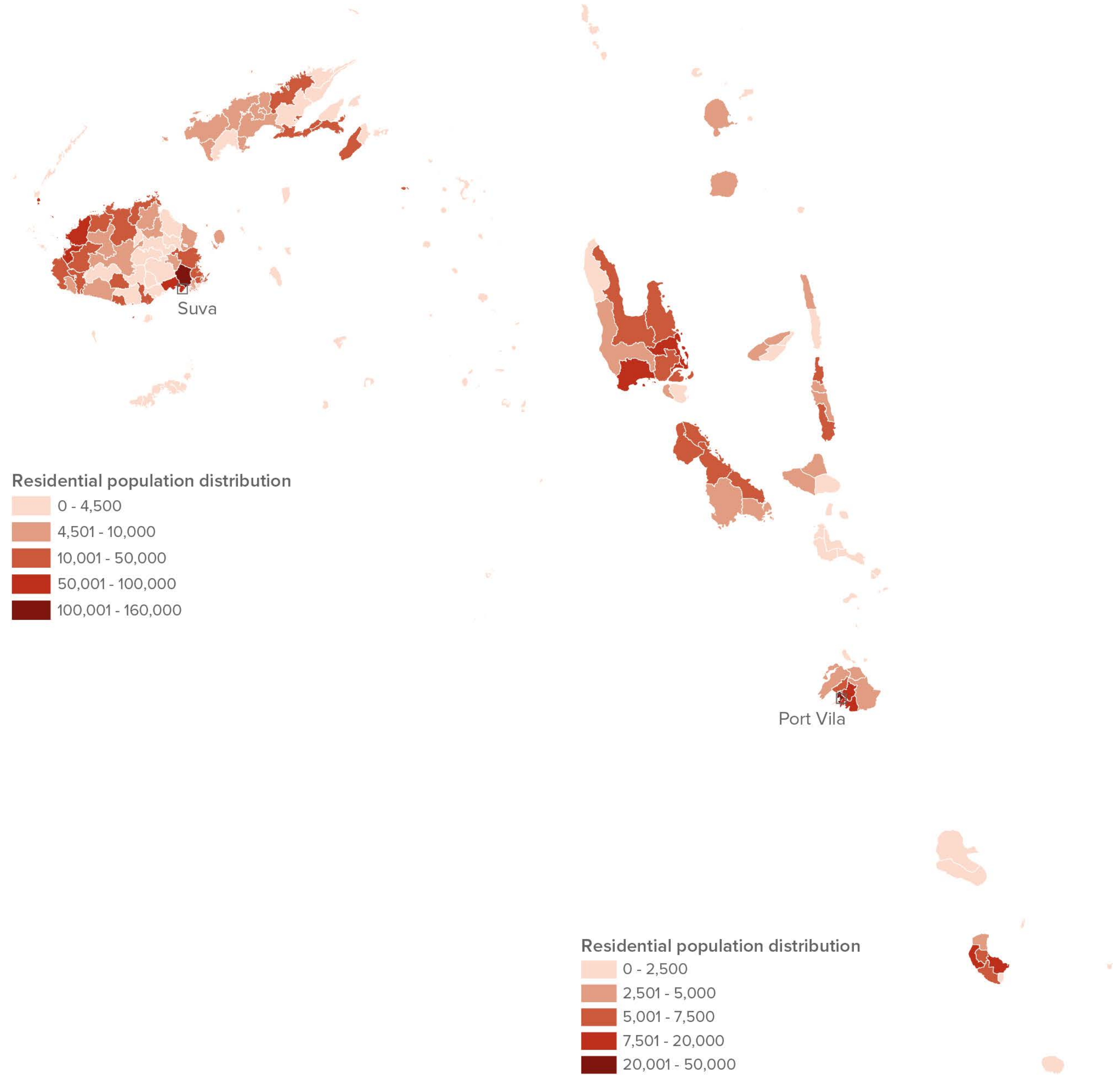


Figure 5: Residential population distribution at the reference administrative level for Fiji (main islands) and Vanuatu

Population by livelihood

We used a number of layers to determine the distribution of people dependent on different livelihoods.

For the service and industrial sectors, workplaces are represented at the building level, with footprints derived from the OSM layer and usage from the PCRAFI layer.

For the agricultural sector we determined the areas dedicated to arable and livestock farming by classifying cropland and grassland based on the European Space Agency (ESA) global land cover map at 10m resolution based on Sentinel-1 and Sentinel-2 data.[6]

We derived the number of workers per sector from percentage values extracted from census data and the International Labour Organization (ILO) database (see table 1). The latter includes a wide range of data on the labour market, including employment by economic sector, hourly wages, weekly working hours, unemployment and strikes.

We then applied the employment percentages by economic sector to the census population data at administrative levels three and two for Fiji and Vanuatu respectively (see Figure 7)

