Annex A

Climate Change and Cultural Loss in Vanuatu

Expert Report by Anna Naupa and Dr Chris Ballard

KEY MESSAGES

- Culture underpins Vanuatu's social cohesion, stability, and resilience, along with its cultural and natural heritage, which cannot be treated separately from each other.
- Climate change and related harm to the environment has already had a direct impact on Vanuatu's cultures, culture bearers, cultural sites and resources, resulting in cultural loss and damage across Vanuatu's many islands. This loss and damage has occurred through both rapid-onset climate change events (cyclones, extreme rainfall events and flooding, drought) and slow-onset events (temperature rise, loss of biodiversity, ecosystem degradation, ocean acidification, sea level rise, and salinization).
- Cultural loss and damage include loss of tangible and intangible cultural heritage, bio-resources, and traditional knowledge (including traditional ecological knowledge), as well as reduced local resilience.
- These losses and damages can be further experienced in ways that overlap and compound each other, through: a) injury and disease; b) displacement; c) degradation and loss of access to cultural sites; d) loss of cultural materials, or access to them, essential for cultural expression, such as pandanus (*natangura*) thatch for mat weaving and house construction; e) a range of economic impacts including livelihoods that undermine cultural practices and cultural reproduction.
- Displacement from ancestral lands and ecosystems induced by climate events has already led to grave cultural losses and is a form of loss in itself. These losses are intergenerational, as they involve cultural transmission and survival.
- Increase in the intensity, scale and severity of climate-related events has exposed limits to cultural adaptation. Recovery intervals between extreme weather events are getting shorter, increasingly overwhelming people's capacity to draw on and implement cultural adaptation.
- The transmission of culture in Vanuatu is being affected by the cascading effects of climate change on all aspects of life in Vanuatu. Compounding climate impacts are pushing the limits of cultural resilience in the longer term, leading to further severe erosion and loss of tangible and intangible heritage across Vanuatu, and undermining local capacity for cultural adaptation to climate change.
- Intensifying climate change-induced strains on Vanuatu's cultures, languages and traditional ways of life undermine the aspirations for resilient development set out in the Vanuatu Government's National Sustainable Development Plan 2016-2030.

I. SUBJECT MATTER AND OUTLINE OF THE REPORT

1. This Expert Report, written at the request of the Republic of Vanuatu, provides a framework for understanding the relationship between culture and the environment in Vanuatu, and for assessing how climate change has impacted this relationship. The report identifies Vanuatu's existing cultural losses attributed to climate change by focusing on both direct and observable impacts, and more complex, indirect forms of impact on culture.

2. Culture underpins Vanuatu's social cohesion, stability, and resilience. Cultural principles, values and systems feature centrally in the Preamble to the Constitution of the Republic of Vanuatu, which states the importance of "Cherishing our ethnic, linguistic and cultural diversity." The Vanuatu National Sustainable Development Plan 2016-2030 embeds culture in national development aspirations and recognises that vibrant cultural identities make possible a peaceful, just, and inclusive society.

3. Vanuatu's cultural and natural heritage are indivisible. Over thousands of years, Indigenous cultural values, knowledge systems, economy and practices have adapted to and been organised in relation to natural marine and terrestrial resources, providing sustainable livelihoods for the population. Across generations, extensive and intricate systems have been developed throughout the archipelago to sustainably manage resources across the varied island environments, mediated through Indigenous social systems. The management of natural hazards, such as cyclones and floods, has also developed over long periods, and is woven into cultural knowledge and practices, however this is now under significant duress due to increasingly severe weather and climate events.

4. Climate change has already substantially undermined the link between culture and the environment and cultural transmission for several Vanuatu communities. Vanuatu is exposed to an exceptional degree to all the natural hazards associated with climate change, including stronger tropical cyclones, coastal flooding, prolonged drought, ocean acidification and sea-level rise. High vulnerability of communities and their exposure to increasingly more intense, more frequent and more prolonged extreme weather events in Vanuatu has already destroyed livelihoods, homes, access to food and safe water. Sustained access to 'place' underpins most cultural practices, and changes to local environments have already, profoundly, impacted social cohesion, and sustainable management practices.

5. In Vanuatu, climate change both introduces novel impacts and acts as a force multiplier for existing hazards and risks to culture. Key changes in Vanuatu's climate that have already impacted directly on culture in Vanuatu include:
   a) Heightened rapid onset extreme weather events, such as cyclones, heavier rainfall events, flooding, drought, storm surges, etc which cause immediate impact to the shelter, food and water security of communities and their cultures, and to their tangible cultural heritage such as cultural sites, monuments and architecture.

b) Slow onset, multi-decadal climate changes such as ocean warming and increases in average air temperature, saltwater intrusion, sea-level rise, and extended drought, which have already resulted in:
    - Increased degradation or loss of marine environments, habitats, and resources, including reef destruction and coral bleaching, seagrass and mangrove loss, and loss of access to or changes in marine resources.
    - Increased degradation or loss of terrestrial environments, habitats, and resources, including invasive species, and loss of access to or changes in terrestrial subsistence resources.
    - Changes to or loss of freshwater resources leading to longer term water insecurity.

6. Culture is currently under assault from both direct and indirect impacts of climate change:
    a) The bearers of culture, the resources and locales for cultural practice, the cultural practices themselves, and the ongoing transmission of culture are all directly impacted.
    b) Climate change effects that impact on the health, livelihoods, and habitats of culture bearers generate indirect impacts on the transmission and viability of culture.
    c) Climate change impacts also undermine the capacity of cultural bearers to draw on culture and traditional knowledge for adaptation and resilience over the longer term.

7. This report addresses the following key questions regarding the impact of climate change on culture and cultural systems in Vanuatu:
    a) How can we characterise the unique diversity of Vanuatu's cultural profile?
    b) How are Vanuatu's many cultures integrated with their local environments?
    c) How does climate change introduce novel effects on culture or act as a force multiplier to existing threats to culture?
    d) How does culture assist in reducing the negative impacts of climate change?
    e) How is the transmission of culture and its capacity for adaptation currently being affected by climate change?

8. This report uses the following definitions of key terms, most of which are adapted from the Pacific Regional Culture Strategy 2022-2023 (SPC 2022):
    - **Culture** refers to the ways of life of particular groups of people, including the values and belief systems, worldviews, philosophies, and knowledge systems that are expressed through their languages.
    - **Cultural heritage** is comprised of both intangible and tangible forms of cultural heritage, which are passed on over time, across generations. In the Vanuatu context, cultural and natural heritage are indivisible.
        - **Intangible cultural heritage** refers to traditions or living expressions of culture, language and oral traditions, performing arts, social practices, rituals, festive events, knowledge and practices concerning nature and the universe and heritage arts and crafts.

    - **Tangible cultural heritage** includes movable cultural heritage (heritage arts/crafts, paintings, sculptures/carvings, coins, manuscripts, etc.); immovable cultural heritage (ancestral cultural landscapes, archaeological sites, etc.); and marine cultural heritage (including oceans, rivers, lakes, etc., as well as shipwrecks, underwater ruins, and cities).
- **Place** refers to the emotional, symbolic, and spiritual connection to the environment.
- **Traditional knowledge** consists of the knowledge, know-how, skills, and practices that are developed, sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity. This can be considered as a subset of the community's intangible cultural heritage. In a Vanuatu context, traditional knowledge encompasses traditional ecological knowledge (TEK), indigenous knowledge (IK) and local knowledge (LK) and Indigenous Local Knowledge (ILK).
- **Traditional ecological knowledge** refers to the body of knowledge, beliefs, values, traditions, practices, institutions, and worldviews that are developed, sustained, and held by Indigenous and local communities in close relationship with their natural environment. TEK comprises all knowledge and practices and Indigenous understandings of custodianship within a broad and holistic cultural ecology of land, sky and sea (see Traditional knowledge).
- **Transmission of culture** is the transfer of the knowledge and skills essential for the enactment or embodiment of cultural heritage.
- **Vulnerability** is the degree to which a system is susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is always multi-dimensional and incorporates non-economic dimensions (Lavell et al. 2012; https://www.un.org/ohrlls/mvi).
- **Resilience** is the ability of a system, such as a community, and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner (Lavell et al. 2012).
- **Kastom** is a term in Vanuatu's lingua franca, Bislama, to mean all forms of cultural heritage, practice, and traditional knowledge.
- **Climate change adaptation is** 'the process of adjustment to actual or expected climate and its effects in order to moderate harm or take advantage of beneficial opportunities' (IPCC 2023: 5-6).

9. This report proceeds as follows:
    - Section II summarises the expertise and qualifications of the co-authors, and the methodology employed in producing this report.
    - Section III elaborates on the context of Vanuatu's culture and environment, as documented historically and understood in the present.
    - Section IV addresses climate change impacts and cultural loss in Vanuatu, outlining (A) cultural loss due to direct impacts of climate change, and (B) indirect or complex impacts of climate change impacts on cultural systems.
    - Section V reviews the critical processes of transmission of culture and traditional knowledge, and discusses how this transmission is impacted by climate change.

II. EXPERTISE & METHODOLOGY

10. Anna Naupa is a ni-Vanuatu researcher and academic. Originally trained as an anthropologist-geographer, Anna has worked in Vanuatu cultural research, programming, and policy since 2001. Roles included documenting traditional resource management systems (2001–2004); co-producing Vanuatu's inaugural history curriculum (2004-2005); cataloguing national photographic archives (2005) and working with her island community of Erromango to document, preserve and promote linguistic and cultural heritage (2008– present). She has served as a Gender and Culture Expert on national taskforces and for a UN Expert Group on Women's Land Rights (2007–2013). For the past decade, her professional career has taken her into international relations, where she has worked in senior policy advisory and executive roles, advising 18 Pacific Island Forum member states on Pacific diplomacy priorities, including climate diplomacy and security. Anna served as a Regional Expert to the Pacific 2050 Strategy development process (2021) and represented her island community at COP27's Moana Pavilion, speaking about the impacts of climate change on traditional ecological knowledge and practice. She is a doctoral candidate in the School of Culture, History and Language at the Australian National University, currently undertaking ethnographic fieldwork in Vanuatu. Anna Naupa's CV is at Annexure A.

11. Chris Ballard is Senior Fellow in the School of Culture, History and Language at the Australian National University in Canberra, Australia. He has worked for 40 years with Indigenous communities, mostly in eastern Indonesia and the Pacific (Papua New Guinea since 1984, West Papua since 1987, and Vanuatu since 2001) on a range of issues, including agricultural systems, land rights and human rights, oral traditions and cultural heritage, and disasters and epidemics. He was lead researcher for Vanuatu's first UNESCO World Heritage site, Chief Roi Mata's Domain (inscribed in 2008), and continues to work closely with the local community custodians managing the site. His current research project addresses the local, regional, and global impacts of the massive eruption of the central Vanuatu island of Kuwae in the 15th century, with a particular focus on local oral traditions. Since 2016, he has been working with UNESCO's Living Heritage Unit on the relationship between intangible cultural heritage (ICH) and emergencies (including conflict and disaster), and most recently on ICH and climate change. Chris Ballard's CV is at Annexure B.

12. The short timeframe for this report has precluded original field research or interviews, and the report thus relies on our individual research and experience, as well as a comprehensive survey of the literature on climate change and culture in Vanuatu. It draws on Anna Naupa's own cultural heritage, traditional knowledge, as well as discussions with the Director of the Vanuatu Cultural Centre, Richard Shing. The Vanuatu Cultural Centre is mandated to provide the necessary services for the preservation, protection and development/promotion of important aspects of Vanuatu's rich and diverse cultural heritage. It is tasked to collect, store and disseminate information (tangible and intangible) about Vanuatu's cultural heritage.

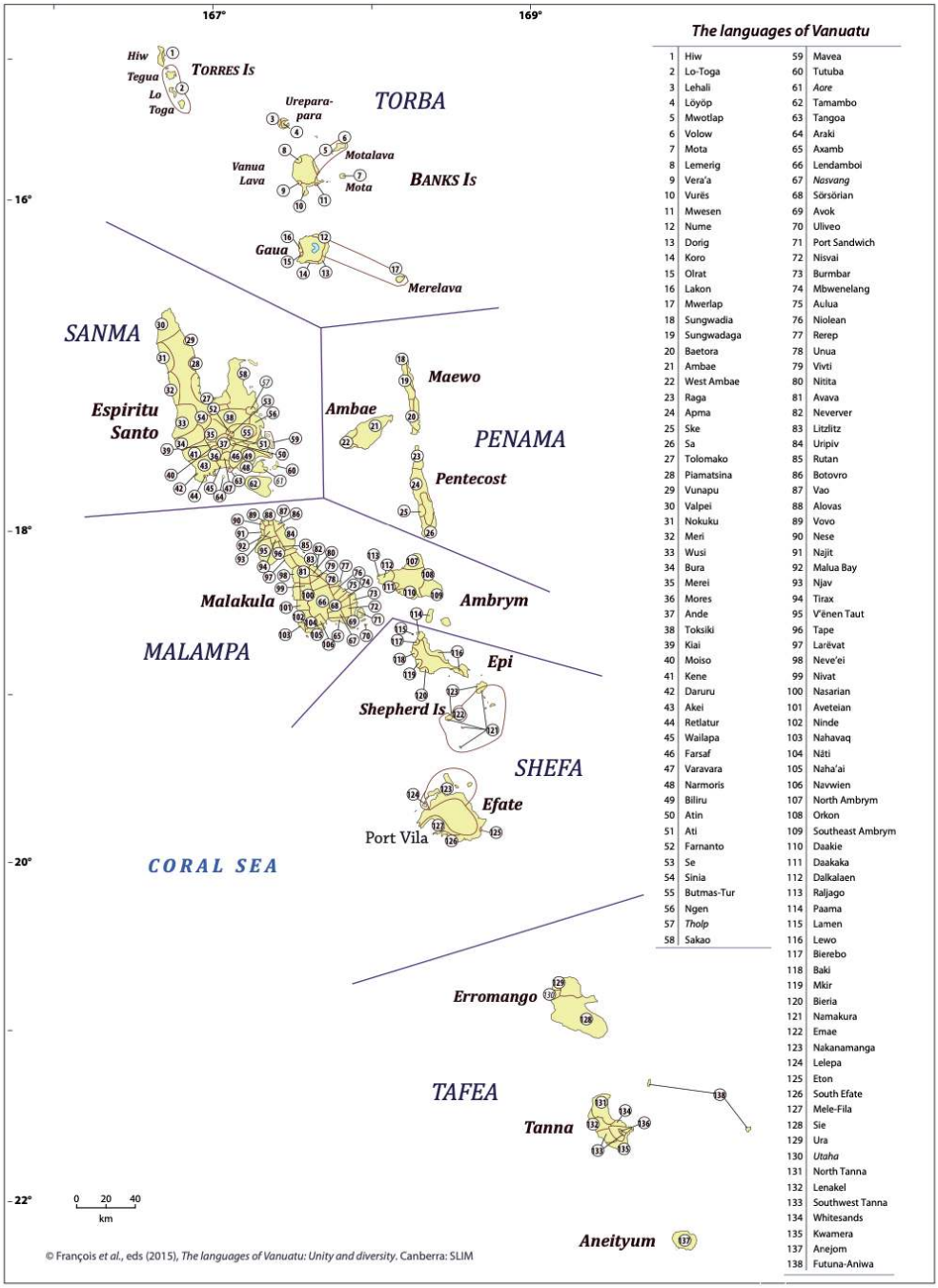
13. Information contained in this report has secured the appropriate cultural permissions for written publication.

14. Statements or testimonies about the impacts of climate change reflect local understandings of climate change as well as an intimate knowledge of local environments and indicators of change. This report reproduces these statements without qualification or formal assessment of their correspondence with global scientific understandings of climate change.

III. CULTURE AND ENVIRONMENT IN VANUATU

15. If language is a proxy for culture, then Vanuatu is per capita the most culturally diverse country in the world, with an estimated 138 languages for a total population of just 330,000 (François, Franjieh, Lacrampe & Schnell 2015; DataReportal 2023 – see Fig.1). This cultural and linguistic variation reflects in situ adaptation and diversification over more than 3,000 years of continuous occupation of the archipelago and its considerable ecological diversity, further influenced by cultural, linguistic, and genetic contact with neighbouring regions. Cultural difference in Vanuatu is not passively developed and enacted, but actively promoted and enhanced to create and sustain highly localised identities.

Figure 1 — A reference map of Vanuatu's 138 vernacular languages



The languages of Vanuatu

1	Hiw	59	Mavea
2	Lo-Toga	60	Tutuba
3	Lehali	61	*Aore*
4	Löyöp	62	Tamambo
5	Mwotlap	63	Tangoa
6	Volow	64	Araki
7	Mota	65	Axamb
8	Lemerig	66	Lendamboi
9	Vera'a	67	*Nasvang*
10	Vurës	68	Sörsörian
11	Mwesen	69	Avok
12	Nume	70	Uliveo
13	Dorig	71	Port Sandwich
14	Koro	72	Nisvai
15	Olrat	73	Burmbar
16	Lakon	74	Mbwenelang
17	Mwerlap	75	Aulua
18	Sungwadia	76	Niolean
19	Sungwadaga	77	Rerep
20	Baetora	78	Unua
21	Ambae	79	Vivti
22	West Ambae	80	Nititа
23	Raga	81	Avava
24	Apma	82	Neverver
25	Ske	83	Litzlitz
26	Sa	84	Uripiv
27	Tolomako	85	Rutan
28	Piamatsina	86	Botovro
29	Vunapu	87	Vao
30	Valpei	88	Alovas
31	Nokuku	89	Vovo
32	Meri	90	Nese
33	Wusi	91	Najit
34	Bura	92	Malua Bay
35	Merei	93	Njav
36	Mores	94	Tirax
37	Ande	95	V'ënen Taut
38	Toksiki	96	Tape
39	Kiai	97	Larëvat
40	Moiso	98	Neve'ei
41	Kene	99	Nivat
42	Daruru	100	Nasarian
43	Akei	101	Aveteian
44	Retlatur	102	Ninde
45	Wailapa	103	Nahavaq
46	Farsaf	104	Nāti
47	Varavara	105	Naha'ai
48	Narmoris	106	Navwien
49	Biliru	107	North Ambrym
50	Atin	108	Orkon
51	Ati	109	Southeast Ambrym
52	Farnanto	110	Daakie
53	Se	111	Daakaka
54	Sinia	112	Dalkalaen
55	Butmas-Tur	113	Raljago
56	Ngen	114	Paama
57	*Tholp*	115	Lamen
58	Sakao	116	Lewo
		117	Bierebo
		118	Baki
		119	Mkir
		120	Bieria
		121	Namakura
		122	Emae
		123	Nakanamanga
		124	Lelepa
		125	Eton
		126	South Efate
		127	Mele-Fila
		128	Sie
		129	Ura
		130	*Utaha*
		131	North Tanna
		132	Lenakel
		133	Southwest Tanna
		134	Whitesands
		135	Kwamera
		137	Anejom
		138	Futuna-Aniwa

16. No single Indigenous language or culture is dominant in Vanuatu. Instead, national-level communication is achieved through three national languages: Bislama, the creole lingua franca, along with English and French. Numerically, all of Vanuatu's 138 Indigenous languages can thus be considered minority languages. The 2019-2020 NSDP Baseline Survey on wellbeing in Vanuatu reports that 80% of the population aged 3 years or more speak an Indigenous language as their first language, and of those aged 12 and above, 70% of Vanuatu's population speak Indigenous languages every day (VNSO 2021: 15).

17. Vanuatu's rich cultural heritage is also expressed through an extensive body of traditional ecological knowledge, developed over thousands of years. This knowledge is organised into discrete bodies or systems, is place-specific (Mondragon 2018; Rarai et al., 2022: 2244), and includes traditional indicators drawn from close observation of environmental change – in plants, animals, astronomy and meteorology (e.g. wind direction and strength, cloud patterns) — to forecast and manage weather and climate (VMGD 2023: 7). Traditional knowledge pervades all aspects of life and cultural practice more generally, and is transmitted verbally, visually and sensorily. There is a broad-based faith in the power of customary or *kastom* knowledge to assist in managing climate change impacts (Davies 2015: 62).

18. Vanuatu society reflects an exceptional integration of culture and the environment through:
    - Trans-species relationships and co-adaptation of people, environment, and hazards.
    - Cultural resource security.
    - Psychosocial and fertility dynamics between people and their environment.
    - Managing vulnerabilities and exposure to hazard risk.

    Each of these aspects of the culture-environment relationship is discussed below, drawing on selected examples from across the country.

Trans-species relationships and co-adaptation of people, environment and hazards

19. The symbolic and psychological importance of 'place' in Vanuatu's diverse cultures manifests in people-nature relationships, co-adaptations with the environment and a sense of identity. Across Vanuatu's islands, cultural groups are socially organised around the relationship between people and their local environments, forming customary governance systems. Governance is intimately bound up with local environments and changing socio-economic conditions; it is both a strength of Vanuatu society and a vulnerability when governance breaks down. These social systems are intricately linked to local marine and terrestrial environments, assigning roles and responsibilities to clans and kinship groups which collaborate to maintain harmonious relations within the community and with the environment. Table 1 provides selected examples of the rich cultural diversity across Vanuatu's islands.

Table 1. Examples of people-environment relations

Northern Vanuatu
Vanua Lava, in Vanuatu's northern province of Torba, has different names for 96 varieties of the nutritious tuber, taro (*Colocasia esculenta).* The name of a specific taro generally corresponds to specific individuals in the social group, colloquially referred to as 'taro-men' of Vanua Lava (Caillon & Degeorges 2007: 2924). Taro-men are viewed as the guardians of traditional culture; their traditional knowledge and sustainable management of the wide variety of taro cultivars demonstrates the indivisibility of the natural and the cultural, and sustains the *suqe* social system that was a major component of traditional governance and inter-island relations (Campbell 1990: 406; Caillon & Degeorges 2007: 2924). Taro plants represent a historical map of Vanua Lava

society, mediating the past and the present by establishing a link with ancestral spirits who have conferred knowledge, plant material and taro plantations to the present-day cultivators (Caillon & Degeorges 2007: 2926). Through the *suqe* customary governance system that maintains social order between the Torres and Banks islands, taro from Vanua Lava would be exchanged for yams in neighbouring Mota Lava and Mota islands, for example during periods of disaster (Campbell 1990: 407). Any changes in a local ecosystem impact social relations management under the customary governance system.