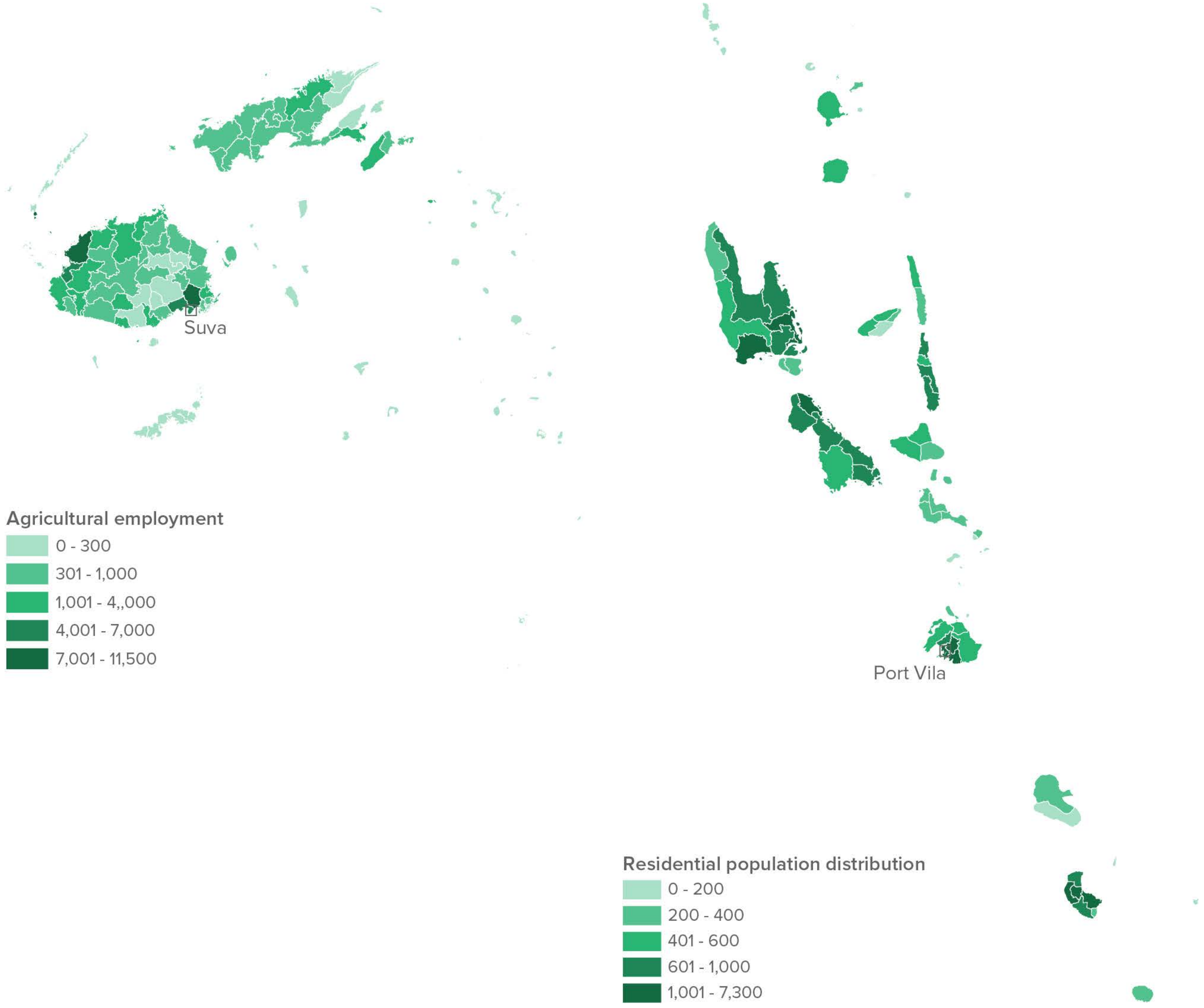


Figure 6: Agricultural employment in the administrative levels of reference for Fiji (main islands) and Vanuatu

Within each administrative unit, the students and employee populations are associated to schools and workplaces weighting with the overall available surface, thus also considering the number of floors (see Figure 8 for the distribution of the Service employed).

We also devised a procedure to avoid potential double counting. To evaluate the % of the population who could suffer flood impacts on both their livelihoods and housing, we associated each worker's home with their workplace.

Figure 7: Distribution of main occupancy at building level and areas of cropland and grassland

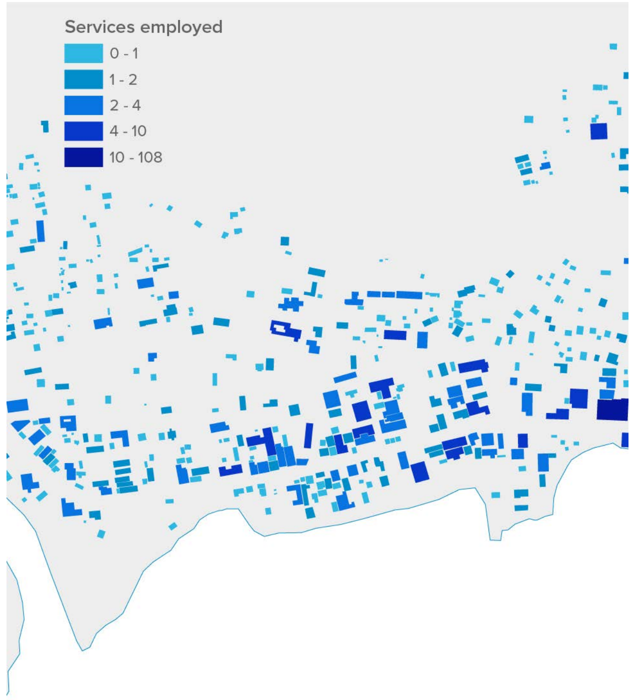


Figure 8: Distribution of service employment at the building level

CENSUS and ILO DATA	VANUATU	FIJI
Population	300,019	882,407
Employed population	78,004	353,955
Employment in agriculture 2019	44,463	63,712
Employment in Cropland	36,904	52,881
Employment in Grassland	7,559	10,831
Employment in services 2019	22,621	240,689
Employment in industry 2019	10,921	49,553

Table 1: Statistical data on population and employment

The association followed the criterion of minimum distance between each industrial or services building, or cropland or grassland area, and each residence. For each employment sector workers were first assigned to houses in the nearest area within a given distance, for example a radius of one kilometre. Once these houses were occupied, the distance was increased and again workers were assigned to houses. The procedure was repeated until all workers were assigned to houses. The same procedure was used for basic service users. At the end of the process, each house was associated with its occupants' workplaces, schools and hospitals (see figure 10).

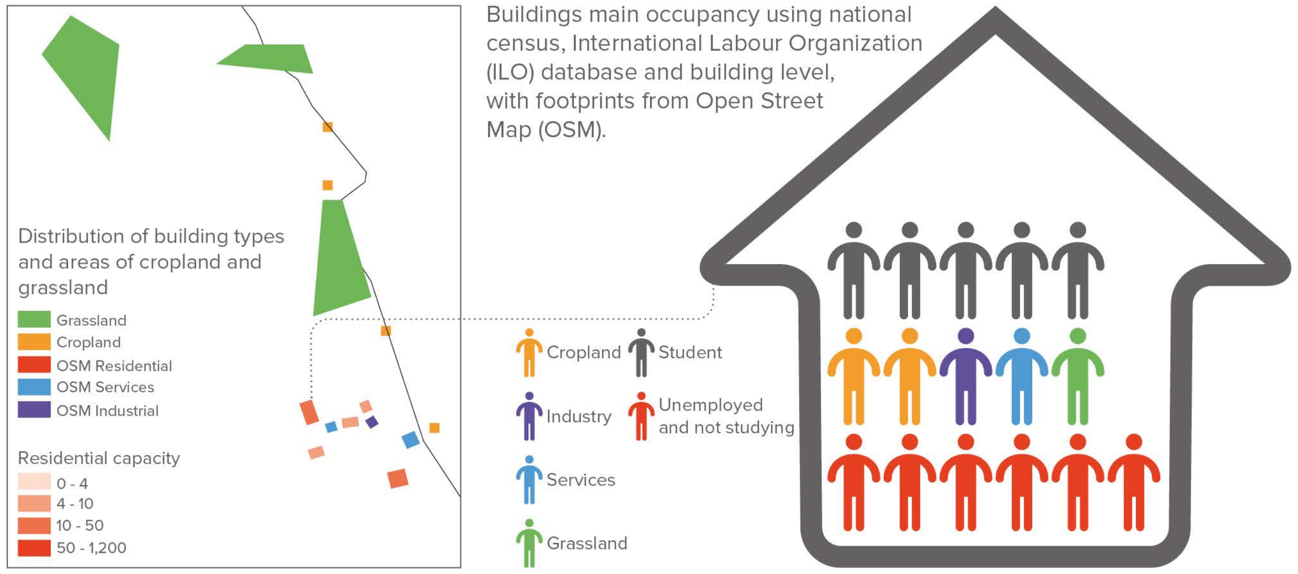


Figure 9: Example of identification of workers/students with, their workplaces/schools and designated health centres for each residential building

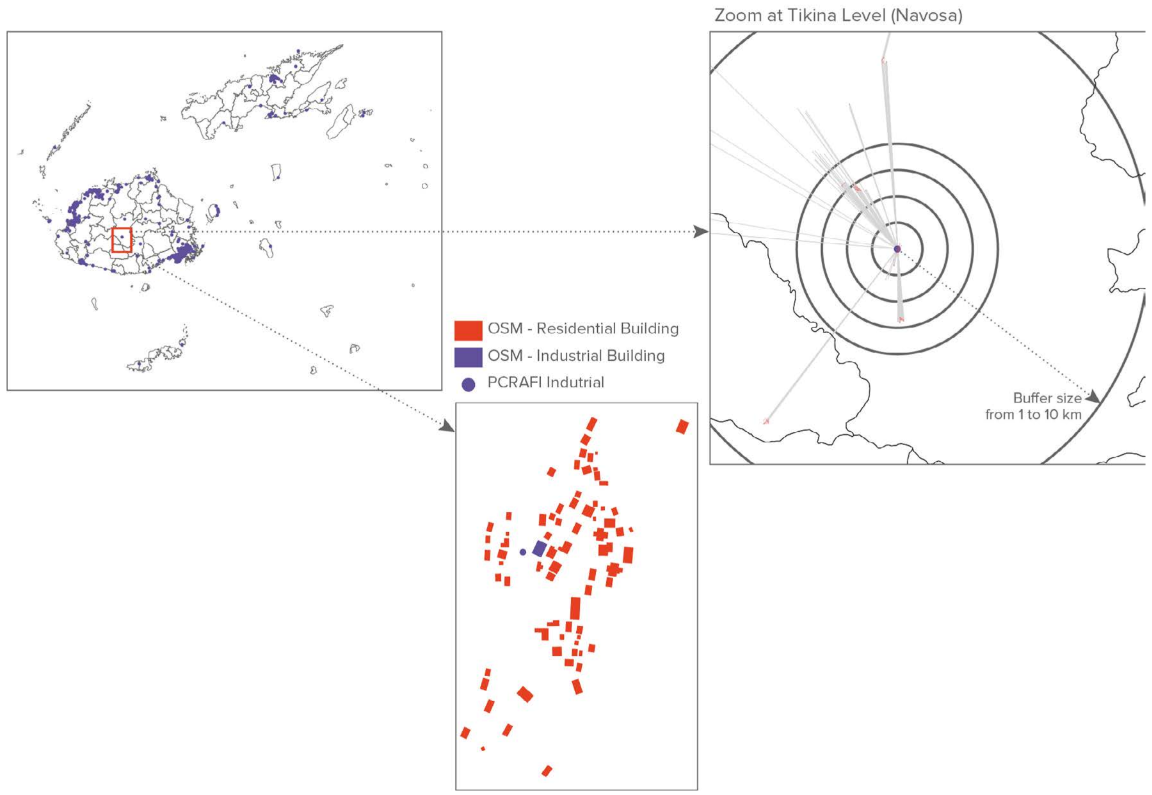


Figure 10: Example of identification of workers/students and their workplaces/schools and designated health centres for each residential building

Flood hazard assessment

To best predict possible flood scenarios, we used a chain of climate, hydrological and hydraulic models.

We applied the Continuum hydrological model to all basins in the Fiji and Vanuatu at a one-kilometre resolution, obtaining flow series for each pixel in current and projected climate conditions. We then used this information as input for the REFLEX hydro-morphological model developed by CIMA to create hazard maps at 30-metre resolution for different return periods[7]. Return periods of T=5, T=10, T=50, T=100, T=200 and T=250 years in current and projected climate conditions were selected to represent the different frequency and intensity of possible events for each country.

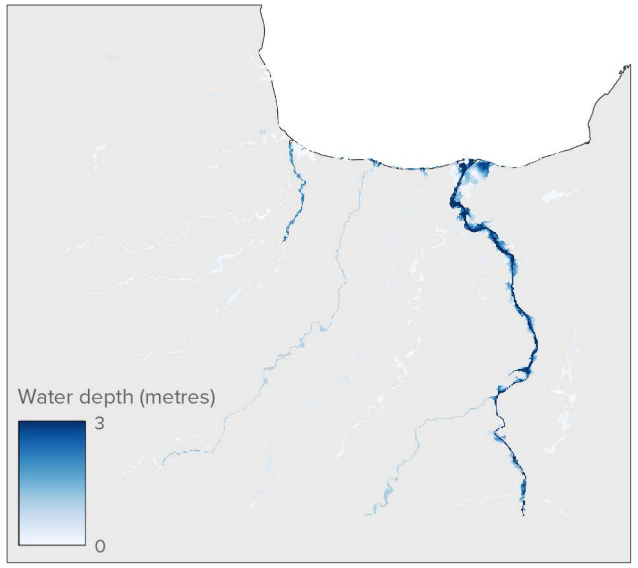


Figure 11: Example of water depth (m) hazard map for the Fiji main island.

In large domains, a set of mutually exclusive and collectively exhaustive possible hazard scenarios that may occur in the country, including the most catastrophic ones, is generated expressed in terms of frequency, extension of the affected area and intensity at different locations, keeping the historical spatial correlation of events. In the case of Fiji and Vanuatu, however, given the limited geographical extension of the islands, hazard maps for given return periods were used as hazard scenarios for impact computation.

On this basis we developed hazard maps for each country under current, optimistic projected and pessimistic projected climate conditions, with mid and long-term time horizons as described on page 17.

After Cyclone Lusi, Santo Island, Vanuatu.© OCHA, Vanuatu Humanitarian Team, March 2014

Flood impact assessment

Each hazard map was used as input for the evaluation of impacts in terms of people potentially displaced. To this end, the following actions were performed and applied to each map:

- We obtained a value for water depth for each assets by overlaying the assets with the hazard map through the RASOR platform and assigned it to each feature in the exposure model, such as residential buildings, industrial and service buildings, crop and grazing areas and schools.[8]
- We used specific physical vulnerability functions, depending on the physical characteristics of the assets, to evaluate the expected damage ratio.
- We considered assets with a level of damage over a given threshold unable to fulfil their function, whether it be residential, commercial, agricultural or service provision.
- We considered the populations assigned to such assets likely to be displaced. To avoid double counting, we only accounted once for people deemed to have lost their home and livelihood in the same scenario.
- We aggregated the number of people potentially displaced in each sector at the lowest administrative level.
- We then used these impacts to obtain AAD and PMD values.

Scan the QRcode to see the video animation.

Ba, Western Divison, Fiji
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Results - Fiji

We produced results for Fiji from administrative level zero, the country as a whole, to level three, its tikinas.