Central Vanuatu

Social and environmental responsibilities are also interwoven in the *naflak* or *namatrao* kinship system of Efate in central Vanuatu, which organises clan identities in accordance with matrilineal totems. These divide into coastal totems for matrilines with origins along the coast (usually marine species such as the *nawita*/octopus, *pakoa*/shark, etc) or in the interior (with totems such as *nawi*/yam, *naniu*/coconut etc). *Naflak* identities are inherited through the maternal line, and those who share an identity are referred to as a *nakainanga*, tracing descent from a common female ancestor (Fingleton, Naupa and Ballard 2007: 28). This shared identity confers certain responsibilities on the clan, which plays a key role in the traditional resource management of its totemic species. The *naflak* species connections are evident in social ceremonies such as weddings and funerals, and embody a social safety net of shared support for provision of food, labour, land and psycho-social support in times of need. Marriages under the *naflak* system can also be an important strategy for land access, facilitating inter-clan relations (Naupa 2004).

Southern Vanuatu

On co-author Naupa's ancestral island of Erromango in southern Vanuatu, knowledge of place is intimately linked to a clan's standing in the social order of the island. A kinship group's *namarawan* or origin source binds them to place, typically categorised as sea or stone; those who came from the sea and have marine totems, and those who came from the land, marked by stone. The fourth largest island in Vanuatu, Erromango is estimated to have had a population of more than 10,000 at the point of European contact (Spriggs 2007). Kastom roads, which mediate inter-clan relations across the sea- and landscape, are organised to connect the sea and land clans across the island under a common customary governance system, called the *simanlou*. In addition to their sea or stone totem, each clan has unique links with *menuc* (birds), *nei* (trees), food crops, *nakave* (kava) and *nu* (water), as well as the spiritual realm in relation to each clan's ancestral land. These totemic relationships confer custodianship obligations to the clan, as well as specific identities and symbols for use in traditional peace-making ceremonies like the *nevsem*. Historical movements of particular species or individuals across the island via kastom roads are recorded through traditional songs and marked through the naming of the land and seascapes. The sacred bond between human and species is honoured through specific rituals. For example, at Potnarvin in northeastern Erromango, a traditional story recounts a time when the guardian of the whale, a man named Rungu, failed to complete the customary protocol of honour, violating the sacred bond and resulting in a local tsunami (Naritantop 2022: 25). The transgression of the spiritual bond with nature and place is often recounted as a cautionary tale to

underscore the importance of maintaining a healthy relationship to the environment and place.

20. Across Vanuatu, many cultural groups are associated with a range of different totems, including specific types of fish, octopus, giant clams, turtles, sharks and moray eels, as well as various terrestrial resources such as varieties of yam and taro (Hickey 2006: 17). Totemic systems have different names across the islands, such as the *naflak* or *namatrao* system on Efate, the *tupunis* on Tanna, or the *suqe* in the Banks Islands. The practice of not consuming one's ancestral totems out of respect and reverence for them also serves as a management strategy by reducing harvesting pressure on those resources. In some areas, highly controlled, ritualized harvests of totemic species are undertaken for exchange to other areas. The range of traditional resource management systems across the archipelago embodies the profound co-adaptation of people with their local environment, ensuring the sustainability of the sacred relationship between people and nature.

Figure 2. The late Chief Murmur of Mangaliliu, reconsecrating the World Heritage site of Chief Roi Mata's Domain in the aftermath of Cyclone Pam, 2015. (Photo: Chris Ballard)



21. Cyclones are the most regular and familiar form of natural hazard in Vanuatu, often affecting the entire archipelago and occurring several times each year. To an important degree, culture in Vanuatu has developed in the context and with the knowledge of cyclones. The locations of settlements and gardens reflect centuries of observation on cyclone patterns, and the subsistence systems have been developed around the seasonal recurrence of cyclones. On many islands, moderate cyclones are even welcomed as a source of mineral nutrients for garden soils. The impact of climate change on cyclone intensity, frequency and seasonality is already a cause for considerable concern, as it calls into question not just the traditional knowledge relating to cyclone management, but also the entire cultural edifice that is woven through with a familiarity with cyclones as a natural and partly predictable occurrence. Community leaders express their concern over the new form of cyclones, as well as their de-contextualisation from local culture when defined as new and unfamiliar disasters that seemingly require external assistance: as Richard Matanik of Lelepa Island says, "When did cyclones become disasters?"

Cultural resource security

22. If traditional resource management is the cultural bedrock of human-environment relations, then traditional knowledge that enhances human security is the next layer of cultural practice upon which food, water and shelter security are assured. Bio-resources are primarily accessed for food production, traditional architecture, kastom medicine and canoe-making, as well as for ceremonial purposes. Sustainable management of local ecosystems, underpinned by harvest, preparation and production techniques developed across generations, further embed people within their local ecosystems.

23. Table 2 elaborates on the range of cultural use of bio-resources in Vanuatu.

Table 2. Selected examples of cultural use of bio-resources in Vanuatu

Traditional food and water security techniques
Traditional knowledge relating to food security, such as famine foods, food preservation techniques, crop selection and diversity, traditional pest control, kastom magic and harvesting *tabus* (managed seasonal bans on harvest), as well as the practice of planting extra gardens for additional food security, is widespread (Rarai et al. 2022; Granderson 2017, 2018). These traditional risk management strategies ensure food security through times of resource variability and climatic hazards, and also include producing and preserving food surpluses, accessing specific famine foods, planting disaster-resilient crops and communal pooling of resources (e.g., Campbell 1990; Nakashima et al. 2012). The production of food surpluses is not only for own-use storage but also for traditional, reciprocal inter-island exchange in times of food scarcity. For example, in the Banks Islands, the *suqe* customary governance system binds people politically, economically, and socially throughout the island group and is regularly leveraged during disasters to obtain additional relief supplies from other islands as needed (Campbell 1990: 407-9). Across the Vanuatu archipelago, a wide

variety of techniques for storing and preserving food are practised, such as specialised storage of yams and fermentation of breadfruit (e.g. in the Banks Islands, Campbell 1990: 409). Similarly, water management techniques through *tabus*, the importance of the young green coconut (for drinking) and knowledge of water sources are employed to ensure a community's water security.

Traditional architecture

The traditional *nakamal* or meeting house (*nakamal* is the common Bislama term, with different terms found in local languages) is significant across Vanuatu cultures as a central site for chiefs, *kastom* governance and ceremonies. In recent decades the *nakamal* has become more multi-purpose for communities, and often also serves as a cyclone shelter and place of refuge (Christie 2017: 7). The centrality of the *nakamal* to community life is enduring. Construction of the *nakamal* uses local materials; trees for posts and beams, bamboo for walls, thatching from the sago palm (*natangura*), wild cane or coconut leaves, and fibrous vine-ropes to bind the parts together. Tree varieties are wide-ranging across the islands, with *namariu* (Acacia spirorbis*),* whitewood *(*Endospermum medullosum) and *natora (*Intsia bijuga) being commonly favoured hardwoods in traditional construction (Wheatley 1992: 282). Across the islands, specific *kastom* protocols are observed in the construction of the *nakamal*, which in turn reinforces social codes and maintains traditional knowledge, including through song (Christie 2017: 9). As the first President of the Malvatumauri National Council of Chiefs, the late Chief Willie Bongmatur, has described, "A chief without a *nakamal* is nothing" (Christie 2017: xi). A common feature of the dual cyclone shelter function of the *nakamal*, is the roofs reaching from the ground to the central roof ridge, creating a dome-like structure able to withstand high winds. Traditional *nakamal* served as evacuation centres during severe tropical cyclone Pam in 2015 (DSPPAC 2016: 51). However, the availability of local plant materials for *nakamal* construction, as well as other residential construction, is regularly stressed by the increased intensity of cyclones each year. Severe tropical cyclones have destroyed several historic *nakamal*, including every historic *nakamal* on the island of Tongoa, and the Malvatumauri Nakamal for the National Council of Chiefs, all of which sustained significant damage during the Category 5 Cyclone Pam in 2015 (DSPPAC 2015: 51)

Canoe building

Traditional outrigger canoes are an essential mode of transport in coastal villages as well as used in inshore fisheries. *Tamanu* (Calophyllum inophyllum*)* is a common coastal tree species widely used in canoe-building, as are the canoe tree *(*Gyrocarpus americanus*)*, blue wood (Hernandia moerenhoutiana) and blue water (Pterocarpus indicus) (Wheatley 1992: 277). Canoe styles vary across islands and cultural groups, and are made according to strictly prescribed protocols based on area-specific cosmologies or beliefs (Hickey 2006: 13). As the intensity of tropical cyclones increases in the Vanuatu region, cyclone storm surges are causing much more severe damage to Vanuatu's coastlines. This has led to the loss of older and larger coastal trees across Vanuatu, drastically reducing the number of individual trees available for traditional canoe construction. The loss of coastal trees is also leading to increased coastal erosion from subsequent cyclones and sea level rise.

Traditional medicines

Vanuatu's biocultural diversity promotes a wide range of traditional medicinal plant knowledge and use across the archipelago, with traditional medicine being particularly valued in more remote islands (Bradacs et al. 2011). A 2011 study of ethnopharmacology in the islands of Loh, Ambrym and Aneityum documented over 133 medicinal plant species, with the highest diversity of plants found for the most common diseases of the skin, gastrointestinal, respiratory, and urogenital systems (Bradacs et al. 2011: 438). A diverse range of trees, shrubs and herbs are used in differing ways across the country depending on local conditions. Common species used across the islands are the coconut (Cocos nucifera*),* whose bark is used for backache and wound treatment, and the pawpaw (Carica papaya) whose flower is chewed to treat ciguatera fish poisoning.

Place-based health

24. Connections to ancestral lands and places of belonging are essential elements of Vanuatu peoples' connection to the land, terrestrial and marine environments (MacDonnell 2021: 286). For example, research into the affected population's post-disaster mental health following the aftermath of Category 5 Tropical Cyclone Pam in 2015 has observed that:

> Closely bound communities and extended families were generally described as important support mechanisms that facilitated post-disaster restoration to damaged infrastructure and agriculture. One participant described how strong community networks ensured the well-being of children, the elderly and other vulnerable sub-groups (Dawes et al. 2019: 6).

25. Social and extended family networks are important coping mechanisms following a severe disaster, and together with traditional healers and *kastom* medicine are vital for psychosocial health following disasters (Dawes et al. 2019: 7). However, even tightknit social and extended family networks are coming under considerable strain due to the increased frequency of severe climate change-induced disasters with shorter recovery intervals. Between 2010 and 2020, the proportion of people receiving support in a community dropped from 84% to 71% (VNSO 2020: 160). Labour migration, domestically to urban centres as well as internationally, are common coping strategies to support families in need due to cyclones and other climate impacts, however this in turn dilutes the availability of local manpower for support during cyclones and other hazard events (e.g. in rapid garden harvests, securing shelter, clean-up etc., DSPPAC 2020), and is further undermining resilience in the longer term.

Managing cultural vulnerabilities and exposure to hazard risk

26. Traditional knowledge used to predict weather, seasons and extreme events draws on close observation of animal and plant behaviour as indicators of environmental change. Observation of atmospheric conditions and meteorological factors such as

wind direction and strength, and cloud structure also inform traditional forecasting of extreme weather events. For example, traditional knowledge holders from Espiritu Santo, Epi, Pentecost and Malekula islands observe that when the Pacific Emerald Dove (Chalcophaps longirostris) nests closer to the ground, it signals the coming of a strong cyclone in the next few months (VMGD 2023: 13). On Malekula, an increase in sea foam signals warming sea temperatures preceding cyclone season. On Erromango, a change in wind direction to the north (*nomporavu manwo*) and north-west (*nomporavu orog*) signals that a storm or cyclone is imminent (Naupa 2022: 60). On Tanna, the dry season is observed to commence when the mackerel feed close to shore. As a study of communities in northern Vanuatu has observed, "Local knowledge... enables assessment of climatic conditions and changes at a level of granularity far beyond the one achievable with the available weather data for the region" (Nef et al 2021: 13).

27. Traditional weather indicators are used by communities to adequately prepare for the season that is signalled, and to manage potential food, water and shelter insecurity. Combined with *kastom* protocols for the sustainable management of resources (see paragraphs 19-20), this traditional knowledge assists communities to manage exposure to hazard risk and supports localized short-term resilience in the immediate aftermath of tropical cyclones in Vanuatu. Climate change is already disrupting traditional knowledge of weather and climate indicators (see para. 37).

IV. CLIMATE CHANGE AND CULTURAL LOSS

28. Climate change has already generated cultural losses in Vanuatu. Key dimensions of climate-related cultural loss and damage have been experienced in the areas of agriculture, water supply, biodiversity, fisheries and tourism (as a site for promoting cultural reproduction) and include:
    - Loss of culturally significant reef and pelagic species
    - Losses to culturally significant crops from climatic events and invasive pests
    - Impacts of climatic hazard events on material cultural heritage, including traditional houses and other structures, and spaces for cultural performance and practice, as well as loss of the natural resources (such as timber, roofing, ropes and weaving materials) required to repair or replace these structures
    - Cascading impacts of climate change on community livelihoods, leading to out-migration of youth, and thus loss of the human resources required for cultural practice and performance, as well as interruption to the transmission of culture.

29. Cultural loss and damage occur through both rapid onset events (cyclones, extreme rainfall events and flooding, drought) and longer term or slow onset events (increasing temperatures; loss of biodiversity; land and forest degradation; ocean acidification; sea level rise; and salinization) associated with climate change (UNFCCC n.d.; McNamara et al. 2023). This distinction is significant: rapid onset events are harder to adapt to and draw heavily on local resilience, presenting the most direct and immediate threat to tangible cultural heritage; while slow onset events incur

compounding threats that erode and undermine intangible cultural heritage and traditional knowledge.

30. This Section outlines the impacts of climate change on culture in Vanuatu to date. It is organised in two parts, according to the nature of the impact: Part A outlines the direct, largely tangible impacts of climate change on culture; Part B outlines the indirect impacts brought about by climate change's cascading and compounded impacts on culture.

A. Climate change-induced cultural loss in Vanuatu today.

31. Climate change-induced cultural losses have been identified in a recent Pacific Island-wide study as the second most-feared form of loss from climate change, after loss of land (Clissold et al 2023). Climate change has already caused considerable direct impacts to tangible cultural heritage, including in Vanuatu, through damage to cultural sites, graveyards, and "natural" sacred sites (UNFCCC 2013). "Traditional landmarks that have been culturally significant for generations have been affected, lost or displaced by severe weather events and cause disputes over land ownership and property boundaries" (participant 72 in McNamara et al. 2023).

32. In addition to these direct losses to the material or tangible elements of culture, climate change also imposes profound damage and loss on the immaterial or intangible aspects of culture. This damage to intangible aspects of culture can occur through the loss of elders and practitioners and their knowledge, damage to the locations for the performance of culture (such as dance, ceremony, or worship), or loss of the material resources required for cultural practice (such as pandanus fronds required for weaving, or the materials and artefacts necessary for dance).

33. Climate-induced landslides have been responsible for devastating cultural loss. For example, between early 2022 and January 2023, the villages of western Santo Island experienced a combination of extreme rainfall events from a rare multi-year La Niña event and a series of earthquakes of over M4.6, which destabilised the mountainside eventually causing the entire village and gardens of Molpoi community to be submerged on two occasions by devastating landslides (Bartlett 2023: 71). The immediate destruction of homes and livelihoods extended to the 600+ hectare Molpoi Conservation Area, managed under customary governance and home to endangered and endemic bird species such as the Santo Mountain Starling (Aplonis santovestris) and the Santa Cruz Ground Dove (Pampusana sanctaecrucis); as well as other previously undescribed flora and fauna which hold considerable spiritual and cultural value for the Molpoi villagers (Bartlett 2023: 72). The climate-fuelled landslides also destroyed ancestral burial sites and the sacred Su stones, the latter being critical to the transmission of chiefly titles and customary land rights but now lost forever (Bartlett 2023: 72). Working with the community in the aftermath of the extreme events, Chris Bartlett (2023: 73) notes:

> Earthquakes can and do cause landslides on their own, but in the case of the people of Molpoi, the climate influenced triple dip La Niña, extreme localised

rainfall, and a lack of early warning or technical support have combined. These events have led to the permanent displacement of an Indigenous community and incalculable non-economic loss and damage to its people.

Figure 3. The 2022-23 climate-fuelled landslides at Molpoi, western Santo submerged homes, gardens, burial and spiritual sites up to 3km inland to the coast. (Digital Earth Pacific, SPC 2024)



34. Loss from regular coastal flooding is already causing the degradation of coastal cultural sites in many of Vanuatu's islands. For example, archaeological surveys of rock art in Vanuatu in the 1990s determined that most rock art sites were found within 1km of the coastline, often located in limestone caves and shelters, cliffs and outcrops, boulders (usually of volcanic origin), and beach rock platforms, and are thus particularly vulnerable (Bedford et al. 1998). This climate-fuelled action exacerbates co-existing geomorphological forces on the island-scape, combining to compound threats to cultural sites. Coastal rock art provides some of the earliest records of human habitation and local cosmologies:
    - On the western coast of Maewo island, the rock art sites of Huti and Siligi contain coastal boulders with motifs associated with the local grade-taking ceremony, the Gwatu. Jeffrey Uli Boe, a National Museum fieldworker from the island, says the motifs were produced at the birth of the Creation Being, Tagaro - credited for creating the islands of Maewo, Ambae and Pentecost - and have been used across generations to signal male and female leadership ranks (Bedford et al. 1998: 188). Regular coastal inundation from cyclones, such as Cyclone Harold in 2020, is causing two types of erosion: along the

coastline where these sites are found, and; erosion of traditional governance due to the disruption to traditional ceremonies (DSPPAC 2020: 49).

- On the island of Erromango, known for extensive rock art sites containing both engraved and painted motifs, the rock art documents historical events over centuries. For example, the first use of kava at Potnarvin village in eastern Erromango is marked by coastal boulders which hold the story of the early kava and food trade between coast and inland communities, and etchings in old lava flows document the number of ceremonies held over years (Wilson 1999). Coastal erosion from regular storm surge is causing these sites to disintegrate, fragmenting cultural heritage and collective memory.

35. Degradation of the marine and terrestrial ecosystems within which Vanuatu's cultural systems are embedded has had immediate consequences on cultural life. Depletion of marine resources (due to declining reef health from bleaching, ocean acidification, increasing ocean temperatures or cyclone damage, for example) and decreasing productivity of gardens (due to heat or changed rain patterns, for example) has direct impacts on subsistence gardening and fishing (Nef et al. 2021). The same impacts cause loss of forest resources for *kastom* practices (e.g. ceremonial foods, *kastom* medicine, *nakamal* construction, weaving). The impacts of climate change-induced extreme weather events on cultural resources, and the effects on the area and quality of their habitats, have been significant. For example, Cyclone Uma in 1987 was assessed to have reduced tropical rainforest cover by 30% (Baldwin et al. 1992: 305). Cyclone Harold in 2020 destroyed the natural environment in parts of northern Vanuatu, directly affecting 37% of households' access to traditional sources of food, medicine, and shelter (DSPACC 2020: 16). Twin cyclones Judy and Kevin in 2023 devastated agricultural and forest stands, affecting the food and agricultural sources for 84% of households (DSPACC 2023: 31).

36. Climate change is affecting the resources and traditional knowledge used in cultural practice, through direct destruction of local environments. Testimonies to this include:
    - Traditional planting of yam, which is unable to adapt to rapid climate change: "The cultural ways of planting are not adaptive to these fast changes caused by the climate which is now leading to a loss of cultural practices and knowledge" (participant 59, quoted in McNamara et al. 2023).
    - "Most of our weaving materials have been damaged… and we no longer practice our cultural practices" (participant 57, quoted in McNamara et al. 2023).
    - "Medicinal plants are becoming more difficult to find due to plants [being] destroyed by cyclones" (participant 71, quoted in McNamara et al. 2023).

37. Climate change is challenging planning that is based on reliable prediction of the transition between seasons using traditional climate knowledge (Granderson 2018; Nef et al. 2021: 10), and producing an increase in out-of-season cyclones and rainfall, for example; heavier rainfall events and extended droughts also combine to produce water insecurity (BOM 2014, SPC 2016). These abrupt changes from sun to rain have also had a major impact on traditional farming practices. In the Banks Islands (Nef et al. 2021:9), an island group where the taro crop is central to its social system. Trees

fruiting out of season or not in season are increasingly observed by communities, and subverting traditional planting calendars (Granderson 2017: 556):

- At Siviri village on Efate Island, one informant says, “Dry times do not emerge at the expected time of the year and “rain comes now, at any time, unexpected”’, “*Ol taem i difren, i nomo olsem befoa*”, “Everything is crazy! You cannot predict anything now.” (Pascht 2019: 240)
- Elsewhere in Vanuatu, people report that ‘Planting seasons have changed and now they don’t know when to plant various crops so find it really hard to grow sufficient crops” (Davies 2015: 56)
- “Before climate change it was easier to teach children about how to predict weather… however it has become harder to do so with unpredictable weather patterns meaning that cultural/traditional practices and knowledge sometimes lose their value because people can no longer rely on such knowledge” (participant 73, quoted in McNamara et al. 2023).

38. Environmental degradation following climatic events has been documented, creating conditions conducive to the proliferation of new invasive weeds and pests (Wilson and Nojima 2018). A particularly damaging example of a pest species novel to Vanuatu has been the Coconut Rhinoceros Beetle (Text Box 1). In December 2023, the Vanuatu Government confirmed a new threat to the agricultural sector, the Fall Armyworm (Spodoptera frugiperda), believed to have been introduced via cyclone relief supplies from New Zealand and Australia earlier in the year.

Text Box 1. New climate-change induced pests are destroying Efate's coconut culture.

Following twin severe cyclones Judy and Kevin in March 2023, the volume of fallen trees and deadwood created conditions that propelled an exponential growth in the population of the destructive Coconut Rhinoceros Beetle (Oryctes rhinoceros, CRB) on Efate Island (SPC 2023: 13). The extent of damage to coconut palms on the island is severe (see figure below, SPC 2023: 14).