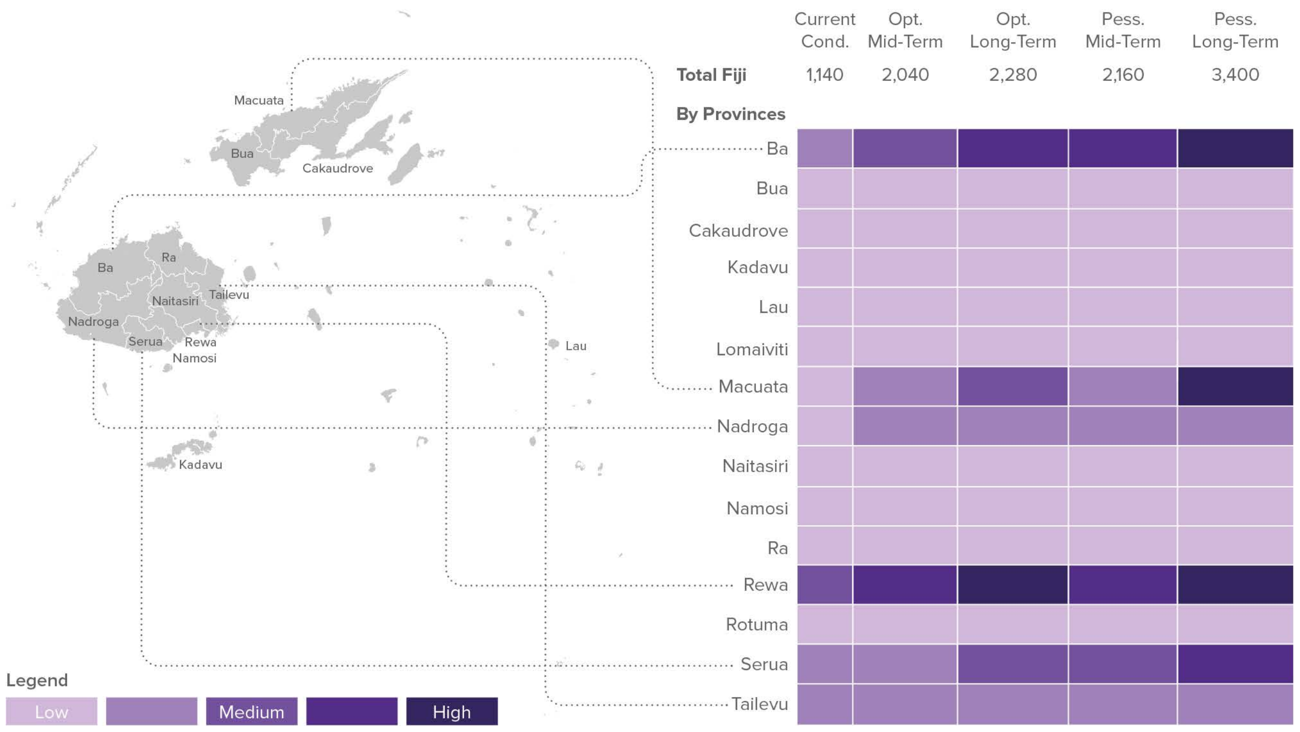
The country-level analysis revealed an AAD value of around 1,100 people, or about 0.1 per cent of the population. The results highlight a non-negligible influence of climate change even under medium-term projections. AAD values in current conditions double in both the optimistic and pessimistic medium-term scenarios and triple in the pessimistic long-term scenario.

When we analysed the effects of climate change at administrative level two, the mid-term projection results did not differ substantially between the optimistic and pessimistic scenarios. Instead, they diverge under long-term projections towards the end of the 21st century with AAD values much higher in the pessimistic scenario.

While climate change strongly influences the absolute numbers of people potentially displaced considerably increases the expected spatial patterns of potential displacement do not significantly change in current climate conditions compared with the projections, being the western part of Viti Levu the most affected area.

AAD expresses an average number of expected displacements, but it tends to hide potential outlier events. For this reason, it is useful to compare PMD curves for present and projected conditions, which show the number of people potentially displaced by frequent events – those with low return periods - and rare events – those with high return periods (see figure 17).

The curves show that displacements would increase significantly for higher return periods. Under current climate conditions, for example, they would more than double when comparing rfrequent events of T=5 years with rare events of T=250. In the pessimistic scenario under long-term projected conditions, a 250-year event might be expected to displace 28,000 people, or three per cent of Fiji's current overall population.



	Current Cond.	Opt. Mid-Term	Opt. Long-Term	Pess. Mid-Term	Pess. Long-Term
Total Fiji	1,140	2,040	2,280	2,160	3,400

Figure 12: AAD values at admin levels 0 and 2 for current climate conditions, and mid and long-term projections under optimistic and pessimistic scenarios

The disaggregation of PMD at 100-year return period at country level by displacement trigger shows that in current climate conditions almost 60 per cent of risk is connected to loss of housing. Among the remaining 40 per cent connected to the loss of livelihoods, people working in the service sector are the most affected. Roughly the same is true under long-term climate projections, although the ratio of displacement linked to loss of livelihoods would rise to more than 45 per cent (see figure 16).

In terms of people's place of origin shows that almost 60 per cent of displacement would be from rural areas in current conditions. This decreases significantly to 45 per cent under projected climate conditions. Factors such as future population growth and urbanisation, which might significantly change these estimates, are not considered in the modelled future scenarios (see figure 15).

The PMD curves are even more alarming when read in terms of frequency. An event with a 250-year return period under current conditions is expected to happen much more frequently towards the end of the century, on average every 25 years under the optimistic scenario and every five years under the pessimistic scenario.

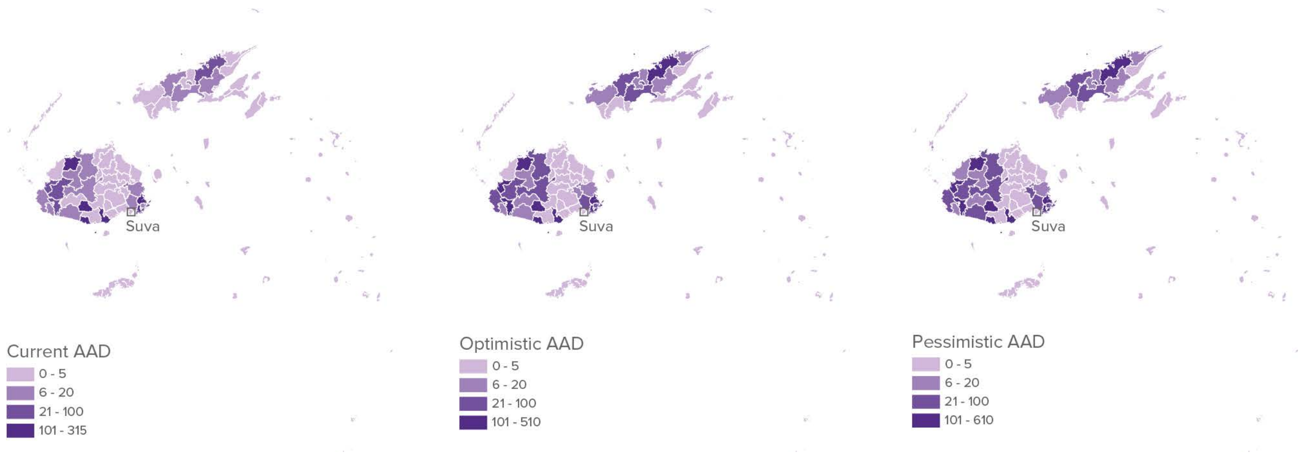


Figure 13: AAD for Fiji in current climate conditions and in long-term projections under optimistic and pessimistic scenarios. Results are aggregated at admin level 2.

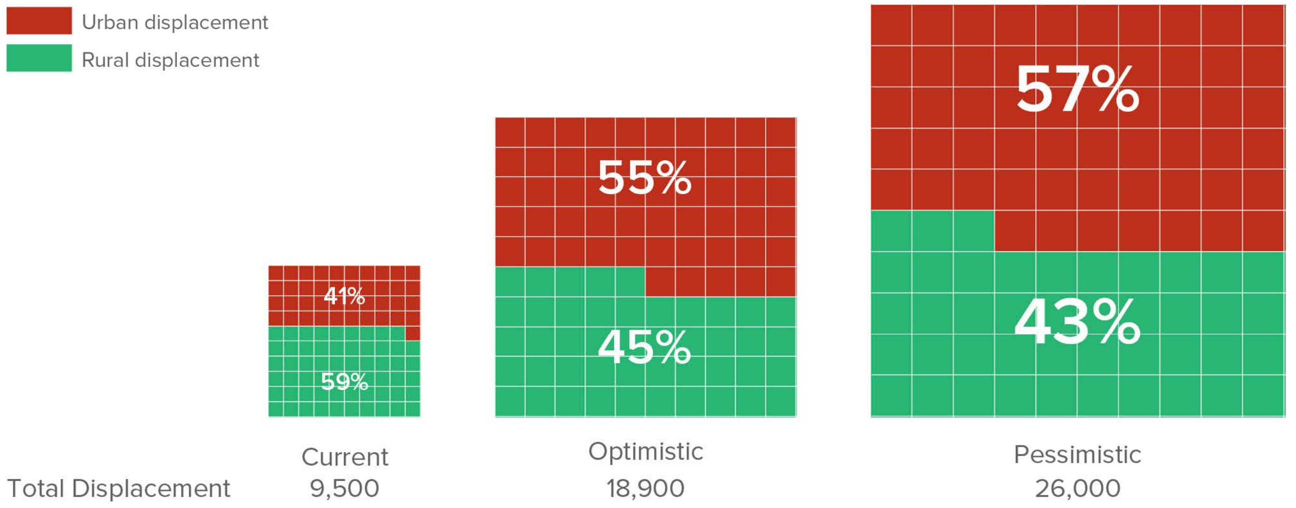


Figure 14: Origin of people's displacement for a 100-year flood event (PMD at 100yrp) at country level

The spatial distribution of potential displacement triggered by an event with a 100-year return period is similar to the AAD distribution. A flooding event with a 100-year return period could displace 9,000 people, or almost one per cent of the country's population.

This suggests that the worst-affected tikinas under current conditions would remain so in future, also considering rare events. This is confirmed by both mid and long-term projections.

Even under the optimistic climate scenarios, Fiji could experience future flooding that could have the potential to cause disruption to basic services at the country level (see box1)

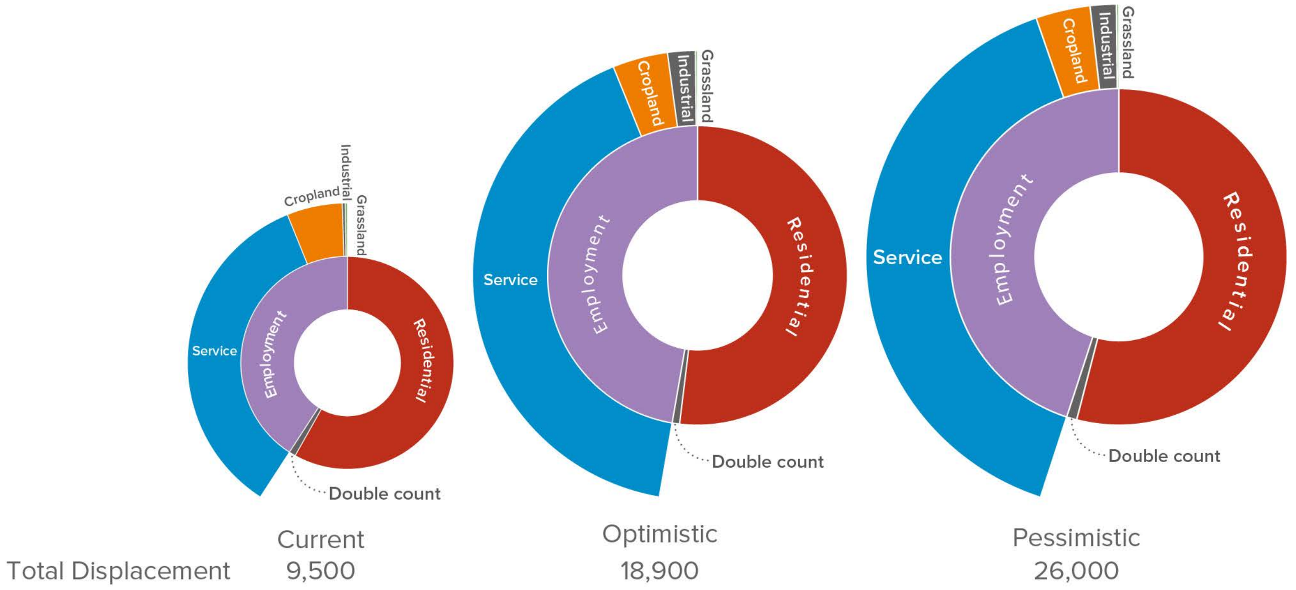


Figure 15: Displacements for a 100-year return period flood event (PMD at 100yrp) disaggregated by cause of diplacement

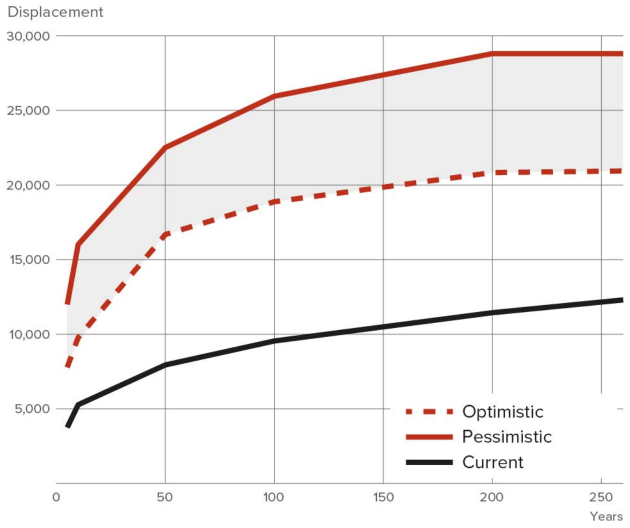


Figure 16: PMD curves for current climate conditions and long-term projections under both optimistic and pessimistic scenarios.

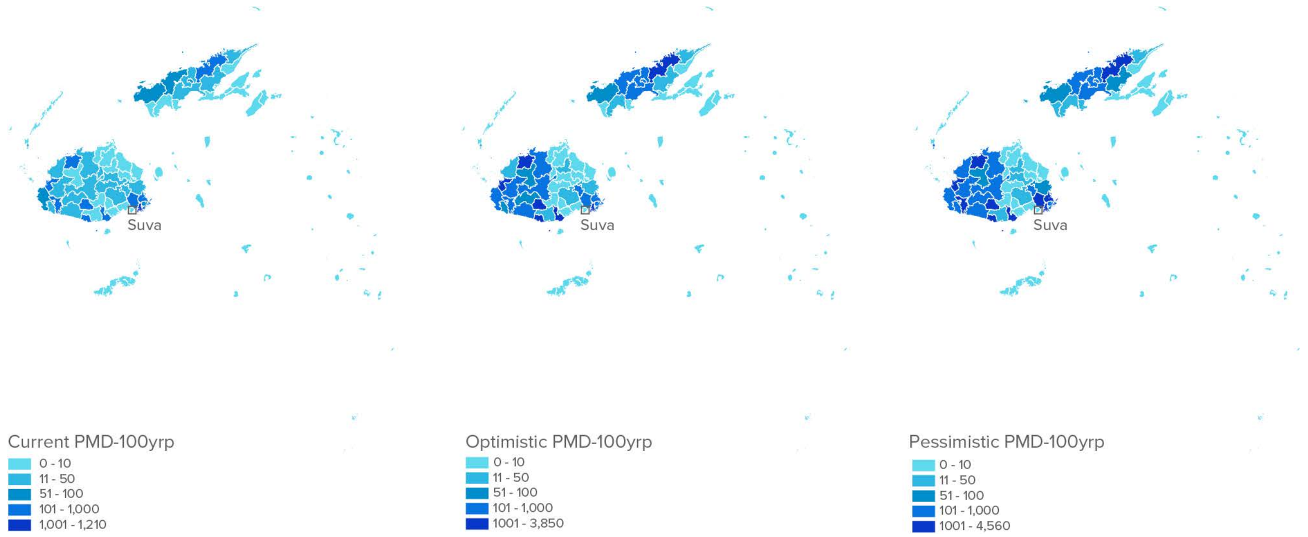


Figure 17: PMD values for a 100-year return period event in current climate conditions and long-term projected conditions under optimistic and pessimistic scenarios.