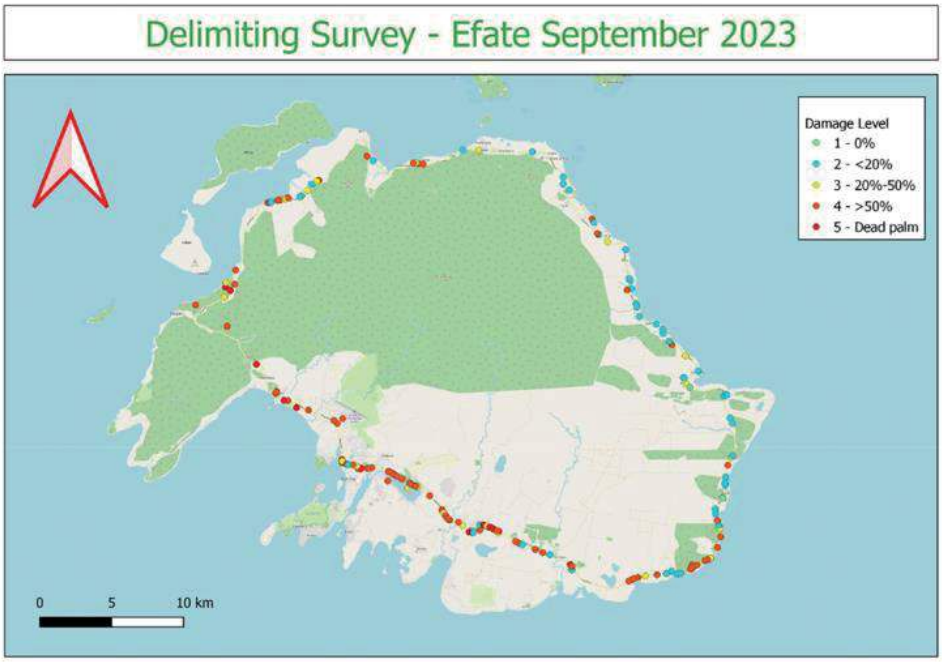


Figure 12. Updated delimiting survey map of Efate showing the extent and severity of damage.

As a vital cultural crop across all aspects of village life, for food production, domestic shelter, baskets, fans, brooms, and ceremonial purposes, this has a significant and direct impact on the ability to maintain cultural practice. For example, the traditional symbolic act of gifting a germinating coconut (*navara*) in cultural ceremonies on Efate must now look elsewhere to source healthy plants. Similarly, there is subsequential increased dependency on imported store-bought items for household items such as baskets, brooms and fans, placing new financial pressures on the household level due to the devastation of their local coconut tree stands. The coconut also has a significant role in custom stories on the island. For the Efate *naflak naniu* (coconut) matriline, it also has implications on their ability to fulfill their custodianship role within the codified social system, with potential cultural identity implications (ref. paras 23-24).

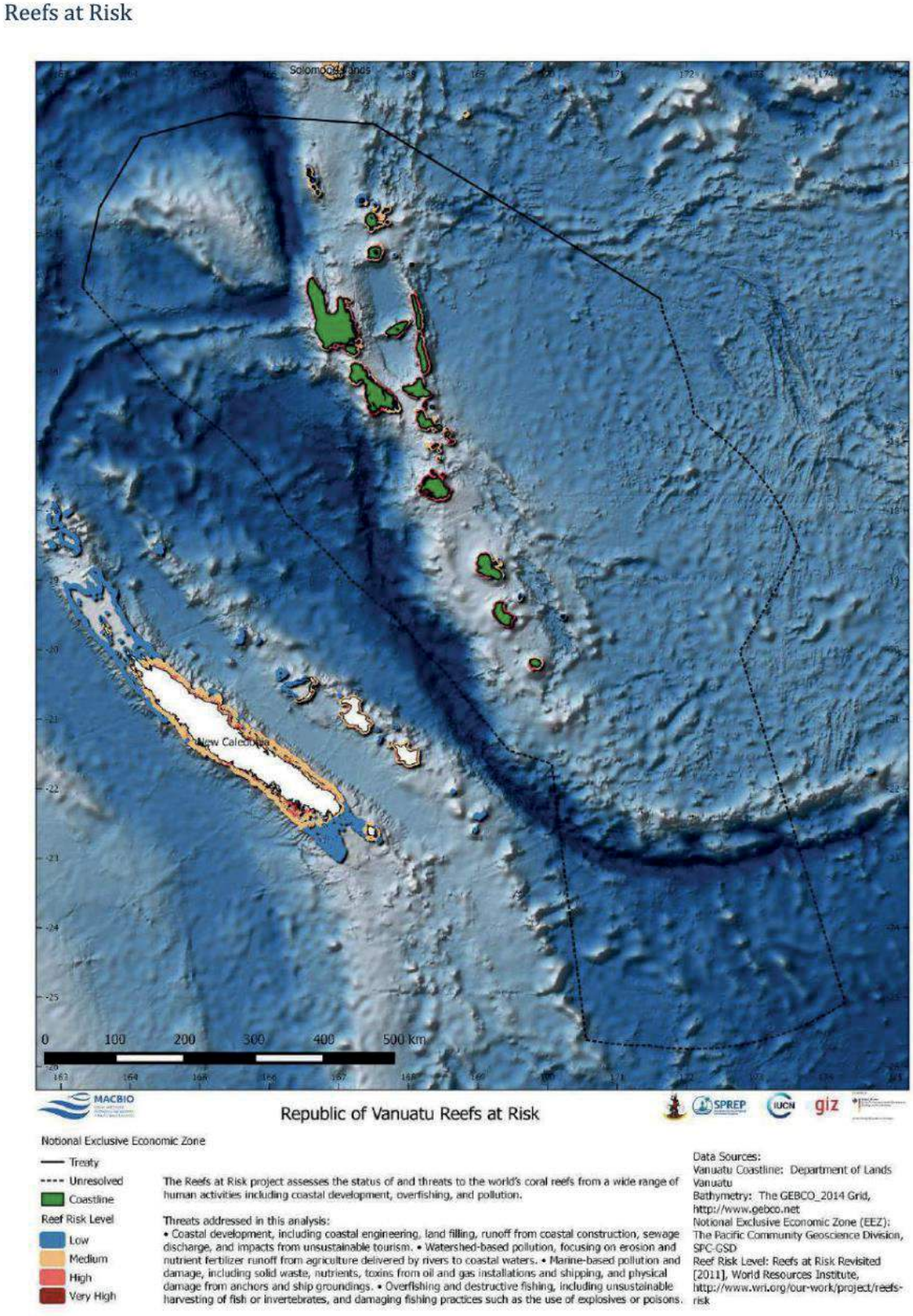
Referred to as 'the tree of life' in Vanuatu, the ubiquity of the coconut in cultural life, origin stories, cosmology and in oral histories is now threatened. With decreasing palm-based food available to CRB on Efate, the beetles have begun feeding on other important plant species such as the sago palm (*natangura*) and pandanus, both vital cultural resources used in weaving for local construction and domestic purposes.

Figure 3. Examples of post-cyclone impacts on culture.
*Note: these documented examples are occurring more broadly across Vanuatu's cultural landscape.



39. Climate change-induced ocean warming and damage to coasts, reefs and mangrove forests caused by cyclones and extreme rainfall events affects the health of Vanuatu's marine ecosystems and greatly harms food security, traditional marine knowledge and resource management practices. In addition, these impacts have strongly gendered implications because, throughout Vanuatu, women are the primary reef gatherers, gathering shellfish and crustaceans according to the season. Changes to the seasons and declining stocks of important food species have flow-on implications for their livelihoods and social positions in relation to their role providing household sustenance (Hickey 2006: 12). Declining reef health places pressure on customary *tabus* (restrictions) to manage seasonal harvesting (see para. 19), sometimes reducing fishing bans or removing species-specific restrictions to maintain pace with household food requirements. Impacts on marine ecosystem health also have implications for traditional economies, for example affecting community fish harvests that contribute to annual cycles of ceremonial feasts or ritualized exchanges with inland villages in return for resources such as yam or fruits from island interiors (Hickey 2006: 14). Moreover, these impacts all affect traditional ecological knowledge and traditional resource management, which are important local community forms of governance with socio-political dimensions and implications for how they interact with state legislation, such as in relation to customary land tenure.

Figure 4. Traditional livelihoods depend significantly on reef resources, now under threat from climate impacts. (VNBSAP 2018: 189)



B. Climate change as a force multiplier, and cascading impacts on culture.

40. Climate change acts as a force multiplier, adding to and exacerbating existing hazards and issues which have already led to cultural losses, and triggering or contributing to cascading impacts. Although these impacts are often less easy to identify and less tangible, and thus do not lend themselves to quantification or assessment for financial loss, they are already causing significant damage and loss to culture, cultural resilience and transmission in Vanuatu.

41. Slow-onset climate events such as ocean acidification, sea level rise and rising sea surface temperatures are forcing changes to marine species, including the loss of culturally significant species, coral bleaching and damage to coral reefs. With more than 75% of Vanuatu's settlements residing on the coast and highly dependent on marine sources of protein, the long-term implications for food security are considerable (Davies 2015: 51). For example, residents of the coastal village of Marou on the high volcanic island of Emau have noted sea level changes since the 1990s, resulting, already, in the loss of settlement areas (Ruehr 2022: 1623-164). On Pele Island, 11 of 23 groundwater wells have been contaminated by salinization over the past 25 years (Perumal 2018: 57). Although inundation at a local level is strongly subject to localised tectonic uplift and subsidence, as demonstrated for Tegua in the Torres Islands (Ballu et al. 2011), cyclones, intense rainfall and storm surges act to compound these effects.

42. Climate change is also contributing to the extreme weather conditions produced by El Niño and La Niña cycles, which have become more variable in the Pacific since about 1960 (Cai et al. 2023). An El Niño phase of the El Niño Southern Oscillation (ENSO) index typically produces drier than normal conditions in Vanuatu, including drought, while a La Niña phase produces wetter than normal conditions, including extreme rainfall events. These extreme weather events have a significant compounding impact on marine and agrobiodiversity over time, an impact that has already been observed in relation to several significant species that underpin sociocultural systems, whose changing habitats signal further social impacts (see Table 3 and Text Box 2). Climate-induced changes in hydrology are also affecting water catchments (DEPC 2018: 17), and in turn undermining the habitability of ancestral lands, triggering displacement, either temporarily or permanently. For example, most of the people from the in-land Lounapkamei village on Tanna Island migrated to Port Vila in 2017 due to the lack of access to potable water (Sanga, n.d.). Relocation away from ancestral lands impacts the exercise of a cultural group's customary land rights and access to land for livelihood, as well as impacts on cultural identities, which are closely tied to place and environment (see paragraphs 45-47 below on the impacts of displacement).

Table 3. Climate change impacts on selected species significant to traditional governance systems and ceremonies

Scientific Name	English (Bislama) Name	IUCN Red List Category / Species health	Climate impact on habitats	Cultural Use (Area)
	Habitat: Marine			
Chelonia mydas	Turtle – green, hawksbill	Endangered	Degradation of nesting beach and feeding habitats, coastal erosion and changing thermal profiles	Clan totem – various islands across Vanuatu
Octopus cyanea	Octopus – common (Nawita)	Least Concern (Unknown)	Ocean acidification and ocean warming affect their coral reef habitats	Clan totem – var. islands across Vanuatu
Thunnus obesus	Bigeye Tuna	Vulnerable	Sea surface temperatures and dissolved oxygen levels and other ocean variables are driving tuna species eastwards across the Pacific (SPC 2018: 2)	Food source
Carcharhinus melanopterus / Triaenodon obesus	Various sharks – black and white tip reef sharks	Vulnerable	Global climate change has already resulted in large-scale coral bleaching events with increasing frequency	Clan totem, important in local mythologies

			causing worldwide reef degradation since 1997.	
	Habitat: Terrestrial			
Cycas seemannii	Namele	Vulnerable	Storm damage	Central to traditional resource management and societal peace-making
Pandanus halleorum	Screw palm (Pandanus)	Vulnerable *Endemic to Vanuatu	Cyclone and flooding damage to habitats	Variety of cultural uses for weaving (mats, baskets, thatch, grass skirts, ceremonies)
Pteropus anetianus	Vanuatu flying fox - endemic	Vulnerable	Cyclone and flooding damage to habitats	Traditional mythology and protein source

This list is not exhaustive and is intended to illustrate the range of culturally significant species under threat from climate change, which have flow-on effects on sociocultural systems. Sources: Vanuatu NBSAP 2018-2030; IUCN Red List.

43. The loss of culturally significant terrestrial habitats and the species they host impacts on the capacity of cultural groups to fulfill customary protocols and obligations that depend on the availability of specific species. For example, a traditional symbol of peace throughout Vanuatu is the *namele* leaf (Cycas seemannii), which is listed on the IUCN Red List as a vulnerable species (see https://www.iucnredlist.org/species/42064/67759797). The 2022 species assessment documents a continuing decline in area, extent, and quality of the habitat. Typically found between 0-600m elevation, habitat decline of the *namele* in the aftermath of the more frequent and more intense cyclones associated with climate change is impacting its availability for use in cultural ceremonies and management of customary *tabus* or seasonal bans on resource harvests, where the *namele* is also a symbol of kastom authority.

44. Traditional ceremonies are central to the transmission of culture and depend on local resources for use in gift exchange. Across both urban and rural populations, ceremonial participation rates are high: 93% of households in Vanuatu participate in at least one traditional ceremony a year, 45% participate in 3 or more traditional funerary rites, and 27% participate in 3 or more marriage ceremonies (VNSO 2021: 20). Traditional coming-of-age ceremonies, grade-taking and peace and reconciliation ceremonies are also prevalent across Vanuatu (with concentration in some provinces, e.g. Malampa and Tafea for the former, Penama for the latter, according to VNSO

2021: 20). The traditional items of wealth in these ceremonies, drawn locally from natural or domesticated resources (e.g. kava, tusker pigs, *namele* cycads, yams, pandanus mats, see table 3 and Text Box 2) play a very significant role in the mediation of social relations of reciprocity. Impacts on the production of key traditional wealth items (such as tusker pigs) in turn impact on key cultural ceremonies that embody and promote social cohesion and peace.

Text Box 2. Climate impacts on kava culture

The traditional narcotic drink kava (Piper methysticum*)* is central to most cultural rituals and ceremonies across Vanuatu's islands. With over 82 kava cultivars in Vanuatu, the island archipelago is understood to be the centre of the origins of kava as a domesticate (Lebot and Levesque 1989). Within traditional local economies, kava plays a key role, alongside pigs, yams, taro and pandanus mats, in ceremonial exchange between and within communities, with 88% of households reporting use of traditional wealth items for ceremonies (VNSO 2021: 74). Kava features in mythologies and social roles may be assigned according to kava varieties found in a locale. For example, on Tanna Island certain families have the right to consume specially grown and decorated kava – named the *tupuga* – at circumcision festivals (Lindstrom 2009: 299). Kava has also been a key item of traditional trade and has had increasing commercial value in recent decades, providing a main source of income for 24% of farming households (VNSO 2021: 11). Traditionally grown beneath tree canopies, any water stress – such as during drought and El Nino seasons – harms cultivation, with diseases and pests also affecting kava production (Davis and Brown 1999: 18, 25). Kava is highly sensitive to the minerals in sea water; "sea water can be blown several kilometres inland during cyclones and strong winds, and cause extensive damage to kava crops" (Davis and Brown 1999: 30). During the un-seasonally early Cyclone Lola in October 2023, kava farmers on Pentecost Island reported large-scale damage to their crops, with a 5-year recovery period (Radio New Zealand 30/11/23).

45. Displacement from ancestral lands and ecosystems induced by slow-onset climate events is perhaps one of the greatest challenges for cultural survival. Climate change, combined with increasing urbanization and development pressures, is compounding the impacts of natural hazards and disasters in Vanuatu (IPCC 2014) and driving evacuation pressures for people facing floods, cyclones, and other hazards.

46. Customary custodianship of land is enshrined in Vanuatu's Constitution and comprises an estimated 97% of all land area (Farran et al. 2011). As Vanuatu's first Minister for Lands, Sethy Regenvanu, states, "Land to ni-Vanuatu is what a mother is to a baby." Land access and usufruct rights are essential for life in Vanuatu society. Governed by diverse customary land tenure systems, sustainably managed access to land-based resources underpins traditional social support systems and inter-community relations. Physical displacement from place, whether long-term or temporary, has direct implications for transmission of culture. Displacement management in Vanuatu necessarily draws on customary systems to facilitate mobility, due to the predominance of customary land tenure and the frequent needs for custom land access for relocated communities. Maintenance of social cohesion and structures in any displacement process is a key consideration and, if not done well, can disrupt

cultural knowledge holders and fragment linguistic communities, weakening cultural production and cultural transmission.

47. Where group cohesion is not able to be maintained in displacement contexts, or movement is to areas which are not on one's own customary territory, the threats to cultural production and transmission are heightened. A particular example is that of language: studies of historical mobility in Vanuatu, often in the rural-urban context, highlight linguistic erosion due to dominance of the lingua franca, Bislama, and the dispersion of linguistic communities (Tonkinson 1968). Similarly, traditional knowledge and practice of cultural performances can be diminished, particularly if the relocation site has different biodiversity or does not provide adequate space for cultural production and performance of rituals. Consideration by displaced communities of their potential to integrate into the customary land tenure system of the host community is also a key factor in determining whether to proceed with displacement through custom networks or to alienated government land (McDonnell 2021; Fitzpatrick 2022).

48. Climate change-related increases in cyclone intensity, stronger El Niño events (Esswein and Zernack 2020) have knock-on effects: "loss and damage to Ni-Vanuatu's human rights are having cascading impingements on many other interconnected human rights and can transcend across generations (for example, interconnected human rights to custom, Indigenous knowledge, family, agency and identity)" (McNamara et al 2023).

49. It is worth noting an emerging problematic use of the term 'resilience' which can deny attention to a broader set of cultural vulnerabilities brought about through climate change impacts. For example, reports on the resilience of communities in the immediate aftermath of cyclones typically focus on traditional knowledge of disaster/famine foods and shelter. However, full recovery of the community in the longer term must necessarily work within customary institutions that are central for addressing any community relocation and cultural transmission matters. In addition to varying degrees of cultural resilience across a timescale, resilience needs to also be considered in the context of the multiple dimensions of vulnerability that local communities face. Despite the importance of culture for climate change adaptation and resilience in Vanuatu, there remains a need to address the structural challenges contributing these dynamics across multiple scales of action, from the global to local (Ensor 2015).

V. TRANSMISSION OF CULTURE

50. Where there has been cultural loss due to climate change, the transmission and thus the sustainability of culture is directly impacted. This fundamental unravelling of culture, exacerbated by climate change, is a process that is already under way, but one which plays out over longer time frames. It is loss, in the present, of future capacity. As discussed in Section IV.A above:

- Cultural practices are often unable to adapt to fast rates of change, "leading to a loss of cultural practices and knowledge" (para 35).
- Craft resources (such as pandanus for weaving) have been depleted, with consequences for production and knowledge reproduction: "we no longer practice our cultural practices" (para 35).
- Before climate change impacted the seasons and predictability of the weather, it was "easier to teach children about how to predict weather…however it has become harder to do so with unpredictable weather patterns meaning that cultural/traditional practices and knowledge sometimes lose their value because people can no longer rely on such knowledge" (para 36).
- Landslides with multiple causes on western Santo, including climate change-induced heavier rainfall, destroyed sacred Su stones which are critical to inheritance of chiefly titles and customary land rights, but which have now been lost forever (para 32).

51. While cultural systems and traditional knowledge are optimizing their adaptive capacity to respond to the novel and cascading threats of climate change and ensure localized resilience in the short term, this act of emergency response and resilience is already a form of cultural loss and harm: re-orienting societal resources to a heightened climate risk diminishes the ability to implement, communicate and transmit cultural knowledge necessary for adaptive strategies. Moreover, adaptation can also be seen, in the cultural context, as a form of loss or damage (depending upon the adaptation required).

52. Shared cultural values and identities contribute to social cohesion and wellbeing, and community-based support systems are a critical safety net in times of crisis, and recognised as such by society and the government. This is underscored by the Vanuatu Government's strong commitment to place culture at the centre of the National Sustainable Development Plan 2016-2030:

> Community, family and kinship ties serve as the primary social safety net, especially for the young, the elderly, people with disabilities and other vulnerable people… The indivisible connections between culture and the social, environmental and economic pillars of the NSDP are reflected in our aspirations, and how we will deliver our national vision. (Government of Vanuatu 2019: 8)

53. Intensifying, climate change-induced strains on Vanuatu's cultures, languages and traditional ways of life undermine the resilient development aspirations of the Vanuatu Government's National Sustainable Development Plan 2016-2030. The Vanuatu Government produced the plan partly in response to the challenge of safeguarding culture and cultural transmission, however these efforts are under increasing pressure, given losses that have occurred and are presently occurring and a worsening climate change outlook, including impacts that are already unfolding (such as reef decline and sea level rise). The scale and urgency of the task is significant given the immense pressure placed on cultural systems by accelerating climate change.

54. The frequency of climate-induced severe weather events, and the subsequently frequent 'states of emergency' render the Vanuatu Government and households in constant crisis mode, focused on basic access to food, water and shelter. The increasing demands on the limited national resources available to respond to frequent climate-induced extreme weather events place even more pressure on community-based systems to facilitate local disaster response efforts. This in turn imposes a reliance on customary groups to drive community resilience and adaptation to the impacts of climate change, drawing on traditional knowledge and practice.

55. Transmission of traditional knowledge and traditional ecological knowledge is currently impacted by climate change with both immediate and longer-term effects. For example, indicator species used as the basis of traditional knowledge of seasons, weather and climate, are in some cases no longer reliable, as they have shifted habitats, range, or breeding behaviours, or have suffered population declines in response to climate change. A large body of knowledge built up over thousands of years is slowly being lost. The Vanuatu Government has undertaken commendable efforts over the past three decades to document traditional ecological knowledge (VKS 2001) and traditional knowledge of indicator species used in forecasting weather and climate (SPREP 2023). These efforts notwithstanding, the rapid transformations to Vanuatu's island environments and biodiversity due to climate change means that this traditional knowledge remains vulnerable to loss. Moreover, documenting this knowledge does not guarantee that it will continue to be practiced in place.

56. Reflecting Vanuatu's archipelagic geography, lack of level of Western-style development, and financially strained state institutions, local communities across Vanuatu's 83 islands remain the primary agents of cultural survival, transmission and adaptation (Cox et al. 2007; Thompson n.d.). With 78% of Vanuatu's population residing in rural areas (VNSO 2020: v), cultural support systems bridge gaps in government services where there are financial and logistical constraints; the link between people and their environments is critical for the ongoing survival of these communities. Strong indigenous systems of support within communities, clans and extended families underpin cultural forms of social protection, and are themselves grounded in traditional knowledge systems, kinship, ties, customary reciprocity and gift-exchange, and a keen sense of 'belonging' through identifying with land and language (Jolly et al. 2014: 5). The effectiveness of these culturally based social 'safety nets' depends on community agency and continued access to traditional lands and environmental resources. It also depends upon a healthy environment.