Box 1: Basic services disruption: Schools severely damaged or destroyed by floods, in Fiji.

Lack of services is not the main trigger of displacement after a rapid-onset event, but combined with loss of housing and/or work, it can be an aggravating factor that heightens vulnerability and makes displacement more likely. Many tikinas ascribed high displacement values linked to loss of housing and/or work are also characterised by a non-negligible lack of services such as education.

Around 600 students would be displaced due to their inability to access to schools because of severe damages, if Fuji suffered a 100-year event.

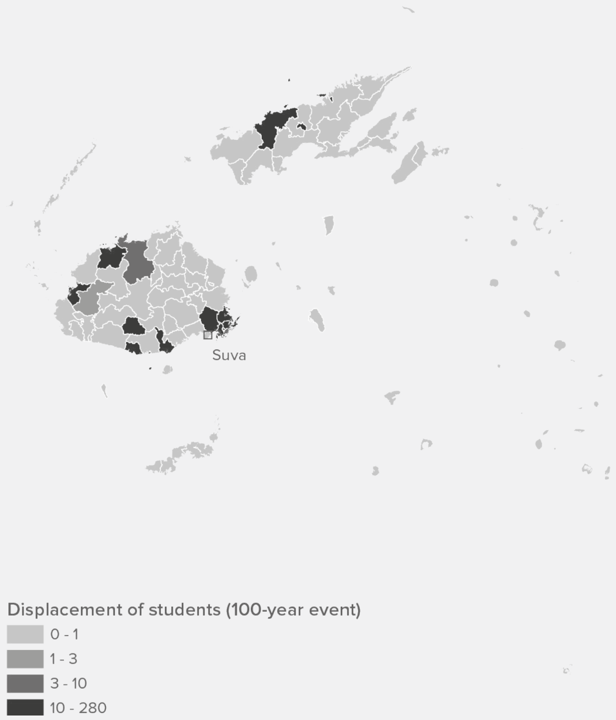


Figure 18: Number of students who would lose education services as result of a 100-year flood event

Results – Vanuatu

We produced results for Vanuatu from administrative level zero, the country as a whole, to level one, corresponding to provinces and level two corresponding to districts. The level-one AAD results under current climate conditions show that Sanma is by far the province most at risk. The same also applies under future conditions, regardless of whether the optimistic or pessimistic projections are considered and the time horizons involved (see figure 20).

For some provinces, such as Penama and Torba, the overall AAD figure is small, and it does not substantially change in projected climate conditions. Other provinces show a significant increase, among them Tafea where AAD is projected to rise almost 20-fold under the pessimistic long-term scenario. For all provinces the mid-term pessimistic projection and the long-term optimistic projection show the same results, identifying a clearly worsening path.

The situation is even more diversified when AAD at district level is considered, as different spatial distribution of most affected districts are shown when comparing current climate conditions and long-term prediction in the pessimistic scenario. Under current climate conditions, only districts in Sanma province reach the highest values of potential displacements, whereas long-term predictions under the pessimistic scenario show hotspots in districts of other provinces, such as Malampa and Tafea.

Figure 19: AAD values at Administrative level 0 and Administrative level 1 for current climate condition and medium/ long-term projections for optimistic and pessimistic scenarios

Figure 20: AAD for Vanuatu in current climate conditions and in long-term projections under optimistic and pessimistic scenarios. Results are aggregated at Administrative level 2.

Rare events in projected climate conditions show a non-negligible proportion of potential displacement being triggered by the combined loss of housing and livelihoods, a situation that would require complex interventions to manage and recover from.

When both frequent and rare events are considered, loss of livelihoods as a result of damage to cropland plays a significant role in triggering displacement. Livelihood losses in the industrial sector are also not negligible for rare events. The difference is probably linked to the industrial sector being less vulnerable to physical damage that the agriculture sector. When, in the case of rare events, both are affected, the stability of a significant proportion of the population is put at risk.

At country level in terms of people's place of origin shows that almost 60 per cent of displacement is likely be from rural areas in current climate conditions. That proportion falls to around 50 per cent under projected conditions.

Factors such as future population growth and urbanisation, which might significantly change these estimates, are not considered in the modelled future scenarios.

The PMD curves show that an event with a 50-year return period could trigger up to 400 displacements under current conditions, but that the figure could almost double in the optimistic future scenario and triple in the long-term pessimistic scenario.

Such an event would pose serious challenges in terms of managing the displacement situation, exhacerbating the potential criticality of the situation in terms of general disaster management.

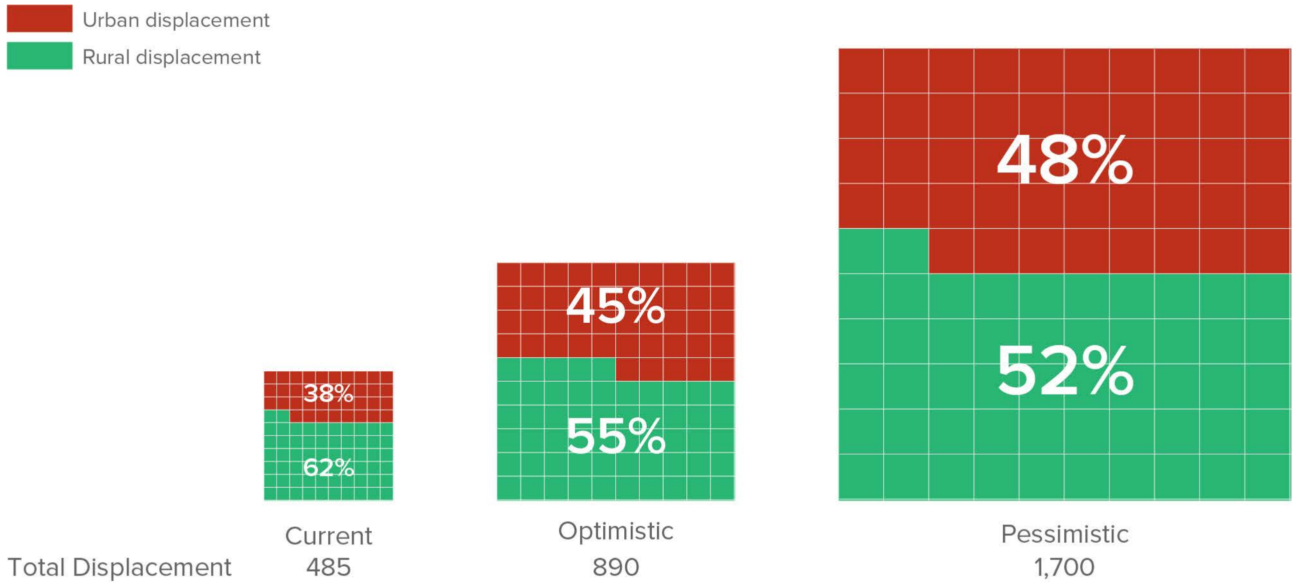


Figure 21: Origin of people's displacement for a 100-year flood event (PMD at 100yrp) at country level