57. Climate-related disasters, displacement and mobility intensify socio-cultural pressures (Naupa 2023). Robust cultural systems have lessened community vulnerabilities for generations, dependent as they are on secure and sustainable access to environmental resources and social cohesion. The changes to these systems, directly to environmental resources, and indirectly through disaster-induced social displacement and erosion of codified systems, undermine cultural survival and resilience. Climate change has directly impacted environment-based resilience, and is undermining socially-based cultural resilience.

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ANNEXURE A – ANNA NAUPA CV

Attached.

ANNEXURE B – CHRIS BALLARD CV

Attached.

SIGNATURES



Anna Naupa, 2 February 2024



Chris Ballard, 2 February 2024

Annex A.1

Anna Naupa

Curriculum vitae

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Mobile: +678 772-3343
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Education & Awards

2022-26 PhD Candidate, School of Culture, History and Language, Australian National University

2014 Master in Public Administration, Harvard Kennedy School, USA
Fellow, Edward S. Mason Program in Public Policy and Management
Lucius N. Littauer Award for Academic Excellence
2004 MA, Geography University of Hawai'i, Manoa
2001 BA (Honors), Geography and Anthropology
University of Hawai'i, Hilo, USA
East-West Center Alumnus
Accredited Partnership Broker & Associate
Vanuatu Independence Medal (2021) for services to Arts and Culture

Country Experience

Pacific & Rim - Vanuatu, Papua New Guinea, Solomon Islands, Fiji, New Caledonia, Nauru, Niue, Palau, Federated States of Micronesia, Samoa, Tonga – and Australia, New Zealand, Japan, Republic of Korea, Laos, Indonesia, USA. (*Desk-based:* Cambodia, Canada, People's Republic of China, Cuba, the EU, France, Germany, India, Italy, Malaysia, Myanmar, Norway, Philippines, Spain, Thailand, Turkey and the UK.)

Citizenship & Languages

Ni-Vanuatu: Bislama, English, French (basic), Sie (basic)

Relevant skills

Strategic leadership, institutional governance, multi-party negotiations, policy analysis and development, international relations, national development, partnership brokering, financial and program management, design, implementation and review, communications and public diplomacy, organisational skills, networking, advanced writing.

Referees

- Available on request.

Selected Professional Research Experience

February 2022 – August 2023
Associate Director - Outreach, Pacific Fusion Centre
Provide analytic oversight of regional security assessments. Other responsibilities include establishing the Centre's reputation for excellence and collaboration, including a legal personality for the Centre, building effective working partnerships across the Pacific security community, aligned to the PIF Boe Declaration.

October 2021 – present (project-based, concurrent with other roles)
Director, Island Minds Ltd
Management oversight and principal consultant for a Vanuatu-based research, analysis and strategic communications management consultancy. Clients have included Blue Ocean Law / Vanuatu Government, CARE Vanuatu, the Pacific Community (SPC), IOM, the European Climate Foundation, Espresso Magazine, the National University of Vanuatu and VBTC for the Press Klab blong Vanuatu expert dialogue series. Assignments span cultural and geopolitical research and analytics, including expert cultural input to Vanuatu's submission to the International Court of Justice on climate change.

October 2021 – February 2022
CSO and Community Services Adviser, Vanuatu-Australia Policing and Justice Program (part-time)
Provided advisory services in support of improving access to justice and social protection for the most vulnerable populations. Facilitated COVID preparedness and planning for the Ministry of Justice and Community Services, including its agencies. Guided policy and programming to support a strengthened chain of justice from communities and customary governance systems into the state system, incorporating GEDSI principles.

2020 – 2022
Regional Expert for Pacific 2050 Strategy Development (Independent, voluntary capacity)
Providing strategic expert input into the Pacific 2050 Strategy Drivers of Change analysis, and future-thinking/foresight contributions on politics and geostrategic issues, culture, employment and economics. Nominated by Vanuatu Government.

2019 – present
Creator & Coordinator, Vanuatu Children's Literature Initiative (Volunteer) www.taftumas.com
Created, co-edited, guided and coordinated research and writing of over 75 community volunteers in the bilingual publication of *Taf Tumas: Different journeys, one people*, an illustrated non-fiction children's book celebrating 40

inspirational ni-Vanuatu men and women to mark Vanuatu's 40th Independence anniversary. Trilingual audio stories aired on radio in Vanuatu, in New Zealand and on social media. The book forms part of the Vanuatu Government's disaster-ready Home School Care Package learning content.

2019 –2023
Advisory Member (Pacific), Developmental Leadership Program (Independent, voluntary capacity)
Providing advisory input into DLP's research priorities and publications for the Pacific, including international learning. Funded by DFAT and managed through the University of Manchester, there are 5 advisory members in total covering Asia, and the Pacific, representing academic, DFAT and development sectors.

December 2018 – October 2021
Country Director, Australia-Pacific Training Coalition (Vanuatu & Nauru)
Provided strategic direction for the transition of APTC from an Australian technical college to a coalition-builder with partner institutions, industry, and the Governments of Vanuatu and Nauru to achieve sustainable country driven TVET reform.

October 2017 – December 2018
Economic Affairs Officer, UN-ESCAP Pacific Sub-Regional Office (Fiji)
Led sustainable development policy research and analysis in support of the Pacific's implementation of the SDGs through the Pacific Roadmap for Sustainable Development, with a focus on the peace-development nexus, Pacific innovations in working with customary institutions and regional financing. Research lead for the 2018 biennial *Pacific Perspectives* report.

July 2014 – October 2017
Regional and International Issues Adviser, Pacific Islands Forum Secretariat (Fiji)
Led geopolitical and policy analysis of respective foreign policy positions towards the Pacific and advised Members in the advancement of agreed Forum positions during partnership talks, such as on climate change and ocean governance. Led and advised the 2015-17 analysis of governance and financing arrangements through CROP agencies, which facilitated greater evidence-based conversations across Pacific SIDS about how to optimise the alignment of pooled finance for the regional agenda.

Feb – Sept 2014
Country Case Author, Gender and Social Protection Policies in the Pacific, Australian National University/UNWOMEN
Conducted expert gender assessment of Vanuatu's social policies, examining both state-centric and informal social protection mechanisms.Collaborated with a team of Australian and Pacific Islander academics to develop several country case studies as part of a Pacific background paper on the topic. This paper was input into UNWOMEN's 2014 *Progress of the World's Women* report. See: https://www.academia.edu/14860383/Jolly_M._et._al._Falling_through_the_net_Gender_and_Social_Protection_in_the_Pacific

Mar 2014
Adviser (New York), Government of Vanuatu Department of Women's Affairs
Provided policy research and advised the Vanuatu Government delegation to the 58th United Nations Commission on the Status of Women (CSW) meeting on the emerging issue of women's access to productive resources. Represented the Vanuatu Government at relevant meetings.

May 2006 – July 2013
AusAID Senior Program Manager – Land, Governance and Gender (Vanuatu)
Designed and managed AusAID's land, democratic governance, civil society and gender programs in Vanuatu, providing strategic direction to implementing partners such as the World Bank (Justice for the Poor Program) and oversight of joint AusAID-NZAID funding for Vanuatu's land reform initiatives. Efficient, effective and transparent management of A$51 million in development assistance over seven years. Managed and co-authored the *Drivers of Change* political-economy analysis of Vanuatu in 2007, which shaped the expansion of AusAID's support to civil society to the country.

2008 – present
Erromango Community/ Erromango Cultural Association Adviser (Volunteer) www.erromango.org
The Erromango Cultural Association is a community organization working to document, protect and promote the languages and *kastom* of my home island of Erromango in order to strengthen traditional governance structures. I advise the organization on fundraising/grant proposals, program management and cultural research. To date we have produced 13 books for children/adults in the vernacular, as well as conducted numerous cultural revival community workshops relating to traditional artforms, governance and land rights.

2004 – 2005
Project Officer, National History Curriculum Project, Vanuatu Cultural Centre
Co-authored, lead researcher and project managed the development of Vanuatu's first-ever national history curriculum, in three volumes plus a teachers' guide. Worked closely with an expert reference group, Ministry of Education, partners and managed all publication logistics.

2001 (contract)
Research Officer, Traditional Resource Management Project, Vanuatu Cultural Centre
Lead researcher into traditional resource management systems across Vanuatu. Conducted interviews with male and female VKS fieldworkers from across the country, report write-up was used to inform cultural approaches through the Vanuatu Environment Unit.

Selected blog posts & publications (full list available upon request)

- *(pending publication).* Naupa, Anna. 2024. "The Melanesian Way in the 21st Century: culture, politics and festivals." *Journal of Pacific History Special Issue on Melanesia.* Honolulu: University of Hawai'i Press.
- *(pending publication).* Naupa, Anna. 2024. "The steering paddle of our canoe: culture in Vanuatu's diplomatic practice." In *Oceanic Diplomacy,* Eds. Greg Fry, George Carter and Gordon Nanau. ANU Press, Canberra.
- Naupa, Anna. August 2023. « Cultural security in the Pacific: why it matters." Lowy Institute, The Interpreter. https://www.lowyinstitute.org/the-interpreter/cultural-security-pacific-why-it-matters-regional-security
- Naupa, Anna. 2022. "Can oceanic diplomacy solve the Pacific's maritime disputes?" Australia Pacific Security College, Canberra. https://pacificsecurity.net/can-oceanic-diplomacy-solve-the-pacifics-maritime-disputes/
- Naupa, Anna. 2022. "Sealed with kava and betel nut: Lessons in Oceanic Diplomacy from the Mota Lava Treaty." InBrief Series. ANU Department of Pacific Affairs, Canberra.
- Naupa, Anna. 2021. "Our language, our land and future – Lessons learned from the Erromangan Cultural Association's promotion of the vernacular in contemporary Vanuatu." In *Papers from the inaugural National University of Vanuatu Symposium on Education, Culture and Identity, 5-7 April 2021,* Port Vila, Vanuatu.
- Naupa, Anna, Sovick, Mere, Olul-Hassen Rebecca, and Ann Howarth. 2021. 'From little things, big things grow: the power of story-telling as part of Vanuatu's independence story.' In *Papers from the inaugural National University of Vanuatu Symposium on Education, Culture and Identity, 5-7 April 2021,* Port Vila, Vanuatu.
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- Naupa Anna, and Derek Brien. May 2018. "Fostering peaceful sustainable development in the Pacific under the 2030 Agenda." UNESCAP Working Paper Series Macroeconomic Policy and Financing for Development Division. https://www.academia.edu/39807785/Working_Paper_Series_Macroeconomic_Policy_and_Financing_for_Development_Division_FOSTERING_PEACEFUL_SUSTAINABLE_DEVELOPMENT_IN_THE_PACIFIC_UNDER_THE_2030_AGENDA
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Annex A.2

Curriculum Vitae **Christopher Hugh Lewis BALLARD**

Work Address	School of Culture, History and Language, College of Asia and the Pacific, The Australian National University, Canberra, ACT 2601, Australia
E-mail	chris.ballard@anu.edu.au
Web pages	https://researchers.anu.edu.au/researchers/ballard-chl https://anu-au.academia.edu/ChrisBallard https://www.researchgate.net/profile/Chris_Ballard3

Research Interests

Indigenous historicity and temporality; disaster, emergency and climate change; cultural heritage and World Heritage; resource ownership and land rights; narrative and memory; violence and colonial encounters; racism and history of "racial science"; social and agricultural transformations; theory and practice in the disciplines of history, anthropology, archaeology and geography; Taiwan, eastern Indonesia, Papua New Guinea, Vanuatu, Solomon Islands, New Caledonia, French Polynesia, Melanesia, Pacific.

Qualifications

1995	Ph.D., Research School of Pacific and Asian Studies, Australian National University. • Thesis title: 'The Death of a Great Land: ritual, history and subsistence revolution in the Southern Highlands of Papua New Guinea.' Available on-line at http://hdl.handle.net/1885/7510
1985	BA (Hons) in Prehistory, Australian National University

Employment

2016-18	Professor, University of French Polynesia, Pape'ete, French Polynesia (1/8/16-31/7/18)
2016	Associate Dean for HDR (Higher Degree by Research) Students, College of Asia and the Pacific, ANU (1/3/2016 – 1/8/2016)
2013-15	Director (Research) and Deputy Director, School of Culture, History and Language, College of Asia and the Pacific, ANU
2010+	Senior Fellow / Associate Professor, School of Culture, History and Language, College of Asia and the Pacific, Australian National University.
2001-2010	Fellow, Division of Pacific and Asian History, Research School of Pacific and Asian Studies, Australian National University.
1995-2000	Research Fellow, Resource Management in Asia Pacific Project, Research School of Pacific and Asian Studies, Australian National University.

Select International Committees

2023-	Member of the Advisory Body and Representative of the Advisory Body on the Board, International Research Centre for Intangible Cultural Heritage in the Asia-Pacific Region (IRCI), Japan.
2023	Member, Panel of Experts of the Collaborative Research Action (CRA) for the European Commission's Joint Project Initiative on Climate and Cultural Heritage.
2018-	Facilitator, Global Intangible Heritage Facilitator Network, UNESCO https://ich.unesco.org/en/facilitator
2018-	Member, Conseil scientifique (Scientific Council), Maison des Sciences de l'Homme – Pacifique (MSH-P) http://www.msh-reseau.fr/msh/maison-des-sciences-de-lhomme-du-pacifique-polynesie-francaise
2013-2019	Member, Conseil scientifique (Scientific Council), Labex CORAIL http://www.labex-corail.fr/

Student Supervision

As of May 2023, I have been Chair for 22 PhD candidates and Co-supervisor for 32 other PhD candidates; supervisor for 8 Masters / MPhil Students; and Convenor for the Honours in Asia and the Pacific program from 2019 to the present.

Select Funded Research Projects and Consultancies

2022-24	Capacity building for safeguarding intangible cultural heritage in emergencies in Small Island Developing States in the Pacific and the Caribbean, UNESCO, Apia, Samoa
2022-23	Concept Note on Climate Change and Intangible Cultural Heritage, Living Heritage Entity, UNESCO, Paris
2021	Facilitator, UNESCO Training Workshop on Intangible Cultural Heritage in Emergencies, Philippines
2020-24	International Assistance for a Geotechnical Study and Risk Assessment of Fels Cave, Chief Roi Mata's Domain, Vanuatu. World Heritage Centre, UNESCO, Paris.
2020	*Deep Histories of Oceania*. Australian-French Association for Research and Innovation (AFRAN) Initiative Grant.
2020-22	Chief Investigator, ARC Discovery Grant, *Kuwae 1452 AD: multi-disciplinary perspectives on a Pacific super-eruption.* DP200102320 (with CI Stuart Bedford).
2020	Training Materials on ICH and Disasters. Report for UNESCO, Paris.
2019	Operational Principles and Modalities for Safeguarding Intangible Cultural Heritage in Emergencies. Report for UNESCO, Paris.
2017	Natural Disasters and Intangible Cultural Heritage in the Pacific: a review. Report for UNESCO, Paris.
2015	Emergency Assessment of the Impacts of Cyclone Pam on the Chief Roi Mata's Domain World Heritage Site, Vanuatu. Report for UNESCO, Paris.
2011-15	Chief Investigator, ARC Discovery Grant, *The Original Field Anthropologist: Nikolai Miklouho-Maclay in Oceania, 1871-1883.* DP110104578 (with CI Jude Philp).
2010-11	Chief Investigator, *The Chiefly Oral Traditions of Central Vanuatu*. Firebird Foundation.

2010-12 Strengthening World Heritage and Protected Area Governance in Vanuatu, AusAID Pacific Public Sector Linkage Program (PPSLP) Grant (with Meredith Wilson and Stepwise Heritage and Tourism Pty Ltd)

2006-09 Chief Investigator, ARC Discovery Grant, *European Naturalists and the Constitution of Human Difference in Oceania: crosscultural encounters and the science of race, 1768-1888.* DP0665356 (with CI Bronwen Douglas).

2005-06 UNESCO World Heritage Preparation Assistance Grant, Chief Roi Mata's Domain, Vanuatu.

Field Experience (ca. 91 months in Indonesia, Papua New Guinea, Vanuatu and the Pacific)

Select Publications: Monographs, Edited Books and Journal Special Issues (n = 16)

1. 2023. Material Encounters. Eds. Bronwen Douglas and Chris Ballard. London & New York: Routledge.
2. 2020. Confronting the Naturalness of Disaster in the Pacific. Special Issue of Anthropological Forum 30(1/2) [Chris Ballard, Maëlle Calandra and Siobhan McDonnell (eds)]
3. 2008. Foreign Bodies: Oceania and the science of race, 1750-1940. Edited by Bronwen Douglas and Chris Ballard. Canberra: ANU E Press.
4. 2005. The Sweet Potato in Oceania: a reappraisal. Edited by Chris Ballard, Paula Brown, R. Michael Bourke and Tracy Harwood. Ethnology Monograph 19 and Oceania Monograph 56. Sydney and Pittsburgh: University of Pittsburgh and University of Sydney.
5. 2001. Agricultural Transformation and Intensification. Special Issue of Asia-Pacific Viewpoint, August/December 2001, 42(2/3). Guest Editors: Bryant Allen and Chris Ballard with Elanna Lowes.

Select Publications: Articles in Refereed Journals (n = 56)

1. 2023. Evidence at Source for the Mid-Fifteenth Century Eruption of Kuwae, Vanuatu. Journal of Applied Volcanology 12: 12. [Chris Ballard, Stuart Bedford, Shane J. Cronin and Sönke Stern] https://doi.org/10.1186/s13617-023-00138-1 / https://rdcu.be/dtyaE
2. 2023. Stones in motion: monuments and chiefly title histories in Central Vanuatu. Archaeology in Oceania 58(1): 20-32. https://doi.org/10.1002/arco.5283
3. 2023. Agarabi pottery production in the Eastern Highlands of Papua New Guinea. Journal of Anthropological Archaeology 69: 101479 https://doi.org/10.1016/j.jaa.2022.101479 [Kristine Hardy, Chris Ballard, Mathieu Leclerc]
4. 2023. Frontier archaeology: excavating Huli colonisation of the Lower Tagali Valley, Papua New Guinea. Cambridge Archaeological Journal 33(3): 391-411. https://doi.org/10.1017/S095977432200035X [Jeremy Ash, Tim Denham, Chris Ballard, John Muke, Joe Crouch]
5. 2022. A night on the island: Jean Guiart and Roi Mata on Lelepa. Journal de la Société des Océanistes 154(2022-1): 93-104. https://doi.org/10.4000/jso.13718
6. 2021. Cyclone Aila and post-disaster housing assistance in Bangladesh. Sustainability 13, 8604. https://doi.org/10.3390/su13158604 [Sebak Saha and Chris Ballard]
7. 2021. Human impacts and Anthropocene environmental change at Lake Kutubu, a

Ramsar wetland in Papua New Guinea. PNAS 118(40): https://doi.org/10.1073/pnas.2022216118 [Kelsie Long, Larissa Schneider, Simon Connor, Niamh Shulmeister, Janet Finn, Georgia Roberts, Atun Zawadiszki, T. Gabriel Enge, John P. Smol, Chris Ballard, Simon G. Haberle]

8. 2020. Confronting the naturalness of disaster in the Pacific. In Chris Ballard, Maëlle Calandra and Siobhan McDonnell (eds) Confronting the Naturalness of Disaster in the Pacific. Special Issue of Anthropological Forum 30(1/2): 1-14. https://doi.org/10.1080/00664677.2020.1729698 [Chris Ballard, Siobhan McDonnell and Maëlle Calandra]
9. 2020 Disaster as opportunity? Cyclone Pam and the transmission of cultural heritage. In Chris Ballard, Maëlle Calandra and Siobhan McDonnell (eds) Confronting the Naturalness of Disaster in the Pacific. Special Issue of Anthropological Forum 30(1/2): 90-107. https://doi.org/10.1080/00664677.2019.1647825 [Chris Ballard, Meredith Wilson, Yoko Nojima, Richard Matanik and Richard Shing]
10. 2020 The lizard in the volcano: narratives of the Kuwae eruption. In Eveline Dürr, Philipp Schorch and Sina Emde (eds) Experiencing Pacific Environments: Pasts, Presents, Futures. Special Issue of The Contemporary Pacific 32(1): 98-123. https://doi.org/ 10.1353/cp.2020.0005

Select Publications: Book Chapters (n = 50)

1. 2024. Monumental underlands: Indigenous archaeology in Melanesia. In Oscar Moro Abadía, Kellie Pollard, Ora Marek-Martinez, Craig Cipolla, Sara L. Gonzalez (eds) The End of Epistemology in Archaeology? Indigenous Knowledges, Ontologies and the Crisis of Traditional Philosophies of Knowledge in Archaeology. [Chris Urwin and Chris Ballard]
2. 2023. Community management of cultural tourism at a World Heritage site: intersections of the 'local' and 'global' at Chief Roi Mata's Domain, Vanuatu. In Marcus L. Stephenson (ed.) Routledge Handbook of Tourism and Small Island States in the Pacific. London: Routledge, pp. 205-218. [Adam M. Trau and Chris Ballard]
3. 2023. The meaning of ditches: an ethnography of field systems and other networks in a New Guinea landscape. In Ian J. McNiven and Bruno David (eds) The Oxford Handbook of the Archaeology of Indigenous Australia and New Guinea. Oxford: Oxford University Press, pp. 449-472.
4. 2022. Transmission's end? Cataclysm and chronology in Indigenous oral tradition. In Ann McGrath and Lynette Russell (eds) The Routledge Companion to Global Indigenous History. London: Routledge, pp. 571-602.
5. 2019. The perfect island. In Shameem Black, Matt Tomlinson and Jack Fenner (eds) Perfection. paradigm_shift 06. Canberra: College of Asia and the Pacific, pp. 12-17. [Chris Ballard and Nicola van Dijk]
6. 2018. Pacific futurities. In Warwick Anderson, Miranda Johnson and Barbara Brookes (eds) Pacific Futures: Past and Present. Honolulu: University of Hawai'i Press, pp. 280-293.

Select Publications: Media, Reports and Other Publications

1. 2023. Climate emergency: roles and risks for intangible cultural heritage. ICH Courier, 56, September 2023, pp. 14-17.

2. 2022. Cultural Heritage and Climate Change: New challenges and perspectives for research. White Paper, JPI Cultural Heritage and JPI Climate. https://www.heritageresearch-hub.eu/white-paper-cultural-heritage-and-climate-change-new-challenges-and-perspectives-for-research/ [Contributing author]
3. 2022. ICOMOS & ICSM CHC White Paper II: Impacts, vulnerability, and understanding risks of climate change for culture and heritage. [Simpson, N.P., Orr, S.A., Sabour, S., Clarke, J., Ishizawa, M., Feener, M., Ballard, C., Mascarenhas, P.V., Pinho, P., Bosson, J.B., Morrison, T., Zvobogo, L.] Charenton-le-Pont & Paris, France: ICOMOS & ICSM CHC. ISBN: 978-2-918086-72-7, https://openarchive.icomos.org/id/eprint/2718/
4. 2021. "Natural" Disasters and Intangible Cultural Heritage. ICH Courier, 48, September 2021. https://ichcourier.unesco-ichcap.org/natural-disasters-and-intangible-cultural-heritage/
5. 2017. Safeguarding and Mobilising Intangible Cultural Heritage in the Context of Natural Hazards. A Desk Study for the Intangible Heritage Section, UNESCO, Paris. https://ich.unesco.org/doc/src/38266-EN.pdf [Meredith Wilson and Chris Ballard]
6. 2015 Community responses to climate change in Vanuatu. World Heritage October 2015, 77: 14-21. [Chris Ballard, Meredith Wilson, Richard Matanik, Brigitte Laboukly]
7. 2015 Port Vila: disaster capital of the world. Canberra Times, 21 March 2015. Available at: http://www.canberratimes.com.au/comment/port-vila-disaster-capital-of-the-world-20150320-1m3p32.htm
8. 2015 Planning ahead to reduce feast and famine after natural disasters. The Conversation 19 June 2015. [Mike Bourke and Chris Ballard] http://theconversation.com/planning-ahead-to-reduce-feast-and-famine-after-natural-disasters-42184
9. 2013 Guide to Chief Roi Mata's Domain World Heritage Site, Vanuatu. Chief Roi Mata's Domain Publication Series 1. Port Vila: Vanuatu World Heritage Advisory Group and Lelema World Heritage Committee. [Meredith Wilson and Chris Ballard]

Unpublished Consultant Reports (n = 78)

Annex B

Attribution of observed global warming to countries

Independent expert report

By Corinne Le Quéré CBE FRS*
Royal Society Research Professor of Climate Change Science, University of East Anglia (UEA), UK.
8 December 2023

I have been asked by counsel for the Republic of Vanuatu to provide an independent expert opinion on the attribution of observed global warming to countries. I am a Royal Society Research Professor of Climate Change Science at the University of East Anglia. I conduct research on the interactions between climate change and the carbon cycle. My research has contributed to understanding how climate change and variability affects the land and ocean carbon sinks, and to understanding the drivers of CO_2 emissions. I was an author of the 3rd, 4th and 5th assessment reports of the Intergovernmental Panel on Climate Change (IPCC), which was awarded the Nobel Peace Prize in 2007. I Chair France's High Council on Climate and I am a member of the UK Climate Change Committee. These are independent expert councils that provide evidence-based advice to inform governments response to climate change. Previously, I directed the Tyndall Centre for Climate Change Research during 2011-2018. I initiated the annual publication of the 'Global Carbon Budget' as part of the Global Carbon Project and directed the update for 13 years. I received multiple awards for my research, most recently the Dr A.H. Heineken Prize for Environmental Sciences 2020. I am a Clarivate Highly Cited Researcher since 2018. I was elected fellow of the Royal Society in 2016. I hold a B.Sc. in physics from University of Montréal (1990), an M.S. in Atmospheric and Oceanic Sciences from McGill University (1992), and a Ph.D. in oceanography at University Pierre et Marie Curie (now part of Sorbonne University, 1999). Further information on my profile is available at: https://research-portal.uea.ac.uk/en/persons/corinne-le-quere

* Acknowledgements: This independent report is largely based on the peer-reviewed publication "National contributions to climate change due to historical emissions of carbon dioxide, methane, and nitrous oxide since 1850" published in *Scientific Data*, and on comprehensive evidence as published by the 6th Assessment report of the Intergovernmental Panel on Climate Change (IPCC). Data have been updated to 2022 where possible. I have been assisted in writing this report by Dr. Matthew W. Jones from the University of East Anglia, and by the Global Carbon Budget team for the updates of the CO_2 emissions data and relevant analysis. I thank J. Gütschow and the PRIMAP-hist team for providing 2022 updates of methane and N_2O emissions.

Summary

1. **It is now well established that climate change is overwhelmingly caused by the emissions of greenhouse gases (GHG) from human activities.** The main drivers of GHG emissions have been the use of fossil fuels, primarily for energy, and to a lesser extent the use of land, primarily from deforestation but also from agriculture. Future GHG emissions from human activities, regardless of their origin, will cause continued rise in global warming and associated climate change, with further impacts and risks.

2. **The level of global warming scales with cumulative emissions of carbon dioxide (CO_2) and with current emissions of methane.** Hence CO_2 emissions need to decrease to "Net Zero" to stabilise the Earth's climate, alongside rapid decreases in methane and other GHG. According to the 6th Assessment report of the Intergovernmental Panel on Climate Change (IPCC), GHG reductions of -43% in 2030 compared to their 2019 levels are needed to limit climate change to 1.5°C above pre-industrial levels, and -21% to limit climate change to well below 2°C above pre-industrial levels in the same time horizon, with Net Zero CO_2 achieved around 2050 and 2070, respectively.

3. **Despite the urgent need to decrease global GHG emissions, emissions have continued to rise in the past decade.** CO_2 emissions, the dominant source of GHG emissions, have continued to rise in the past decade (2013-2022) by 0.2% per year on average. Methane emissions are rising steeply, by 0.9% per year on average over the past decade, but with large uncertainties. All gases combined, global GHG emissions have continued to rise over the past decade, by 0.6% per year on average. These trends are not aligned with limiting global warming well below 2°C or to 1.5°C above pre-industrial levels, which require rapid decreases in emissions of CO_2 and methane in the short term.

4. **Actions to tackle climate change can be effective, but so far, they have not been deep or widespread enough to reverse global GHG emissions.** Global GHG emissions have grown more slowly in the past decade compared to the decade before, although they are still rising. Notably, 26 countries have succeeded in significantly decreasing their CO_2 emissions from using fossil fuels in the past decade while growing their economies. These trends have been attributed to climate and energy policies that support reduced energy use and the substitution of fossil fuel by renewable energy sources. Despite this progress, the actions in place are insufficient and global GHG emissions continue to rise. As a result of continued GHG emissions, global warming has steadily grown each decade.

5. **Cumulative CO_2 emissions and annual methane emissions have clear origin in historical use of fossil fuels and land by countries.** The largest contributors to global cumulative emissions of CO_2 during 1851-2022 were the USA (20.5%), the EU27 (11.7%), China (11.7%), Russia (7.0%); and Brazil (4.6%). The largest contributors to annual methane emissions averaged over the past decade (2013-2022) were China (16.6%), India (8.7%), the USA (6.7%), Brazil (5.8%), and the EU27 (5.4%).

6. **Global warming can be attributed to countries based on their historical emissions of different GHG.** The top 10 contributors to global warming from their historical emissions of GHG during 1851-2022 are the USA (responsible for 17.0% of global warming due to GHG emissions; 0.28°C), China (12.5%; 0.21°C), the EU27 (10.3%; 0.17°C, including Germany 2.9% and France 1.3%), Russia (6.3%; 0.11°C), Brazil (4.9%; 0.081°C), India (4.7%; 0.078°C), Indonesia (3.7%; 0.061°C), the United Kingdom (2.4%; 0.040°C), Canada (2.1%; 0.035°C), and Japan (2.1%; 0.035°C). The 42 industrialised countries of the UNFCCC Annex I list in aggregate account for 45% (0.74°C) of global warming due to GHG emissions during 1851-2022, while the 47 Least Developed Countries (LDCs) in aggregate contributed 6% (0.10°C). The top seven emitters are also the largest contributors to global warming from emissions of GHG during the shorter 1990-2022, with China the largest contributor in that recent period.

7. **For most countries, GHG emissions from fossil fuels are the source of most of their contributions to global warming.** Globally, the use of fossil fuels was responsible for 65% of global warming caused by GHG emissions from human activities during 1851-2022, and 80% for the shorter 1990-2022 period. The use of land was responsible for the remainder, with 35% and 20% contributions to global warming caused by GHG from human activities during 1851-2022 and 1990-2022, respectively. Notable exceptions are Brazil and Indonesia in the top emitters mentioned above, for whom their GHG emissions from land use contribute more to global warming than their emissions from fossil fuel use.

8. **GHG emissions are based on self-reported data by each State with sufficient confidence level to establish the country's contributions to climate change.** Reporting of GHG emissions, and the underpinning energy and land use data, is overseen by the UN, which also verifies the respect of reporting procedures, and increasingly the country's plans and actions. GHG emissions are also produced by several established international institutions. Emissions of CO_2 from the use of fossil fuels, the largest contributor to global warming in most countries, benefit from the most reliable data. GHG emissions from the use of land involve biological processes that have larger uncertainties,

but reporting methodologies are updated regularly with the latest data and understanding. Updates of GHG emissions take place regularly and are closely monitored by the scientific community.

The scientific basis for climate change

1. **It is now well established that climate change is overwhelmingly caused by the emissions of greenhouse gases (GHG) from human activities.** The science of the Earth's climate system is well understood. The greenhouse effect traps heat and warms the Earth's climate, a phenomenon known as global warming. Emissions of GHG from human activities increase the content of heat-trapping gases in the atmosphere, heating the climate system. Warming is observed consistently around the planet, on land and in the oceans, with widespread snow and ice melting, and coherent changes in rainfall patterns, vegetation, and ocean properties. The observed rate of global warming since 1970 has exceeded warming from natural climate variability for at least the past two thousand years where detailed observations exist. The contributions of natural causes to recent warming have been assessed thoroughly by many (30 in the latest IPCC) independent climate centres from around the globe. Natural causes, including the contributions from variations in the sun and from the effects of volcanic eruptions, have contributed practically nothing to the observed warming of the planet since the period 1850-1900 (commonly used to refer to the "pre-industrial" period). Evidence that the warming is caused overwhelmingly by the rise in GHG levels in the atmosphere from human activities has consistently strengthened in all six assessment reports published by the IPCC since 1990.

2. **The increase of GHG in the atmosphere is primarily caused by fossil fuel uses, and by deforestation and other uses of land.** Fossil fuel use is the main source of emissions of carbon dioxide (CO_2), which accounts for 70% of total GHG emissions from human activities today.[1] Activities that use fossil fuels include producing electricity and heat for power, industry and buildings, and transportation. CO_2 emissions are also produced by some industries through chemical processes (for example producing cement). Land use, and in particular deforestation, is another important source of CO_2 emissions. Fossil fuel and land use both contribute significantly to methane emissions (CH_4), which accounts for 18% of total GHG emissions from human activities today. Methane emissions in the land sector are predominantly from livestock rearing, and from landfills and waste. Emissions of nitrous oxide (N_2O) account for 6% of total GHG emissions and are primarily from nitrogen additions for fertilisation in agriculture. Emissions of F-gases account for 6% of total GHG emissions and are primarily due to products used in refrigeration.

3. **Five sectors are responsible for global GHG emissions: energy supply, industry, land use (including agriculture and forestry), transport, and buildings.** Their relative importance depends on whether one considers where emissions are produced or where

they are used (Table 1). Levers for reducing emissions can tackle both the production and the end uses. For example, replacing coal or gas power stations by renewable energy generation is a lever that tackles production, while improving energy efficiency in industry and buildings is a lever that tackles end uses.

Table 1: Sectors responsible for global GHG emissions.

Sector	Percent of global GHG emissions	
	By production	By use
Energy supply	34	12
Industry	24	34
Agriculture, forestry and other land use	22	22
Transport	15	16
Buildings	6	15

Source: IPCC WGIII Summary for policymakers (2022) based on 2019 values

4. **The level of global warming scales primarily with the cumulative emissions of CO_2 over the past, present, and future.** Much of the emitted CO_2 remains in the atmosphere for a long time (a century for 30-50% of the CO_2 emissions, and longer than one thousand years for 15-40% of the CO_2 emissions)[2]. Thus, a large fraction of global warming from CO_2 emissions is irreversible on multi-century time scales unless CO_2 is actively removed from the atmosphere. Because of the long lifetime of CO_2, the level of global warming today is proportional to the cumulative emissions of CO_2 from past and present emissions, regardless of when or where they were emitted. Likewise, additional global warming this century and beyond will depend on the total amount of CO_2 emissions that will be emitted to the atmosphere by human activities between now and 2100 and beyond, regardless of when it will be emitted. Stopping further CO_2 emissions will stop further global warming, and therefore limit risks associated with climate change, but it will not reverse global warming to date. N_2O and F-gases have a long lifetime like CO_2 and therefore warming from these gases is also persistent over centuries and beyond, although their contribution to global warming is much smaller than that of CO_2.

5. **The level of global warming is also influenced by annual methane emissions.** In contrast to CO_2 emissions, methane emissions remain in the atmosphere only around 12 years. This means that if methane emissions were to decrease, the associated global warming would decrease within a few years. Hence the level of global warming caused by methane emissions is related to annual emissions of this gas, rather than to the cumulative emissions as in the case of CO_2. Global warming from methane emissions is thus reversible if methane emissions cease. This property makes the reduction of methane emissions an attractive lever to reduce the level of global warming, although

reductions in methane emissions do not lead by themselves to the stabilisation of world temperatures, which are dependent on cumulative emissions of CO_2 and other long-lived GHG.

6. **Global CO_2 emissions need to reach "Net Zero" to limit further global warming, alongside decreases in total GHG emissions.** Stabilising the climate requires that emissions from CO_2 become Net Zero. This means that CO_2 emissions need to decrease as much as possible, and any residual emissions that cannot be entirely stopped need to be compensated by actively removing CO_2 from the atmosphere (called carbon dioxide "removals"; CDRs). Removals can be done by carefully managing land, for example to achieve more reforestation or afforestation (planting new forests) than deforestation. Additional warming can also be limited by reducing the level of annual methane emissions. Emissions of N_2O and F-gases, which have a long lifetime, also need to be brought down to zero or compensated by removals.

7. **Achieving Net Zero CO_2 cannot rely mainly or even substantially on the deployment of removals based on technology, because of unproven scalability, energy penalties, and costs.** In addition to land-based removals, removals can also, in small quantities, be achieved with technologies based on Carbon Capture and Storage (CCS), but the scalability of technology-based removals is unproven. There are mainly two types of removals using CCS: Bio-Energy with CCS (BECCS) and Direct Air capture with CCS (DACCS). BECCS competes with other uses of land, in particular food production, and therefore its expansion can only be limited. DACCS is particularly energy-intensive and practically inexistent today, and therefore cannot be a substantial solution by mid-century. The use of CCS by itself can help reduce the emissions from some economic sectors (industry and energy in particular), but CCS requires additional energy and does not capture all of the CO_2 emitted, and therefore it cannot, by itself, bring emissions down to zero. The potential for technology-based removals is further limited by the risks of failures or leakages, by the high costs associated with the development and use of these technologies, and by the lack of a monitoring framework and suitable governance. Therefore, achieving Net Zero cannot rely mainly or even substantially on the deployment of such technologies.

8. **Rapid, deep, and widespread cuts in global GHG emissions are needed to limit global warming to well below 2°C above pre-industrial levels and as close as possible to 1.5°C, the aim of the Paris Agreement.** According to the IPCC's 6th Assessment report, limiting climate change to 1.5°C above pre-industrial levels would require a reduction of total GHG by -43% in 2030 compared to their 2019 levels, while

limiting climate change well below 2°C requires a reduction of -21% in the same time horizon (Table 2). Emissions scenarios that limit global warming "well below 2°C" have a peak global warming of 1.7°C (median value across scenarios) and a 67% probability of limiting global warming to 2°C. The emissions would need to continue to decrease afterwards, until CO_2 emissions reach Net Zero around 2050 (for 1.5°C) and around 2070 (for well below 2°C). Net Zero total GHG would also need to be achieved around 2085 if global warming is to be kept to 1.5°C above pre-industrial levels. Note that additional removals, beyond those needed to limit further global warming, could work to reduce the level of warming slightly this century. Estimates of plausible reduced warming after an overshoot (i.e. temporary exceedance of a specified global warming level, followed by a decline to or below that level) are typically in the order of 0.1-0.2°C. They are highly uncertain, likely costly, and could incur additional risks.

9. **Considering implemented climate policies only (not including implementation of Nationally-Determined Contributions (NDCs) under the Paris Agreement that are not yet in law) warming levels of around 3°C could be reached at the end of this century according to the extensive analysis of the IPCC 6th Assessment report[3].** Considering also current NDCs for 2030, including conditional contributions, would still lead to global warming exceeding the "well below 2°C" trajectory (Figure 1). The UNEP Emissions Gap Report of 2023[4] shows that even if NDCs were fully implemented, associated policies would lead to warming of 2.5°C to 2.9°C. The UNEP Production Gap Report of 2023[5] further shows that the assumption of full implementation is highly questionable, given the inconsistency between NDCs and government plans and projection pathways, which would lead to global production levels of 460%, 29% and 82% higher for coal, oil and gas, respectively, than production levels consistent with limiting warming to 1.5°C above pre-industrial levels. Thus, there is a need to strengthen both existing policies and actions, and existing commitments in the short and long term in order to limit the worse impacts of climate change.

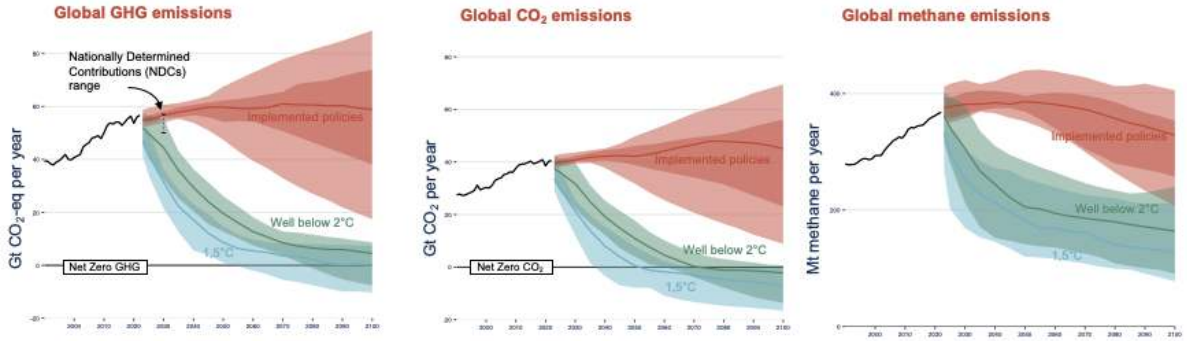
Table 2: Timelines for change in CO_2 and GHG emissions corresponding to current policies and needed for limiting global warming to well below 2°C and as close as possible to 1.5°C.

	Change in global GHG emissions in 2030 (from 2019)	**Year of Net Zero**	
		CO_2	**GHG**
Implemented policies	no change projected		
2°C	−21%	2070	not essential
1.5°C	−43%	2050	2085

Source: IPCC Synthesis Report Summary for policymakers (2023)

10. **Despite the urgent need to decrease global emissions of GHG, they have continued to rise in the past decade, albeit more slowly than in the previous decade.** CO_2 emissions from fossil fuel use, the largest source of GHG emissions, have continued to rise in the past decade (2013-2022) by 0.5% per year on average. This growth is slower than the 2.5% per year growth observed in the decade before this (2003-2012), with the slowdown explained by climate and energy policies worldwide. CO_2 emissions from the use of land show a small but uncertain decline in the past two decades, with a slight decrease in emissions from deforestation and stable or slightly increasing removals from reforestation and afforestation (new forests). Growth in total CO_2 emissions from fossil and land use combined has substantially slowed in the past decade, but CO_2 emissions are still increasing by 0.2% per year on average (see Figure 1). Methane emissions are growing steeply, by 0.9% per year on average over the past decade, but with large uncertainties. With all three gases combined, global GHG emissions have continued to grow over the past decade, by 0.6% per year on average. These trends are not aligned with limiting warming well below 2°C or to 1.5°C above pre-industrial levels, which require emissions of CO_2 and methane to decrease rapidly.

Figure 1: Emissions trajectories consistent with limiting warming to well below 2°C and as close as possible to 1.5°C, compared to trajectories with implemented policies.



Source: Scenarios from the IPCC Synthesis Report Summary for policymakers (2023)[3]; data for 1990 to 2022 are from Jones et al. (2023) based on the Global Carbon Budget 2023[6] and PRIMAP-hist[7].

Global warming from global GHG emissions

11. **Global warming from human activities reached 1.15°C in the past decade (2013-2022) and can be attributed to historical emissions of specific GHGs.** Emissions from CO_2, methane and N_2O generated global warming of 1.16°C, 0.42°C, and 0.08°C above pre-industrial levels, respectively, for a total warming contribution from GHG during 1851-2022 of 1.66°C. The warming from GHG was partly offset by cooling of 0.5°C mainly from pollution by aerosols.[8] Thus, for the contribution to global warming from GHG gases, CO_2,

methane and N_2O accounted for 70%, 25% and 5%, respectively, whereas the contribution from F-gases remained negligible. Emissions from fossil fuel and land uses were responsible for 65% and 35% of global warming caused by human activities during 1851-2022, respectively. For the shorter 1990-2022 and 2013-2022 periods, GHG emissions from fossil fuel use accounted for a larger (and growing) proportion of the additional global warming induced by human activities, with 80% and 83%, respectively.

12. **Global warming caused by human activities has steadily grown each decade in spite of growing knowledge on the impacts and risks of climate change.** GHG emissions from human activities caused 0.1°C of global warming in the 1950s, rising to 0.24°C in the 2010s (Figure 2). Each decade has been substantially warmer than the previous one since 1960 as a result of human-induced global warming from GHG emissions. Individual years can be slightly warmer or cooler from the superposed natural variations that modulate annual temperatures.

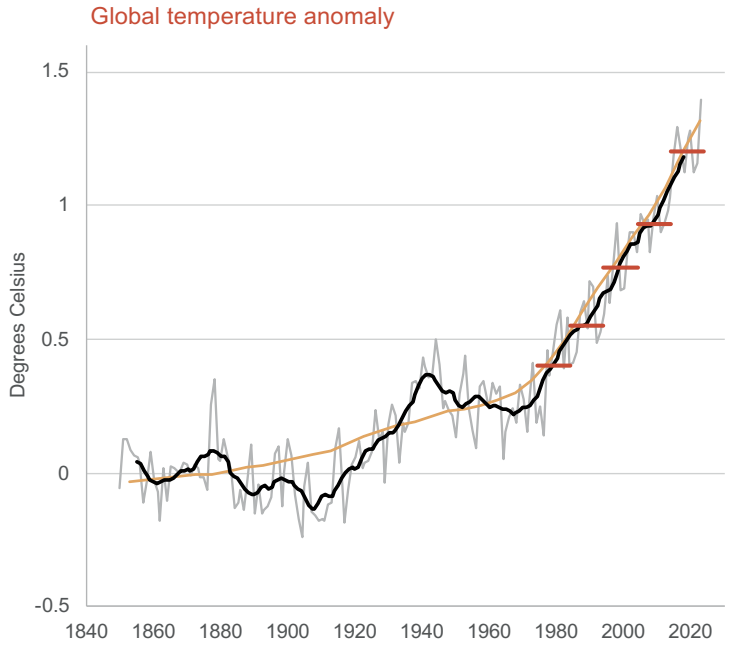


Figure 2: Observed global temperature change from the pre-industrial period (1850-1900), with the contribution of global warming due to human activities (in yellow).