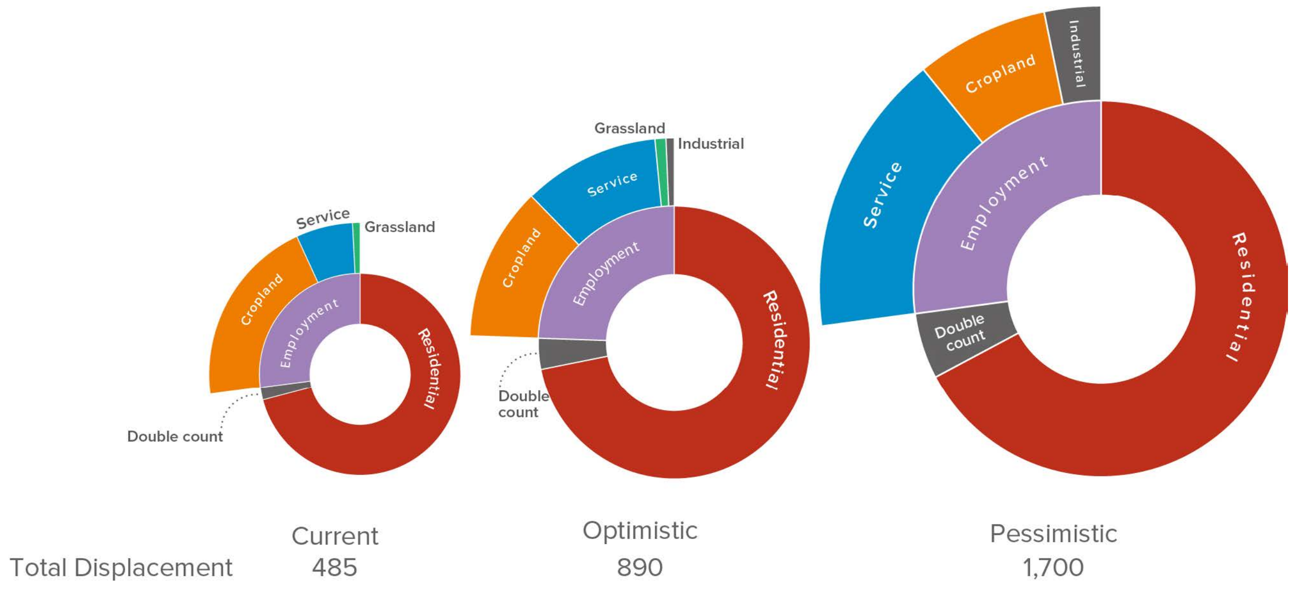


Figure 22: Displacements for a 100-year return period flood event (PMD at 100yrp) disaggregated by cause of diplacement

When the results under different return periods, time horizons and climate scenarios are considered, a general worsening trend becomes apparent both in terms of absolute figures and the spatial distribution of potential displacement. A flooding event with a 100-year return period could displace 500 people.

Even if current conditions suggest that critical situations are unlikely to arise, Vanuatu could experience future events that have the potential to cause serious damage at the country level and pose major challenges in terms of managing displacement (see box 2).

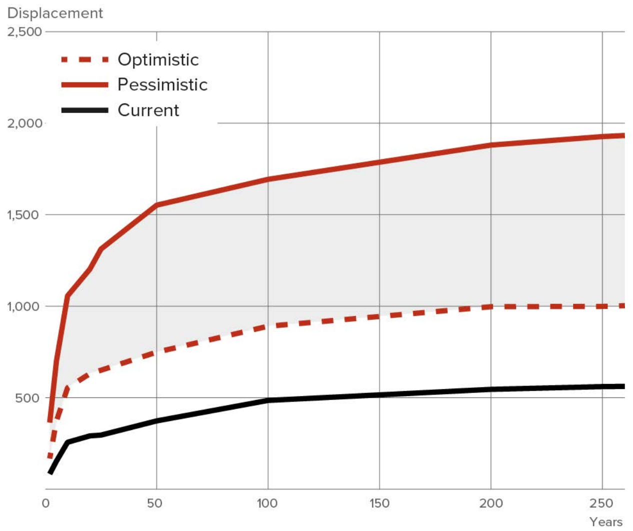


Figure 23: PMD curves for current climate conditions and long-term projections considering both optimistic and pessimistic scenarios.

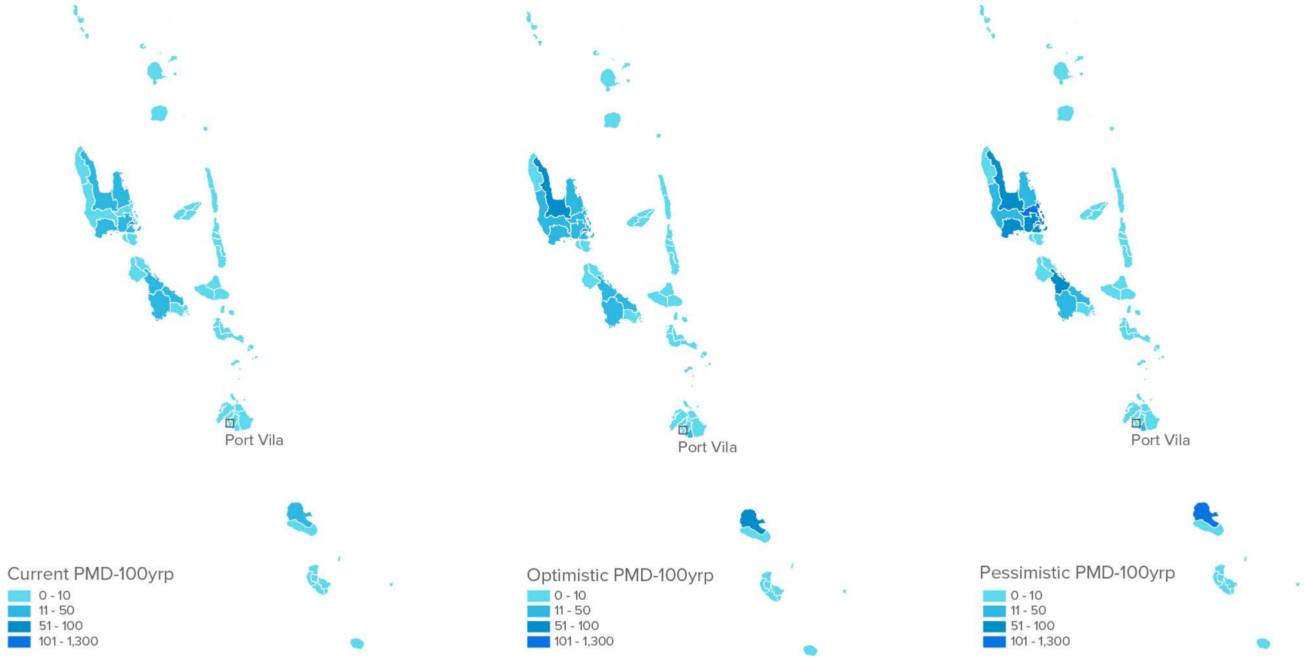


Figure 24: Displacement for a 100-year return period flood event (PMD at 100yrp) in current climate conditions and long-term projected conditions, considering both optimistic and pessimistic scenarios.