Source: HadCRUT5 for the observations (grey for annual, black for 10-year running average, red for decadal averages); Forster et al (2023) for the human contribution (yellow; average of three estimates)

Reporting of country and regional GHG emissions

13. **GHG emissions are based on self-report by each State with sufficient confidence level to establish the country's contributions to climate change.** Reporting of GHG emissions, and the underpinning energy and land use data, has taken place for decades. For energy-related emissions, reporting is generally a function of reported energy use, multiplied by emissions per unit of energy use at the level of the fuel type and activity. As

for energy, process emissions (e.g. from cement production) are also a function of reported production multiplied by an emissions factor. For land-related emissions, reporting is generally a function of the activity level (e.g. for agriculture and forest management) or of the changes in land-uses (e.g. for deforestation), and can be integrated in time to consider lags associated with decay or regrowth of vegetation and wood products. Emissions from energy-related uses are typically more reliable than emissions from land-related uses because the latter involve biological processes that are more difficult to monitor. Emissions related to products and services produced in another country, so-called “consumption-emissions”, can also be estimated based on economic databases that follow the input and output within countries. Consumption-based methodologies have higher uncertainties than the standard “territorial-based” emissions, but they provide an approximate estimate of the country’s reliance on others. International bunker fuels from international aviation and shipping are not included in countries emissions according to the UNFCCC methodologies, although there are country-based estimates (for example from the International Energy Agency). Bunker fuels represent 3% of global emissions.

14. **The UNFCCC oversees and verifies the application of reporting procedures of GHG emissions by countries, and increasingly their plans and actions.** Until 2023, only reporting for States listed in Annex I of the UNFCCC was required, with verification done at a technical level by the UNFCCC. Annex I countries are industrialised countries and economies in transition (including countries from the Former Soviet Union). Annex I countries submit a GHG inventory every year, and an evaluation of progress every two years. UNFCCC teams visit countries to verify their reporting and governance practices. From 2024, the UNFCCC reporting process will be reinforced to apply to all countries, and to verify that actions are taken place to meet the set objectives. The UNFCCC also details methodological updates based on IPCC reports, including for the relative effects of different GHGs on global warming. The UNFCCC processes are reinforced in countries where independent climate councils exist. Because of the processes and the scrutiny in place, GHG emissions reported by countries are generally the most reliable source of data on GHG emissions and their evolution through time.

15. **GHG emissions by countries are also reported by international institutions, with regular updates.** Several international institutions have developed the capacity to keep track of global, regional, and national emissions inventory. The International Energy Agency reports CO_2 emissions from fossil energy use by all top emitters. Research organisations have developed the capacity to report emissions by country (beyond those

that report to the UNFCCC), building on methodologies developed by the IPCC and country reports for energy and land uses. These include the Global Carbon Budget[6], the Global Methane Budget[9], and the Global N_2O Budget[10] by the Global Carbon Project, the Indicators of Global Climate Change[1] published for the first time in 2023, and PRIMAP-hist[7]. The report here uses the latest available emissions and their contribution to warming estimated consistently with the latest IPCC findings as described in Jones et al (2023)[8], and updated to include emissions data for year 2022[6,7]. CO_2 emissions from the uses of land are based on IPCC methodologies and differ from the country reports to UNFCCC[11] (see methods).

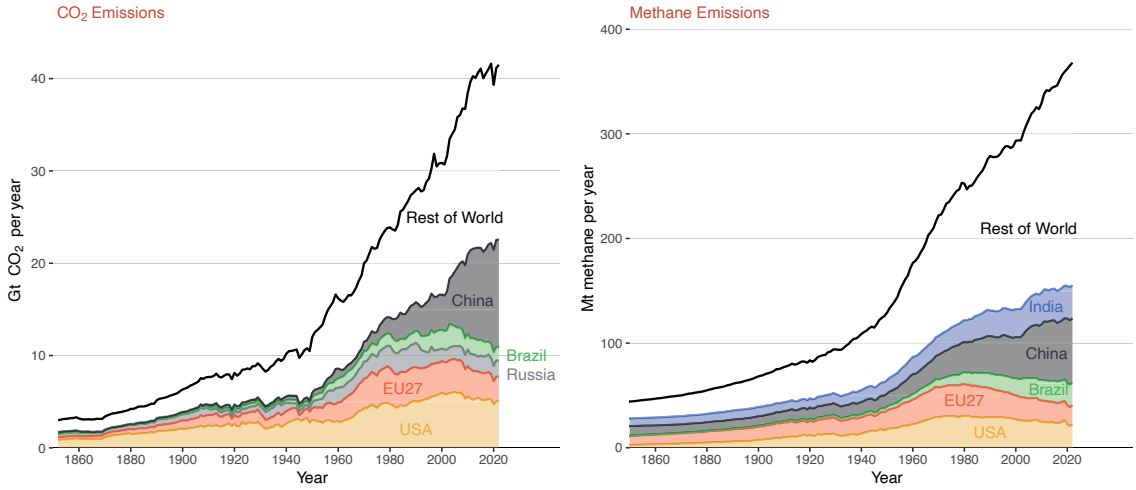
16. **Independent monitoring of countries' GHG emissions with earth observations provides complementary information.** Earth observations of GHG levels or associated indicators, either from surface data (e.g. Mauna Loa station) or from satellite data (e.g. the OCO-2 sensor), provide additional information that help attribute regionally the growth in global GHG levels. Earth observations provide complementary information that indicate more precisely where emissions come from, for example around cities or large industries. Earth observations measure the concentration of GHG in the atmosphere, which result from the combination of emissions from human activities and natural processes. The emissions from human activities can then be inferred, but the uncertainties are higher than emissions estimated using energy and land use data reported by States.

Country and regional GHG emissions and trends

17. **Cumulative CO_2 emissions, the main cause of human-induced climate change, has clear origin in historical use of fossil fuels and land by countries.** The largest contributors to cumulative emissions of CO_2 during 1851-2022 were the USA (20.5%), whose emissions peaked around 2005; the EU27 (11.7%), with emissions decreasing since the early 1980s; China (11.7%), with most of its emissions occurring since 2000; Russia (7.0%); and Brazil (4.6%) (see Figure 3). All 42 industrial countries of the Annex I in aggregate account for 52% of cumulative CO_2 emissions, while all 47 Least Developed Countries (LDCs) in aggregate contributed 4.5%. As a result of the long-term trends in emissions by countries, the patterns have shifted in recent decades. The largest contributors to cumulative emissions of CO_2 during 1990-2022 were China (19.4%), the USA (15.5%), the EU27 (9.3%), Brazil (5.1%), and Russia (4.8%). Globally, land use contributed 31% and fossil fuel use 69% to cumulative CO_2 emissions during 1851-2022. Land use emissions were the dominant source of global CO_2 emissions globally until the 1950s.

18. **Annual methane emissions, the second largest cause of human-induced climate change after cumulative emissions of CO_2, is from current use of fossil fuels and land by countries.** The largest contributors to annual methane emissions averaged over the past decade (2013-2022) were China (16.6%), India (8.7%), the USA (6.7%), Brazil (5.8%), and the EU27 (5.4%). All 42 industrial countries of the Annex I in aggregate account for 22.4% of annual methane emissions, while all 47 Least Developed Countries (LDCs) in aggregate contributed 10.6%.

Figure 3: Annual emissions for CO_2 and methane for the top five emitters for the period 1851-2022.



19. **Annual CO_2 emissions from fossil fuel use have peaked and decreased in 26 countries over the past decade (2013-2022), while their economies grew.** These are: Belgium, Brazil, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, Israel, Italy, Jamaica, Japan, Luxembourg, the Netherlands, Norway, Portugal, Romania, Slovenia, South Africa, Sweden, Switzerland, the United Kingdom, the USA, and Zimbabwe, as well as the EU27 in aggregate.[6] The decreasing trends in fossil fuel CO_2 emissions have been attributed to climate and energy policies in many of those countries, associated with decreases in energy use and with renewable energy progressively replacing fossil energy.[3] The annual rate of decrease in fossil fuel CO_2 emissions has consistently reached 3-4% per year in the United Kingdom, Denmark, and Finland. In contrast, most countries where emissions did not decrease saw renewable energy use increasing alongside fossil energy use, not replacing it. [12]

20. **Annual CO_2 emissions from fossil fuel use continue to rise or decrease only slowly in many industrialised countries of UNFCCC Annex I**. These include Australia,

Slovakia, Austria, New Zealand and Canada, whose fossil fuel CO_2 emissions decrease in the past decade but not significantly, and Poland, Russia and Hungary, whose emissions continue to rise. Fossil fuel CO_2 emissions also grow strongly in many emerging economies, including in Southeast Asia, including Indonesia, the Philippines, and Viet Nam, the most populous countries.

21. **Growth in annual CO_2 emissions from fossil fuel use has slowed in many emerging economies, but emissions continue to grow.** This includes China, whose emissions grew by 1.8% per year during the past decade compared to 7.9% per year during the decade before this. Likewise for India, emissions grew 3.3% per year in the past decade compared to 6.7% per year during the decade before this.

22. **Annual CO_2 emissions from land use remain high, pushed up by deforestation.** The biggest emitters of CO_2 from land use are Brazil, Indonesia, and the Democratic Republic of the Congo, which together account for 56% of land use CO_2 emissions of the past decade. The trends in country's CO_2 emissions from deforestation are difficult to quantify on an annual basis because of lags in decay and regrowth associated with biological processes. Several countries see a small net sink of CO_2 from land use. This means that their management actions in the land sector lead to more absorption of CO_2 than emissions, which generally occurs in regions where there has been historical abandonment of agriculture followed by reforestation and afforestation. Some of these trends have flattened in the past decade. Those sinks are fragile as they depend on the health of the ecosystems, which are affected by climate change.

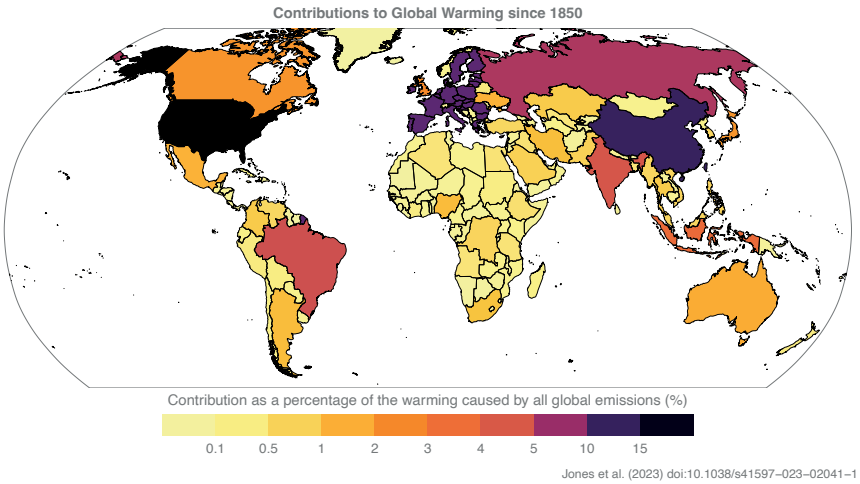
23. **The growth patterns in annual methane emissions tend to follow the growth patterns observed for annual CO_2 emissions in the past decade mentioned above.**

Country and regional contributions to global warming

24. **The warming that occurred so far can be attributed to countries based on their historical emissions of GHG.** Using the emissions of different GHG by country that are available annually since 1850, it is possible to estimate the contribution of each country to observed global warming by considering the different lifetime of specific GHG (CO_2, methane and N_2O), and accounting for the influence of each of these GHG on global temperatures (Figure 4; see Methods). The warming attribution to countries can be done separately for different periods (for example 1851-2022 or 1990-2022) by considering only the country's emissions during these periods. The warming attribution can also be done

for the total warming, for the warming due to fossil fuel and land use emissions separately, and for the warming due to different GHG.

Figure 4: Contributions to global warming caused by GHG emissions from human activities during 1851-2022 per country or region (for the EU27).



25. **The top 10 contributors to global warming from historical emissions of GHG during 1851-2022 are the USA (responsible for 17.0% of the global warming in 2022 due to their historical GHG emissions; 0.28°C), China (12.5%; 0.21°C), the EU27 (10.3%; 0.17°C, including Germany 2.9%, France 1.3%, Poland 1.0% and Italy 0.9%), Russia (6.3%; 0.11°C), Brazil (4.9%; 0.081°C), India (4.7%; 0.078°C), Indonesia (3.7%; 0.061°C), the United Kingdom (2.4%; 0.040°C), Canada (2.1%; 0.035°C), and Japan (2.1%; 0.035°C).** The GHG emissions from these contributors, together with those from Australia (1.5%; 0.025°C), Mexico (1.4%; 0.023°C), Ukraine (1.4%; 0.022°C), Nigeria (1.2%; 0.019°C), Argentina (1.2%; 0.019°C), and Iran (1.1%; 0.019°C), amount to three quarters of the global warming due to GHG emissions during 1851-2022 (Table 3). Of those countries, most of their contributions to global warming originate from fossil fuel sources, except for Brazil, Indonesia, Australia, and Argentina where emissions from land uses, including agriculture and forestry, account for more than half of the attributed global warming. Emissions from bunkers (international shipping and aviation) are also important and are entirely from fossil fuels. All 42 industrial countries of the Annex I in aggregate account for 45% (0.74°C) of global warming due to historical GHG emissions (1.66°C), while all 47 Least Developed Countries (LDCs) in aggregate contributed 6% (0.10°C). Although the exact country contributions may vary a little based on the data sources, especially for emissions related to land use, the dominant patterns are robust.

26. **The same countries figure among the largest contributors to global warming from emissions of GHG during the shorter 1990-2022, with China the largest contributor in that period (see Annex A).** The dominance of emissions from fossil fuels has further strengthened over the recent time period, while CO_2 sinks on managed land by a few countries make a small contribution to reducing the rate of global warming (see Annex A).

Table 3. Largest contributors to global warming from GHG emissions during 1851-2022, with the fraction due to emissions from fossil fuels and from land use.

Rank	Country	Warming contribution (°C)	Percent of global warming	Cumulative percent	Fossil fraction	Land fraction
1	USA	0.282	17.0%	17.0%		
2	China	0.208	12.5%	29.5%		
3	EU27	0.170	10.3%	39.8%		
4	Russia	0.105	6.3%	46.1%		
5	Brazil	0.082	4.9%	51.0%		
6	India	0.078	4.7%	55.7%		
7	Indonesia	0.061	3.7%	59.4%		
	Germany	0.047	2.9%			
8	United Kingdom	0.040	2.4%	61.8%		
9	Canada	0.035	2.1%	63.9%		
10	Japan	0.035	2.1%	66.0%		
11	Australia	0.025	1.5%	67.5%		
12	Mexico	0.023	1.4%	68.9%		
13	Ukraine	0.023	1.4%	70.2%		
	France	0.022	1.3%			
	Bunkers	0.020	1.2%	71.4%		
14	Nigeria	0.019	1.2%	72.6%		
15	Argentina	0.019	1.2%	73.7%		
16	Iran	0.019	1.1%	74.9%		
	Poland	0.017	1.0%			
17	South Africa	0.017	1.0%	75.9%		
18	Kazakhstan	0.014	0.87%	76.8%		
19	Thailand	0.014	0.87%	77.6%		
	Italy	0.014	0.87%			
20	Colombia	0.014	0.87%	78.5%		

Principles and limits to country attribution

27. **The attribution of GHG emissions and associated global warming can be done within set principles and limits.** Available emissions data provide a strong and coherent basis for assessing country's contributions to global warming using known correspondence between emissions and observed warming. Attribution estimates can be done from 1851 or from any year chosen as start year. Emissions reported by the countries themselves are generally the most reliable source of information and will be increasingly scrutinised by the UNFCCC. Improvements in methodology for emissions accounting takes place continuously, and attention is particularly needed to improve the estimates of emissions from land uses which use different conventions from those of the IPCC[11].

28. **The attribution of global warming at the country level should be made on the basis of their GHG emissions, as is done here**, excluding the cooling effect of aerosols and other pollutants which currently masks part of the warming due to GHG. Aerosols and other pollutants should be reduced to improve air and water quality, and to respect national and international laws on pollution, irrespective of climate objectives. Coordinated policies and actions would avoid pernicious incentives and ensure maximum synergies between climate and air quality policies. Methodologies to estimate country contributions to global warming based on GHG emissions are updated regularly to incorporate the latest data and understanding.

Methods and Data

The method used here is described in Jones et al. (2023)[5] and is consistent with the latest finding of the IPCC. The warming from CO_2 emissions is calculated as a product of the transient response to cumulative emissions (TCRE) of CO_2 assessed by the IPCC at 1.65 °C per 1000 Pg C emitted, with a likely range 1.0–2.3 °C per 1000 Pg C. The warming from N_2O is calculated as for CO_2 but after converting N_2O emissions into equivalent-CO_2 emissions using a global warming potential (GWP) over a time horizon of 100 years reported in the IPCC AR6. The warming from methane is calculated based on the conversion of methane emissions to equivalent- CO_2 emissions using GWP* which takes into account the short lifetime of methane compared to CO_2, and then converting to warming using the TCRE. The contribution of F-gases to warming is neglected in this analysis.

Data sources: CO_2 emissions are from the Global Carbon Budget 2023[6]. Fossil CO_2 emissions are based on country reports to the UNFCCC when they exist, or derived largely from UN energy databases when not, extended to 2022 based on energy growth reported by the Energy Institute. Historical data prior to 1990 and UNFCCC reporting are predominantly derived from the Carbon Dioxide Information Analysis Center (CDIAC). Land CO_2 emissions are based on three bookkeeping method that keep track of reported land-use change and activities, mainly with data from the FAO extrapolated to 2022. These will differ from emissions reported by countries because of differences in scope and in data sources[11]. Methane and N_2O emissions are from the PRIMAP-hist database, which prioritises data reported by countries to the UNFCCC with a preliminary assessment for year 2022.

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Annex A: Largest contributors to global warming from GHG emissions during 1990-2022, with the fraction due to emissions from fossil fuels and from land use

Rank	Country	Warming contribution (°C)	Percent of global warming	Cumulative percent	Fossil fraction	Land fraction
1	China	0.140	20.5%	20.5%		
2	USA	0.080	11.7%	32.2%		
3	EU27	0.043	6.3%	38.5%		
4	Brazil	0.040	5.8%	44.3%		
5	India	0.039	5.7%	50.0%		
6	Indonesia	0.030	4.4%	54.3%		
7	Russia	0.026	3.8%	58.1%		
8	Japan	0.017	2.4%	60.6%		
	Bunkers	0.013	1.9%	62.5%		
9	Canada	0.012	1.8%	64.3%		
10	Iran	0.012	1.7%	66.0%		
11	Mexico	0.012	1.7%	67.7%		
12	Saudi Arabia	0.009	1.4%	69.1%		
	Germany	0.009	1.4%			
13	South Africa	0.008	1.2%	70.3%		
14	Australia	0.008	1.2%	71.4%		
15	South Korea	0.008	1.2%	72.6%		
16	Pakistan	0.008	1.1%	73.7%		
17	Nigeria	0.007	1.1%	74.8%		
18	Democratic Repub	0.007	1.0%	75.8%		
19	Türkiye	0.006	0.9%	76.7%		
20	Malaysia	0.006	0.91%	77.6%		

Annex B: Country contributions to global warming (excel spreadsheet)

Annex B.1

Annex to report by Corinne Le Quéré, "Attribution of observed global warming to countries", 2023.
Last revised on 22 December 2023

Data source:
All data are updated from Jones et al. (2023) National contributions to climate change due to historical emissions of carbon dioxide, methane, and nitrous oxide since 1850. Scientific Data, 10, 155.
https://www.nature.com/articles/s41597-023-02041-1

Technical note:
The data shows the contributions to global warming from countries or regions due to their greenhouse gases (GHG) emissions during 1851-2022, which are consistent with the latest findings of the IPCC.
Global warming due to GHG emissions was 1.66 Celcius during 1851-2022, and it was partly offset by cooling of 0.5 Celcius mainly from pollution by aerosols.
Full technical details are described in the publication by Jones et al. (2023).
The 27 countries of the European Union (EU27) are considered in aggregate because they report their emissions as a group to the United Nations. Data from each country is also provided.