Box 2: Basic services disruption: Schools severely damaged or destroyed by floods, in Vanuatu

The disruption of basic services such as healthcare and education tends not to be the main trigger of displacement after a rapid-onset event, but combined with loss of housing and/or work, it can be an aggravating factor.

In Samna, around 400 students would be displaced due to their inability to access to schools because of severe damages, if the island suffered a 100-year event in current climate condiations. This could increase the vulnerability of the families concerned and make displacement more likely.

Figure 25: Number of students who would lose education services as result of a 100-year flood event

Cyclone Pam, Vanuatu
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Conclusion

Despite decades of evidence to the contrary, it is still a common perception that disasters are natural and human factors are not relevant. Approaches to flood-risk mitigation often focus on structural hazard mitigation measures, while the exposure and vulnerability of people and assets tends to be overlooked. It is essential, however, that the latter components are not neglected when dealing with displacement risk, which is intimately linked to people's vulnerability.

This report details the first attempt to develop and use a flood displacement risk model that employs a new method of assessing vulnerability. The approach evaluates the number of people that riverine floods might be expected to displace by considering the potential loss of homes and livelihoods, particularly the possible loss of work and with it income.

We performed a probabilistic risk assessment using a recent technique involving a modeling chain that integrates climatic, hydrological and hydraulic modeling, and impact estimation. The quantification of risk is expressed in terms of AAD and PMD, computed under current climate conditions and long-term projections according to optimistic and pessimistic scenarios.

People who may lose access to critical services such as education were also quantified. Losing such access may not trigger displacement per se, but it acts as an aggravating factor that heightens vulnerability and makes movement more likely.

The sixth assessment report from the Intergovernmental Panel on Climate Change (IPCC) states: "Heavy precipitation will generally become more frequent and more intense with additional global warming." It also says: "Climate and weather extremes are increasingly driving displacement in all regions ... with small island states disproportionately affected."[10]

To quantify the potential effects of these predictions on displacement in Fiji and Vanuatu, we integrated climate projections into the hydrological and hydraulic modelling chain, using both optimistic and pessimistic scenarios to estimate building-level impacts.

The results show that flood displacement risk is likely to double by 2060 in both countries, and under the pessimistic long-term scenarios AAD is expected to triple in Fiji and quadruple in Vanuatu.

PMD curves reveal an even more alarming trend when read in terms of frequency. Events with a 250-year return period under current climate conditions are expected to occur on average every five to 25 years towards the end of the century.

Technological advances and growing international recognition of the scale and increasing risk of disaster displacement mean the time is right for more and better-coordinated action to build on good practices and address the challenge, particularly on the availability of data to inform effective displacement risk models.

There is more work to do before future hazard risks can be quantified in a way that is meaningful for decision making when "riskscapes" evolve constantly. Our efforts will inevitably be enhanced as more data becomes available to constrain and calibrate our models. For that and through open access data, we need to understand population and socioeconomic patterns, and fluctuations in the frequency and intensity of hazards linked to climate change, develop a more accurate terrain model and obtain more hydrometeorological data.

With funding from the EU, this cutting-edge methodology provides solid basis for the development of new ways to assess displacement risk for sudden hazards from the sub-national to the global scale. Disaster displacement risk exists in every country in the world. Now is the moment to show our collective commitment to leave no one behind.

After Cyclone Pam, Bay village on Tanna Island, Vanuatu
© OCHA/Karina Coates, April 2015.

Endnotes

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6 European Space Agency, Worldwide land cover mapping, 2022

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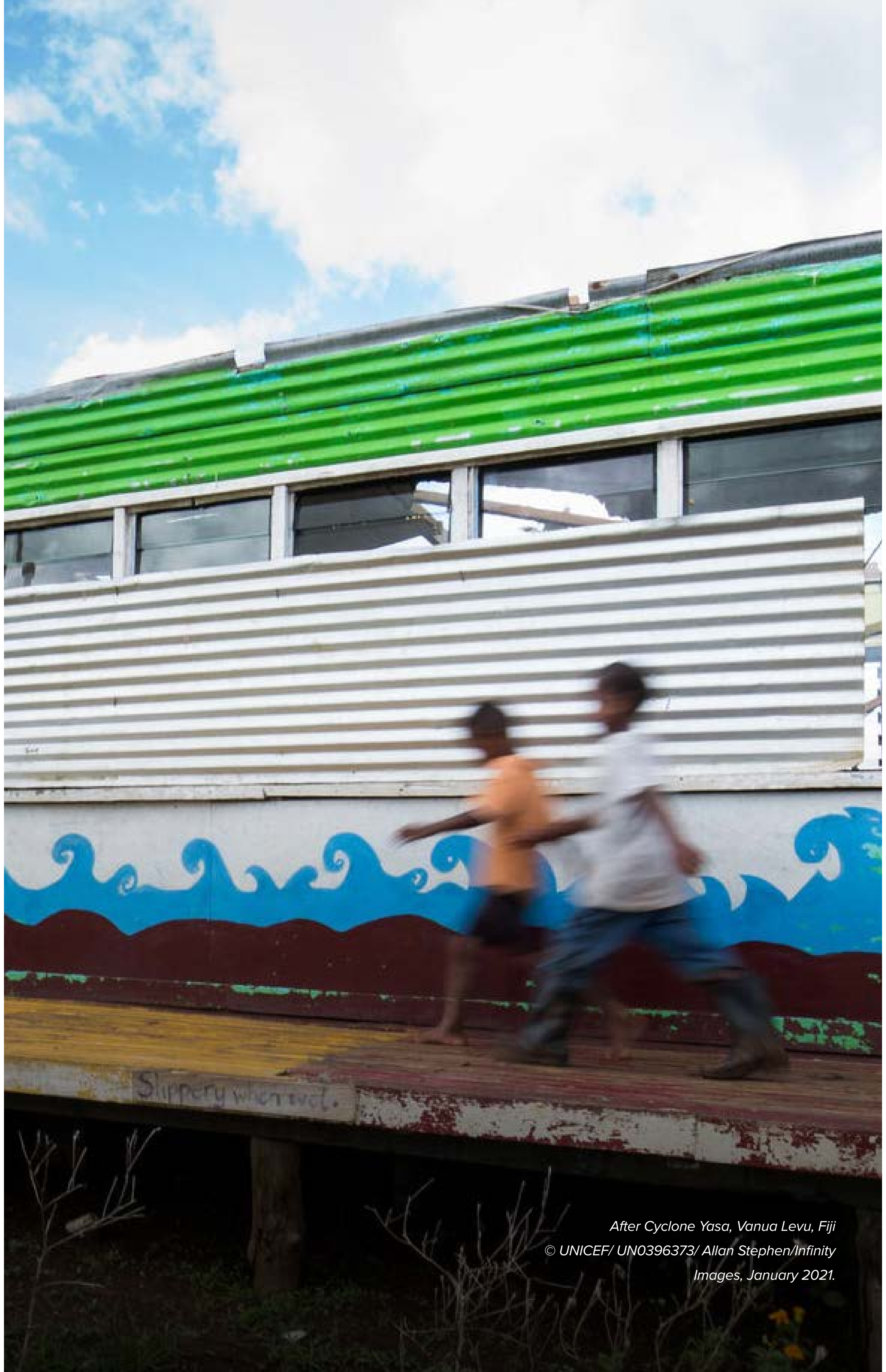

After Cyclone Yasa, Vanua Levu, Fiji
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