Region definitions:

Region	Number of countries	Long name and description
ANNEXI	42	United Nations: Parties include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.
OECD	38	Organisation for Economic Co-operation and Development
G7	7 plus EU27	Group of Seven
ANNEXII	23	United Nations: Parties consist of the OECD members of Annex I, but not the EIT Parties.
LMDC	24	Like-minded developing countries
BASIC	4	Brazil, South Africa, India and China
EIT	15	Economies in Transition
LDC	47	Least Developed Countries

Country contributions to warming due to greenhouse gases (GHG) over the period 1851-2022 (including the EU27 in aggregate)

		Contribution to global warming due to GHG (degree Celsius)						Contribution to global warming (percent of global warming due to GHG)	Relative contribution to warming within each country (percent of country warming)				
Country or region	**Rank**	**Total**	**From fossil fuel**	**From land use (LULUCF)**	**From CO2 emissions**	**From methane emissions**	**From N2O emissions**	**Total**	**Fron fossil fuel**	**From land use (LULUCF)**	**Fron CO2 emissions**	**From methane emissions**	**From N2O emissions**
USA	1	0.28250	0.22113	0.06137	0.23677	0.03504	0.01070	17.0%	78.3%	21.7%	83.8%	12.4%	3.8%
China	2	0.20757	0.16998	0.03759	0.13495	0.06339	0.00923	12.5%	81.9%	18.1%	65.0%	30.5%	4.4%
EU27	3	0.17030	0.15316	0.01714	0.13514	0.02385	0.01130	10.3%	89.9%	10.1%	79.4%	14.0%	6.6%
Russia	4	0.10515	0.07270	0.03245	0.08093	0.02029	0.00393	6.3%	69.1%	30.9%	77.0%	19.3%	3.7%
Brazil	5	0.08179	0.01692	0.06488	0.05364	0.02466	0.00350	4.9%	20.7%	79.3%	65.6%	30.1%	4.3%
India	6	0.07779	0.04103	0.03676	0.03731	0.03395	0.00653	4.7%	52.7%	47.3%	48.0%	43.6%	8.4%
Indonesia	7	0.06076	0.01781	0.04295	0.04397	0.01468	0.00211	3.7%	29.3%	70.7%	72.4%	24.2%	3.5%
Germany		0.04747	0.04558	0.00189	0.04140	0.00387	0.00220	2.9%	96.0%	4.0%	87.2%	8.1%	4.6%
United Kingdom	8	0.03987	0.03642	0.00345	0.03511	0.00301	0.00175	2.4%	91.3%	8.7%	88.1%	7.5%	4.4%
Canada	9	0.03480	0.02029	0.01451	0.02784	0.00558	0.00137	2.1%	58.3%	41.7%	80.0%	16.0%	3.9%
Japan	10	0.03459	0.03215	0.00244	0.03195	0.00168	0.00096	2.1%	92.9%	7.1%	92.4%	4.9%	2.8%
Australia	11	0.02495	0.01158	0.01336	0.01452	0.00737	0.00306	1.5%	46.4%	53.6%	58.2%	29.5%	12.3%
Mexico	12	0.02340	0.01528	0.00812	0.01400	0.00768	0.00172	1.4%	65.3%	34.7%	59.8%	32.8%	7.4%
Ukraine	13	0.02256	0.01685	0.00571	0.01789	0.00326	0.00140	1.4%	74.7%	25.3%	79.3%	14.5%	6.2%
France		0.02153	0.02011	0.00142	0.01648	0.00309	0.00196	1.3%	93.4%	6.6%	76.5%	14.4%	9.1%
Bunkers		0.01976	0.01976	0.00000	0.01976	0.00000	0.00000	1.2%	100.0%	0.0%	100.0%	0.0%	0.0%
Nigeria	14	0.01945	0.01182	0.00763	0.00717	0.01156	0.00072	1.2%	60.8%	39.2%	36.9%	59.4%	3.7%
Argentina	15	0.01912	0.00607	0.01305	0.01132	0.00651	0.00129	1.2%	31.7%	68.3%	59.2%	34.0%	6.7%
Iran	16	0.01885	0.01700	0.00185	0.00946	0.00875	0.00064	1.1%	90.2%	9.8%	50.2%	46.4%	3.4%
Poland		0.01698	0.01600	0.00098	0.01246	0.00348	0.00103	1.0%	94.2%	5.8%	73.4%	20.5%	6.1%
South Africa	17	0.01674	0.01313	0.00360	0.01205	0.00395	0.00074	1.0%	78.5%	21.5%	72.0%	23.6%	4.4%
Kazakhstan	18	0.01449	0.00861	0.00588	0.01107	0.00289	0.00053	0.87%	59.4%	40.6%	76.4%	19.9%	3.6%
Thailand	19	0.01449	0.00600	0.00849	0.00896	0.00499	0.00053	0.87%	41.4%	58.6%	61.9%	34.5%	3.7%
Italy		0.01447	0.01312	0.00135	0.01136	0.00221	0.00090	0.87%	90.7%	9.3%	78.5%	15.3%	6.2%
Colombia	20	0.01444	0.00341	0.01103	0.01003	0.00389	0.00052	0.87%	23.6%	76.4%	69.5%	26.9%	3.6%
Saudi Arabia	21	0.01295	0.01281	0.00014	0.00788	0.00490	0.00017	0.78%	98.9%	1.1%	60.9%	37.8%	1.3%
Pakistan	22	0.01254	0.00555	0.00700	0.00338	0.00805	0.00111	0.76%	44.2%	55.8%	26.9%	64.2%	8.9%
Democratic Republic of the Congo	23	0.01157	0.00142	0.01014	0.00920	0.00193	0.00044	0.70%	12.3%	87.7%	79.5%	16.6%	3.8%
Viet Nam	24	0.01126	0.00448	0.00678	0.00633	0.00449	0.00044	0.68%	39.8%	60.2%	56.2%	39.9%	3.9%
Philippines	25	0.01117	0.00313	0.00805	0.00706	0.00380	0.00031	0.67%	28.0%	72.0%	63.2%	34.0%	2.8%
South Korea	26	0.01106	0.01006	0.00100	0.00920	0.00155	0.00030	0.67%	91.0%	9.0%	83.2%	14.0%	2.7%
Malaysia	27	0.01101	0.00520	0.00581	0.00827	0.00248	0.00026	0.66%	47.2%	52.8%	75.1%	22.5%	2.4%
Myanmar	28	0.01074	0.00123	0.00951	0.00651	0.00366	0.00057	0.65%	11.4%	88.6%	60.6%	34.1%	5.3%
Türkiye	29	0.01073	0.00815	0.00258	0.00633	0.00338	0.00102	0.65%	75.9%	24.1%	59.0%	31.5%	9.5%
Venezuela	30	0.01035	0.00584	0.00451	0.00637	0.00366	0.00032	0.62%	56.4%	43.6%	61.6%	35.4%	3.1%
Spain		0.00996	0.00818	0.00178	0.00711	0.00211	0.00074	0.60%	82.1%	17.9%	71.4%	21.2%	7.4%
Ethiopia	31	0.00814	0.00158	0.00656	0.00288	0.00424	0.00103	0.49%	19.4%	80.6%	35.4%	52.0%	12.6%
Iraq	32	0.00769	0.00723	0.00046	0.00231	0.00520	0.00017	0.46%	94.1%	5.9%	30.1%	67.7%	2.2%
Netherlands		0.00758	0.00632	0.00126	0.00580	0.00126	0.00052	0.46%	83.4%	16.6%	76.6%	16.6%	6.9%
Egypt	33	0.00712	0.00582	0.00129	0.00342	0.00324	0.00046	0.43%	81.9%	18.1%	48.0%	45.5%	6.5%
Tanzania	34	0.00701	0.00091	0.00611	0.00426	0.00222	0.00053	0.42%	12.9%	87.1%	60.7%	31.7%	7.6%
Belgium		0.00697	0.00641	0.00056	0.00582	0.00081	0.00034	0.42%	92.0%	8.0%	83.5%	11.6%	4.9%
Bangladesh	35	0.00695	0.00253	0.00442	0.00189	0.00425	0.00080	0.42%	36.4%	63.6%	27.3%	61.2%	11.5%
Angola	36	0.00674	0.00211	0.00464	0.00368	0.00259	0.00047	0.41%	31.2%	68.8%	54.6%	38.4%	7.0%
Algeria	37	0.00671	0.00606	0.00064	0.00254	0.00401	0.00015	0.40%	90.4%	9.6%	37.9%	59.9%	2.3%
Uzbekistan	38	0.00650	0.00491	0.00159	0.00342	0.00278	0.00031	0.39%	75.5%	24.5%	52.6%	42.7%	4.7%
Romania		0.00592	0.00486	0.00106	0.00434	0.00111	0.00047	0.36%	82.1%	17.9%	73.2%	18.7%	8.0%
Czechia		0.00588	0.00609	-0.00020	0.00503	0.00058	0.00027	0.35%	103.5%	-3.5%	85.6%	9.8%	4.6%
Belarus	39	0.00556	0.00271	0.00285	0.00410	0.00067	0.00079	0.34%	48.7%	51.3%	73.7%	12.0%	14.2%
Peru	40	0.00527	0.00171	0.00356	0.00341	0.00162	0.00024	0.32%	32.4%	67.6%	64.7%	30.7%	4.5%
Taiwan	41	0.00521	0.00504	0.00016	0.00433	0.00076	0.00012	0.31%	96.8%	3.2%	83.2%	14.6%	2.3%
New Zealand	42	0.00508	0.00121	0.00387	0.00272	0.00175	0.00061	0.31%	23.8%	76.2%	53.5%	34.4%	12.1%
Côte d'Ivoire	43	0.00488	0.00063	0.00425	0.00418	0.00061	0.00010	0.29%	12.9%	87.1%	85.6%	12.4%	2.0%

Bolivia	44	0.00479	0.00078	0.00401	0.00329	0.00132	0.00018	0.29%	16.2%	83.8%	68.7%	27.6%	3.7%
Sudan	45	0.00464	0.00093	0.00371	0.00153	0.00259	0.00053	0.28%	20.1%	79.9%	32.9%	55.8%	11.3%
United Arab Emirates	46	0.00446	0.00441	0.00005	0.00245	0.00197	0.00003	0.27%	98.9%	1.1%	55.0%	44.2%	0.8%
Madagascar	47	0.00427	0.00037	0.00390	0.00295	0.00103	0.00029	0.26%	8.7%	91.3%	69.1%	24.1%	6.8%
Chile	48	0.00417	0.00229	0.00188	0.00282	0.00117	0.00018	0.25%	55.0%	45.0%	67.7%	28.1%	4.2%
Ecuador	49	0.00398	0.00122	0.00276	0.00279	0.00107	0.00011	0.24%	30.6%	69.4%	70.2%	26.9%	2.9%
Sweden		0.00390	0.00287	0.00103	0.00299	0.00062	0.00029	0.23%	73.6%	26.4%	76.6%	16.0%	7.4%
Qatar	50	0.00389	0.00388	0.00001	0.00104	0.00284	0.00001	0.23%	99.7%	0.3%	26.7%	73.0%	0.3%
North Korea	51	0.00388	0.00311	0.00077	0.00289	0.00083	0.00015	0.23%	80.2%	19.8%	74.6%	21.5%	3.9%
Turkmenistan	52	0.00379	0.00286	0.00093	0.00168	0.00199	0.00012	0.23%	75.5%	24.5%	44.3%	52.5%	3.1%
Finland		0.00374	0.00256	0.00118	0.00238	0.00111	0.00025	0.23%	68.5%	31.5%	63.7%	29.6%	6.7%
Kenya	53	0.00368	0.00117	0.00251	0.00126	0.00207	0.00035	0.22%	31.8%	68.2%	34.1%	56.3%	9.6%
Zambia	54	0.00359	0.00046	0.00313	0.00233	0.00081	0.00044	0.22%	12.8%	87.2%	65.0%	22.7%	12.3%
Paraguay	55	0.00331	0.00023	0.00309	0.00208	0.00105	0.00018	0.20%	6.9%	93.1%	62.7%	31.8%	5.5%
Mongolia	56	0.00319	0.00079	0.00239	0.00193	0.00095	0.00031	0.19%	24.9%	75.1%	60.6%	29.7%	9.6%
Mozambique	57	0.00317	0.00066	0.00251	0.00190	0.00099	0.00028	0.19%	20.9%	79.1%	60.0%	31.1%	8.9%
Kuwait	58	0.00308	0.00306	0.00001	0.00143	0.00163	0.00002	0.19%	99.6%	0.4%	46.6%	52.9%	0.6%
Cuba	59	0.00307	0.00109	0.00198	0.00220	0.00069	0.00018	0.19%	35.5%	64.5%	71.6%	22.5%	5.9%
Greece		0.00306	0.00241	0.00066	0.00219	0.00065	0.00022	0.18%	78.5%	21.5%	71.4%	21.3%	7.3%
Hungary		0.00300	0.00269	0.00031	0.00237	0.00033	0.00031	0.18%	89.7%	10.3%	78.9%	10.9%	10.2%
Austria		0.00299	0.00291	0.00008	0.00228	0.00051	0.00019	0.18%	97.3%	2.7%	76.5%	17.2%	6.3%
Cameroon	60	0.00296	0.00081	0.00214	0.00180	0.00100	0.00016	0.18%	27.5%	72.5%	60.8%	33.9%	5.3%
Denmark		0.00292	0.00208	0.00084	0.00221	0.00045	0.00027	0.18%	71.3%	28.7%	75.5%	15.4%	9.1%
Morocco	61	0.00285	0.00175	0.00110	0.00143	0.00120	0.00022	0.17%	61.5%	38.5%	50.0%	42.1%	7.9%
Norway	62	0.00285	0.00230	0.00055	0.00155	0.00108	0.00021	0.17%	80.9%	19.1%	54.5%	38.0%	7.4%
Uganda	63	0.00281	0.00059	0.00223	0.00144	0.00113	0.00024	0.17%	20.8%	79.2%	51.2%	40.2%	8.6%
South Sudan	64	0.00269	0.00022	0.00248	0.00061	0.00142	0.00066	0.16%	8.0%	92.0%	22.7%	52.7%	24.7%
Libya	65	0.00269	0.00259	0.00010	0.00106	0.00159	0.00004	0.16%	96.3%	3.7%	39.4%	59.0%	1.6%
Chad	66	0.00268	0.00023	0.00245	0.00052	0.00181	0.00035	0.16%	8.5%	91.5%	19.6%	67.5%	12.9%
Guatemala	67	0.00262	0.00066	0.00196	0.00185	0.00068	0.00008	0.16%	25.0%	75.0%	70.7%	26.1%	3.2%
Bulgaria		0.00261	0.00222	0.00039	0.00192	0.00047	0.00022	0.16%	85.0%	15.0%	73.6%	18.2%	8.2%
Cambodia	68	0.00246	0.00029	0.00217	0.00143	0.00093	0.00010	0.15%	12.0%	88.0%	58.0%	37.9%	4.1%
Uruguay	69	0.00233	0.00036	0.00197	0.00088	0.00121	0.00023	0.14%	15.3%	84.7%	37.9%	52.1%	10.0%
Azerbaijan	70	0.00222	0.00172	0.00050	0.00139	0.00074	0.00010	0.13%	77.3%	22.7%	62.5%	33.2%	4.4%
Slovakia		0.00221	0.00208	0.00013	0.00181	0.00029	0.00012	0.13%	94.1%	5.9%	81.6%	13.1%	5.3%
Nicaragua	71	0.00217	0.00019	0.00198	0.00167	0.00043	0.00006	0.13%	8.9%	91.1%	77.1%	20.0%	3.0%
Nepal	72	0.00216	0.00041	0.00175	0.00084	0.00113	0.00019	0.13%	19.2%	80.8%	38.8%	52.5%	8.7%
Oman	73	0.00215	0.00211	0.00005	0.00066	0.00147	0.00002	0.13%	97.7%	2.3%	30.8%	68.4%	0.8%
Guinea	74	0.00207	0.00024	0.00182	0.00125	0.00069	0.00013	0.12%	11.8%	88.2%	60.4%	33.4%	6.2%
Serbia	75	0.00205	0.00158	0.00048	0.00146	0.00042	0.00017	0.12%	76.9%	23.1%	71.3%	20.4%	8.3%
Ghana	76	0.00202	0.00075	0.00127	0.00111	0.00079	0.00013	0.12%	37.0%	63.0%	54.7%	39.0%	6.4%
Portugal		0.00193	0.00156	0.00037	0.00129	0.00050	0.00014	0.12%	80.8%	19.2%	66.6%	26.0%	7.4%
Syria	77	0.00190	0.00152	0.00038	0.00101	0.00078	0.00012	0.11%	80.1%	19.9%	53.1%	40.8%	6.1%
Congo	78	0.00188	0.00075	0.00113	0.00108	0.00074	0.00006	0.11%	40.1%	59.9%	57.7%	39.3%	3.1%
Switzerland	79	0.00179	0.00150	0.00029	0.00143	0.00025	0.00011	0.11%	83.8%	16.2%	79.9%	14.1%	6.0%
Zimbabwe	80	0.00179	0.00065	0.00114	0.00103	0.00058	0.00017	0.11%	36.1%	63.9%	57.7%	32.6%	9.7%
Lithuania	81	0.00177	0.00088	0.00089	0.00137	0.00018	0.00022	0.11%	49.6%	50.4%	77.4%	10.1%	12.5%
Israel	82	0.00170	0.00163	0.00007	0.00114	0.00051	0.00006	0.10%	95.6%	4.4%	66.7%	29.9%	3.4%
Niger	83	0.00169	0.00020	0.00149	0.00062	0.00087	0.00019	0.10%	11.7%	88.3%	36.9%	51.6%	11.5%
Honduras	84	0.00164	0.00031	0.00133	0.00119	0.00038	0.00006	0.09873%	19.0%	81.0%	72.9%	23.5%	3.6%
Sri Lanka	85	0.00161	0.00060	0.00101	0.00096	0.00055	0.00010	0.09708%	37.2%	62.8%	59.4%	34.4%	6.3%
Trinidad and Tobago	86	0.00157	0.00155	0.00003	0.00076	0.00077	0.00005	0.09475%	98.3%	1.7%	48.1%	48.7%	3.3%
Bahrain	87	0.00157	0.00156	0.00000	0.00046	0.00111	0.00000	0.09434%	99.9%	0.1%	29.1%	70.7%	0.2%
Somalia	88	0.00154	0.00028	0.00126	0.00030	0.00101	0.00022	0.09264%	18.0%	82.0%	19.7%	65.9%	14.4%
Laos	89	0.00149	0.00019	0.00130	0.00104	0.00041	0.00005	0.09003%	13.0%	87.0%	69.3%	27.4%	3.3%
Mali	90	0.00149	0.00021	0.00129	0.00029	0.00094	0.00027	0.08997%	13.7%	86.3%	19.1%	62.8%	18.1%
Burkina Faso	91	0.00148	0.00028	0.00120	0.00051	0.00080	0.00017	0.08921%	18.7%	81.3%	34.7%	53.7%	11.6%
Gabon	92	0.00140	0.00080	0.00061	0.00072	0.00067	0.00001	0.08454%	56.9%	43.1%	51.6%	47.5%	0.9%
Dominican Republic	93	0.00139	0.00059	0.00080	0.00082	0.00050	0.00007	0.08361%	42.5%	57.5%	59.0%	36.3%	4.8%

Afghanistan	94	0.00135	0.00035	0.00100	0.00053	0.00069	0.00014	0.08157%	25.9%	74.1%	38.9%	51.1%	10.1%
Singapore	95	0.00127	0.00126	0.00001	0.00099	0.00022	0.00006	0.07657%	99.1%	0.9%	78.3%	17.2%	4.5%
Central African Republic	96	0.00125	0.00007	0.00118	0.00047	0.00053	0.00025	0.07500%	5.3%	94.7%	38.0%	42.3%	19.7%
Tunisia	97	0.00124	0.00084	0.00039	0.00067	0.00048	0.00009	0.07451%	68.3%	31.7%	54.5%	38.6%	6.9%
Papua New Guinea	98	0.00120	0.00024	0.00096	0.00090	0.00019	0.00011	0.07224%	19.7%	80.3%	75.0%	15.6%	9.5%
Panama	99	0.00117	0.00023	0.00094	0.00094	0.00020	0.00004	0.07045%	19.8%	80.2%	80.0%	16.9%	3.1%
Yemen	100	0.00115	0.00088	0.00027	0.00031	0.00074	0.00010	0.06902%	76.6%	23.4%	27.0%	64.2%	8.8%
Costa Rica	101	0.00114	0.00023	0.00091	0.00087	0.00023	0.00005	0.06862%	20.2%	79.8%	76.3%	19.8%	4.0%
Estonia		0.00112	0.00087	0.00025	0.00090	0.00014	0.00007	0.06727%	78.0%	22.0%	80.7%	12.8%	6.5%
Malawi	102	0.00103	0.00021	0.00082	0.00068	0.00028	0.00006	0.06193%	20.4%	79.6%	66.6%	27.5%	5.9%
Ireland		0.00102	0.00102	0.00000	0.00118	-0.00047	0.00031	0.06122%	100.0%	0.0%	116.0%	-46.3%	30.3%
Hong Kong	103	0.00102	0.00101	0.00000	0.00076	0.00024	0.00002	0.06120%	99.7%	0.3%	74.7%	23.7%	1.5%
Croatia		0.00100	0.00071	0.00029	0.00068	0.00022	0.00010	0.06020%	70.8%	29.2%	67.7%	22.2%	10.1%
Moldova	104	0.00097	0.00068	0.00029	0.00081	0.00011	0.00005	0.05856%	70.1%	29.9%	83.6%	10.8%	5.6%
Kyrgyzstan	105	0.00096	0.00051	0.00045	0.00063	0.00027	0.00007	0.05810%	53.2%	46.8%	65.6%	27.6%	6.8%
Senegal	106	0.00095	0.00029	0.00066	0.00036	0.00045	0.00014	0.05718%	30.2%	69.8%	38.3%	47.2%	14.5%
Bosnia and Herzegovina	107	0.00094	0.00060	0.00035	0.00069	0.00021	0.00004	0.05690%	63.4%	36.6%	73.5%	22.7%	3.9%
Latvia		0.00093	0.00051	0.00043	0.00075	0.00009	0.00010	0.05630%	54.4%	45.6%	80.1%	9.6%	10.3%
Sierra Leone	108	0.00093	0.00013	0.00080	0.00070	0.00020	0.00003	0.05599%	13.5%	86.5%	75.1%	21.6%	3.3%
Benin	109	0.00088	0.00021	0.00066	0.00055	0.00028	0.00006	0.05289%	24.3%	75.7%	62.2%	31.3%	6.4%
Haiti	110	0.00077	0.00034	0.00043	0.00029	0.00044	0.00004	0.04643%	44.2%	55.8%	37.3%	57.0%	5.8%
El Salvador	111	0.00069	0.00022	0.00047	0.00046	0.00019	0.00004	0.04138%	32.2%	67.8%	66.5%	27.6%	5.9%
Slovenia		0.00069	0.00053	0.00016	0.00048	0.00017	0.00004	0.04131%	76.6%	23.4%	69.8%	25.0%	5.3%
Botswana	112	0.00067	0.00014	0.00054	0.00029	0.00026	0.00012	0.04065%	20.5%	79.5%	43.2%	38.5%	18.3%
Tajikistan	113	0.00066	0.00031	0.00035	0.00034	0.00027	0.00005	0.04002%	47.1%	52.9%	51.9%	40.1%	8.1%
Liberia	114	0.00066	0.00012	0.00054	0.00055	0.00010	0.00001	0.03992%	17.9%	82.1%	82.9%	15.4%	1.7%
Equatorial Guinea	115	0.00063	0.00052	0.00011	0.00018	0.00045	0.00000	0.03815%	82.1%	17.9%	28.1%	71.8%	0.1%
Guyana	116	0.00063	0.00007	0.00055	0.00053	0.00008	0.00002	0.03770%	11.8%	88.2%	84.2%	12.3%	3.4%
Jordan	117	0.00060	0.00055	0.00005	0.00035	0.00022	0.00003	0.03610%	91.6%	8.4%	58.0%	37.3%	4.7%
Georgia	118	0.00054	0.00044	0.00010	0.00031	0.00015	0.00008	0.03264%	81.5%	18.5%	58.1%	27.4%	14.5%
Lebanon	119	0.00054	0.00051	0.00003	0.00036	0.00016	0.00002	0.03237%	94.1%	5.9%	66.7%	28.9%	4.4%
Namibia	120	0.00051	0.00008	0.00043	0.00011	0.00027	0.00013	0.03071%	15.7%	84.3%	21.9%	52.8%	25.2%
Rwanda	121	0.00050	0.00013	0.00038	0.00029	0.00018	0.00004	0.03039%	25.0%	75.0%	56.9%	35.2%	7.9%
Burundi	122	0.00050	0.00012	0.00039	0.00031	0.00015	0.00004	0.03039%	23.3%	76.7%	61.8%	29.7%	8.5%
Brunei Darussalam	123	0.00050	0.00045	0.00005	0.00022	0.00027	0.00000	0.02984%	90.5%	9.5%	45.2%	54.1%	0.7%
Togo	124	0.00048	0.00019	0.00029	0.00023	0.00022	0.00003	0.02867%	39.6%	60.4%	47.3%	45.4%	7.3%
North Macedonia	125	0.00042	0.00028	0.00014	0.00031	0.00009	0.00003	0.02537%	67.4%	32.6%	72.5%	20.7%	6.8%
Jamaica	126	0.00041	0.00025	0.00016	0.00034	0.00006	0.00002	0.02472%	61.4%	38.6%	82.3%	13.5%	4.2%
Luxembourg		0.00039	0.00036	0.00003	0.00035	0.00003	0.00001	0.02320%	93.5%	6.5%	89.9%	6.5%	3.6%
Albania	127	0.00038	0.00017	0.00020	0.00020	0.00014	0.00004	0.02271%	46.3%	53.7%	53.8%	36.1%	10.0%
Mauritania	128	0.00037	0.00010	0.00027	-0.00003	0.00031	0.00009	0.02236%	27.4%	72.6%	-7.2%	83.9%	23.4%
Armenia	129	0.00036	0.00023	0.00013	0.00025	0.00008	0.00003	0.02155%	63.2%	36.8%	70.3%	21.8%	7.9%
Bhutan	130	0.00035	0.00004	0.00031	0.00030	0.00004	0.00001	0.02097%	10.6%	89.4%	85.8%	12.5%	1.7%
Eritrea	131	0.00030	0.00007	0.00023	0.00005	0.00020	0.00005	0.01821%	24.8%	75.2%	16.8%	67.1%	16.0%
Curaçao	132	0.00026	0.00026	0.00000	0.00026	0.00000	0.00000	0.01587%	100.0%	0.0%	100.0%	0.0%	0.0%
Timor-Leste	133	0.00023	0.00009	0.00015	0.00012	0.00011	0.00001	0.01406%	36.6%	63.4%	50.9%	46.3%	2.8%
Kuwaiti Oil Fires	134	0.00022	0.00022	0.00000	0.00022	0.00000	0.00000	0.01296%	100.0%	0.0%	100.0%	0.0%	0.0%
Lesotho	135	0.00020	0.00007	0.00013	0.00009	0.00008	0.00002	0.01190%	36.5%	63.5%	46.5%	40.9%	12.6%
Guinea-Bissau	136	0.00020	0.00004	0.00016	0.00009	0.00008	0.00002	0.01186%	20.1%	79.9%	48.0%	41.7%	10.3%
Cyprus		0.00019	0.00017	0.00002	0.00014	0.00003	0.00001	0.01135%	89.4%	10.6%	76.2%	18.0%	5.8%
Belize	137	0.00018	0.00002	0.00016	0.00016	0.00002	0.00000	0.01079%	12.5%	87.5%	87.0%	10.8%	2.1%
Iceland	138	0.00018	0.00009	0.00009	0.00013	0.00003	0.00002	0.01060%	50.2%	49.8%	75.2%	16.0%	8.9%
Suriname	139	0.00017	0.00008	0.00009	0.00012	0.00004	0.00001	0.01036%	46.1%	53.9%	70.7%	24.8%	4.5%
Fiji	140	0.00015	0.00004	0.00011	0.00010	0.00004	0.00001	0.00928%	27.5%	72.5%	66.6%	26.3%	7.2%
Montenegro	141	0.00015	0.00007	0.00007	0.00010	0.00004	0.00001	0.00893%	49.9%	50.1%	68.2%	26.2%	5.6%
Gambia	142	0.00012	0.00003	0.00009	0.00006	0.00006	0.00001	0.00752%	24.3%	75.7%	44.6%	47.5%	7.9%
Swaziland	143	0.00012	0.00003	0.00009	0.00005	0.00006	0.00002	0.00743%	23.1%	76.9%	40.0%	47.4%	12.6%
Bahamas	144	0.00010	0.00010	0.00000	0.00008	0.00002	0.00000	0.00600%	95.9%	4.1%	81.2%	15.9%	2.8%
Mauritius	145	0.00009	0.00009	0.00001	0.00006	0.00003	0.00001	0.00564%	93.6%	6.4%	60.4%	31.7%	8.0%

Vanuatu	146	0.00008	0.00001	0.00007	0.00006	0.00002	0.00000	0.00455%	8.8%	91.2%	74.6%	21.4%	4.0%
New Caledonia	147	0.00007	0.00007	0.00000	0.00007	0.00000	0.00000	0.00434%	100.0%	0.0%	100.0%	0.0%	0.0%
Solomon Islands	148	0.00007	0.00001	0.00006	0.00006	0.00001	0.00000	0.00411%	15.9%	84.1%	87.1%	11.7%	1.1%
Djibouti	149	0.00006	0.00004	0.00003	0.00001	0.00005	0.00001	0.00380%	55.8%	44.2%	15.5%	74.5%	10.0%
Malta		0.00006	0.00005	0.00000	0.00005	0.00001	0.00000	0.00335%	97.1%	2.9%	82.7%	14.1%	3.2%
Kosovo	150	0.00005	0.00005	0.00000	0.00005	0.00000	0.00000	0.00331%	100.0%	0.0%	100.0%	0.0%	0.0%
Barbados	151	0.00005	0.00004	0.00000	0.00003	0.00001	0.00000	0.00277%	90.7%	9.3%	73.2%	21.2%	5.6%
Aruba	152	0.00004	0.00004	0.00000	0.00004	0.00000	0.00000	0.00211%	100.0%	0.0%	100.0%	0.0%	0.0%
Macao	153	0.00003	0.00003	0.00000	0.00003	0.00000	0.00000	0.00187%	99.7%	0.3%	83.2%	15.1%	1.7%
Sint Maarten (Dutch part)	154	0.00003	0.00003	0.00000	0.00003	0.00000	0.00000	0.00182%	100.0%	0.0%	100.0%	0.0%	0.0%
Comoros	155	0.00003	0.00002	0.00001	0.00001	0.00002	0.00000	0.00173%	53.4%	46.6%	18.8%	74.7%	6.5%
Samoa	156	0.00003	0.00001	0.00002	0.00002	0.00001	0.00000	0.00158%	21.8%	78.2%	62.7%	32.1%	5.1%
Maldives	157	0.00002	0.00002	0.00000	0.00001	0.00001	0.00000	0.00116%	99.9%	0.1%	66.1%	31.5%	2.5%
Cape Verde	158	0.00002	0.00001	0.00000	0.00001	0.00001	0.00000	0.00108%	72.6%	27.4%	44.4%	45.4%	10.2%
Greenland	159	0.00002	0.00002	0.00000	0.00002	0.00000	0.00000	0.00093%	100.0%	0.0%	100.0%	0.0%	0.0%
French Polynesia	160	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00087%	100.0%	0.0%	100.0%	0.0%	0.0%
Faeroe Islands	161	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00087%	100.0%	0.0%	100.0%	0.0%	0.0%
Antigua and Barbuda	162	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00085%	101.2%	-1.2%	72.1%	21.7%	6.2%
Saint Lucia	163	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00083%	72.5%	27.5%	66.5%	27.8%	5.7%
Bermuda	164	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00081%	100.0%	0.0%	100.0%	0.0%	0.0%
Tonga	165	0.00001	0.00000	0.00001	0.00001	0.00000	0.00000	0.00079%	33.2%	66.8%	59.7%	30.0%	10.2%
Andorra	166	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00077%	73.5%	26.5%	56.9%	31.8%	11.3%
Seychelles	167	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00061%	97.9%	2.1%	66.7%	29.3%	4.0%
Ryukyu Islands	168	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00057%	100.0%	0.0%	100.0%	0.0%	0.0%
Dominica	169	0.00001	0.00000	0.00000	0.00001	0.00000	0.00000	0.00052%	47.8%	52.2%	61.2%	33.2%	5.6%
Sao Tome and Principe	170	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00046%	59.8%	40.2%	56.8%	38.6%	4.6%
Palau	171	0.00001	0.00001	0.00000	0.00000	0.00000	0.00000	0.00046%	92.7%	7.3%	38.9%	33.8%	27.3%
Saint Vincent and the Grenadines	172	0.00001	0.00001	0.00000	0.00000	0.00000	0.00000	0.00044%	73.1%	26.9%	64.9%	29.7%	5.4%
Panama Canal Zone	173	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00040%	100.0%	0.0%	100.0%	0.0%	0.0%
Grenada	174	0.00001	0.00001	0.00000	0.00000	0.00000	0.00000	0.00037%	96.1%	3.9%	60.3%	33.6%	6.1%
Micronesia (Federated States of)	175	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00033%	40.5%	59.5%	57.4%	38.7%	4.0%
Liechtenstein	176	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00025%	81.8%	18.2%	66.4%	24.6%	9.1%
Bonaire, Saint Eustatius and Saba	177	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00022%	100.0%	0.0%	100.0%	0.0%	0.0%
Turks and Caicos Islands	178	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00022%	100.0%	0.0%	83.1%	16.1%	0.8%
Saint Kitts and Nevis	179	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00022%	94.9%	5.1%	76.5%	12.8%	10.7%
British Virgin Islands	180	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00016%	100.0%	0.0%	100.0%	0.0%	0.0%
Cook Islands	181	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00015%	55.2%	44.8%	64.9%	30.1%	5.0%
Nauru	182	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00015%	97.5%	2.5%	92.3%	7.1%	0.6%
Kiribati	183	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00014%	86.1%	13.9%	43.1%	50.4%	6.4%
Pacific Islands (Palau)	184	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00012%	100.0%	0.0%	100.0%	0.0%	0.0%
Saint Pierre and Miquelon	185	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00010%	100.0%	0.0%	100.0%	0.0%	0.0%
Marshall Islands	186	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00010%	100.0%	0.0%	100.0%	0.0%	0.0%
Anguilla	187	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00009%	100.0%	0.0%	100.0%	0.0%	0.0%
Montserrat	188	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00004%	100.0%	0.0%	100.0%	0.0%	0.0%
Christmas Island	189	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00004%	100.0%	0.0%	100.0%	0.0%	0.0%
Tuvalu	190	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00003%	50.6%	49.4%	23.7%	70.8%	5.5%
Niue	191	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00003%	23.9%	76.1%	90.7%	7.1%	2.1%
Wallis and Futuna Islands	192	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002%	100.0%	0.0%	100.0%	0.0%	0.0%
St. Kitts-Nevis-Anguilla	193	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002%	100.0%	0.0%	100.0%	0.0%	0.0%
Saint Helena	194	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001%	100.0%	0.0%	100.0%	0.0%	0.0%
Leeward Islands	195	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000%	100.0%	0.0%	100.0%	0.0%	0.0%
Antarctica	196	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000%	100.0%	0.0%	100.0%	0.0%	0.0%
Occupied Palestinian Territory	197	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000%	0.0%	100.0%	100.0%	0.0%	0.0%

Group contributions to warming due to greenhouse gases (GHG) over the period 1851-2022

	Contribution to global warming due to GHG (degree Celsius)						Contribution to global warming (percent of global warming due to GHG)	Relative contribution to warming within each country (percent of country warming)				
Group	**Total**	**From fossil use**	**From land use (LULUCF)**	**From CO2 emissions**	**From methane emissions**	**From N2O emissions**	**Total**	**Fron fossil fuel**	**From land use (LULUCF)**	**Fron CO2 emissions**	**From methane emissions**	**From N2O emissions**
GLOBAL	1.660	1.083	0.577	1.156	0.421	0.084	100.0%	65.2%	34.8%	69.6%	25.3%	5.0%
NONANNEX	0.893	0.476	0.417	0.534	0.313	0.046	53.8%	53.3%	46.7%	59.8%	35.0%	5.2%
ANNEXI	0.741	0.580	0.161	0.596	0.107	0.037	44.6%	78.3%	21.7%	80.5%	14.5%	5.0%
OECD	0.654	0.513	0.141	0.524	0.096	0.033	39.38%	78.4%	21.6%	80.2%	14.7%	5.1%
G7	0.562	0.463	0.099	0.467	0.069	0.026	33.85%	82.4%	17.6%	83.1%	12.3%	4.6%
ANNEXII	0.555	0.442	0.112	0.455	0.073	0.027	33.40%	79.7%	20.3%	82.0%	13.1%	4.9%
LMDC	0.480	0.312	0.168	0.284	0.171	0.024	28.88%	65.0%	35.0%	59.2%	35.8%	5.0%
BASIC	0.384	0.241	0.143	0.238	0.126	0.020	23.12%	62.8%	37.2%	62.0%	32.8%	5.2%
EIT	0.190	0.138	0.052	0.146	0.034	0.010	11.44%	72.8%	27.2%	76.9%	18.0%	5.1%
LDC	0.102	0.019	0.083	0.052	0.041	0.009	6.13%	18.5%	81.5%	51.1%	39.9%	9.0%

Annex C

INTERNATIONAL HUMAN RIGHTS LAW OBLIGATIONS OF STATES IN RESPECT OF CLIMATE CHANGE
Expert Report by Professor Martin Scheinin, December 2023

I. THE SUBJECT MATTER AND OUTLINE OF THIS EXPERT REPORT

1. On 29 March 2023 the General Assembly, by resolution A/RES/77/276, requested from the International Court of Justice an Advisory Opinion on 'the obligations of States in respect of climate change'. The General Assembly put to this esteemed Court the following questions:

> *(a)* What are the obligations of States under international law to ensure the protection of the climate system and other parts of the environment from anthropogenic emissions of greenhouse gases for States and for present and future generations;
>
> *(b)* What are the legal consequences under these obligations for States where they, by their acts and omissions, have caused significant harm to the climate system and other parts of the environment, with respect to:
>
> > (i) States, including, in particular, small island developing States, which due to their geographical circumstances and level of development, are injured or specially affected by or are particularly vulnerable to the adverse effects of climate change?
> >
> > (ii) Peoples and individuals of the present and future generations affected by the adverse effects of climate change?

2. This Expert Report, written pursuant to a request by the Republic of Vanuatu, will address both questions (a) and (b). Its starting point will be the notion of 'obligations of States under international law' as it appears in question (a), which is a *de lege lata* question that also concerns pertinent international *human rights law* obligations. Therefore, the framework of international human rights treaties, including the two Covenants of 1966,[1] is central for the analysis that follows below. That said, question (b) is formulated using the past tense ('have caused') and its scope depends on historical facts concerning anthropogenic emissions and resulting harms to the climate system and other parts of the environment that may precede the entry into force of the two Covenants in 1976 or of other human rights treaties. The discussion of both questions (a) and (b) therefore needs to be open to the possibility that States may have breached their international human rights obligations *before* 1976 which would require assessing, under question (a) the content of such obligations as

[1] *International Covenant on Economic, Social and Cultural Rights*, 16 December 1966, United Nations, Treaty Series, vol. 993, p. 3; International *Covenant on Civil and Political Rights*, 16 December 1966, United Nations, Treaty Series, vol. 999, p. 171.

stemming from customary international law, the United Nations Charter,[2] and as codified into the Universal Declaration of Human Rights in 1948.[3] While this report will not engage in a detailed comparison of the substantive content of States' human rights obligations before and after their ratification of the Covenants of 1966, it notes the general overlap and consistency between the catalogues of human rights in the Covenants and in the Universal Declaration and adopts the view that the latter should be understood as a reflection of how the scope of international human rights, as enshrined in customary international law and as referred to in the Charter was understood in 1948.

3. This Expert Report will give attention to the issue of '*particular vulnerability*' mentioned in General Assembly's question (b)(i), the references in both question (a) and question (b)(ii) to '*present and future generations*', and the reference in question (b)(iii) also to '*peoples*'. This report will explore how international human rights law can help in operationalizing, within the framework of legally binding norms of international law, the ideas of particular vulnerability, rights of future generations, and rights of States, peoples and individuals.

4. This Expert Report will proceed as follows: After a brief recapitulation of the qualifications and credentials of the author (section II), a presentation will follow in section III of the general contours of States' obligations under international human rights law in respect of the harmful impacts of anthropogenetic emissions that cause the ongoing global phenomenon, generally known as climate change. Section IV is devoted to a discussion on the 2022 Final Views by the Human Rights Committee in the case of *Daniel Billy et al. (Torres Strait Islanders) v. Australia*, whereafter main section V of this Expert Report will follow, addressing pertinent dimensions of the questions posed by the General Assembly to the Court, through a structured analysis of five distinct but interdependent issues of international human rights law. Finally, the author will present his conclusions (section VI) and a declaration of integrity and impartiality (section VII).

II. QUALIFICATIONS AND CREDENTIALS OF THE EXPERT

5. I have a PhD in law (Helsinki 1991) and have since then worked as a full-time academic scholar, mainly in the field of international human rights law. I have served as full-time professor at the University of Helsinki, Finland (1993-1998), at Åbo Akademi University in Turku, Finland (1998-2008), at the European University Institute in Florence, Italy (2008-2020), and currently at the University of Oxford as British Academy Global Professor (2020-2024).

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[2] *Charter of the United Nations*, 24 October 1945, 1 UNTS XVI.

[3] *Universal Declaration of Human Rights*, General Assembly Resolution 217 A(III) of 10 December 1948.

6. A second main strand of my professional career has been related to the practice of international human rights law and, in particular, under human rights treaties with global reach, adopted by the United Nations General Assembly. In 1997-2004 I served as a member of the Human Rights Committee, the treaty body established under the International Covenant on Civil and Political Rights. Parallel to membership of that Committee, I was the Chairperson of the International Law Association's Committee on Human Rights Law and Practice. In 2005-2011 I was the first holder of the mandate of the United Nations Special Rapporteur on the promotion and protection of human rights and fundamental freedoms while countering terrorism, which mandate included review of national counter-terrorism laws and their application, as to their compatibility with international human rights law.

7. During my career, I have served as expert witness in four cases before the Inter-American Court of Human Rights and in one investor-state arbitration case, as co-counsel in a small number of individual cases before the European Court of Human Rights and -- before being in 1996 elected as member of the Human Rights Committee and again from 2015 when ten years had passed since the end of my term on the Committee -- as counsel in individual communications before the Human Rights Committee and other UN human rights treaty bodies. In the case of *Daniel Billy et al. (Torres Strait Islanders) v. Australia*, to be discussed below, I authored an *amicus curiae* brief at the request by the petitioners. In the case of *Ukraine v. Russia* concerning the CSFT and the CERD, currently pending before this esteemed Court, I wrote at the request of Ukraine an Expert Report concerning the relationship between national security and CERD obligations.

III. SUBSTANTIVE HUMAN RIGHTS OBLIGATIONS OF STATES IN RESPECT OF ANTHROPOGENETIC CLIMATE CHANGE

8. As stated in paragraph 2 above, the normative framework provided by the two Covenants of 1966, as complemented by other global and regional human rights treaties, forms a natural basis for addressing, as a question of *de lege lata,* General Assembly's question (a) that pertains to the obligations of States under international law to ensure the protection of the climate system and other parts of the environment from anthropogenic emissions of greenhouse gases for States and for present and future generations. As of 31 July 2023, the International Covenant on Economic, Social and Cultural Rights has been ratified by 171 States and the International Covenant on Civil and Political Rights by 173 States. This near universal ratification pattern is complemented by a wide range of universal and regional human rights treaties, to the effect that all States in the world have through their voluntary treaty ratifications accepted the catalogue of international human rights as legally binding State obligations. Most significantly, 196 States have ratified the Convention on the Rights

of the Child[4] that in substantive scope covers the whole catalogue of human rights and in personal scope a large share of the world's population of today and in the near future when the harmful effects of climate change upon the enjoyment of human rights are still expected to intensify. It is justified to conclude that all States in the world by 2023 have through their voluntary treaty ratifications accepted as international treaty obligations the whole catalogue of human rights enshrined in the Universal Declaration of Human Rights and in customary international law.[5]

9. What follows from the general overlap between current treaty law, the Universal Declaration of Human Rights and customary norms of international human rights law[6] is that irrespective of the treaty ratification patterns of States or the period of time under assessment – at least since 1945-1948 – the *substantive* human rights obligations of different States to ensure the protection of the climate system and other parts of the environment from anthropogenic emissions of greenhouse gases are by and large the same. The catalogue of human rights in the Universal Declaration provides a sound basis for identifying the substantive human rights obligations of all States, affirmed as a matter of law through the adoption of the UN Charter in June 1945 and then receiving their authentic interpretation in the Universal Declaration in 1948. As will be explained soon below, differences between States as to their human rights obligations are by and large *jurisdictional* in nature, relating to the competence of various human rights treaty bodies or courts to examine reports or complaints concerning alleged breaches of substantive obligations. Importantly, they do not affect the ability or duty of the International Court of Justice, holistically and reflecting the principles of the indivisibility and interdependence of all human rights, to address the substantive human rights obligations of all States in the current Advisory Opinion proceedings.

10. Special consideration must, however, be given to the right of all peoples to self-determination, a right that has its basis in a *principle* of international law recognized *inter alia* in the UN Charter and was reaffirmed as a *human right* in the Covenants of 1966. The emergence and progressive evolution of the law of self-determination have

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[4] United Nations, Treaty Series, vol. 1577, p. 3.

[5] The only qualification that is needed in respect of the conclusion made in the last sentence of the paragraph relates to the United States of America that has ratified neither the Covenant on Economic Social and Cultural Rights nor the Convention on the Rights of the Child. As a consequence, its acceptance as treaty obligations of some of economic and social rights is based on other treaties it has ratified, such as certain Conventions of the International Labour Organization and the International Convention on the Elimination of All Forms of Racial Discrimination (United Nations, Treaty Series, vol. 660, p. 195).

[6] For the methodology for and outcome from determining customary norms of international human rights law, see, William A. Schabas, *The Customary International Law of Human Rights*, Oxford University Press 2021. For methodology, see Chapter 3. As to substantive scope, Schabas writes in Chapter 2.F: 'There is today considerable authority for the view that much if not all of the [Universal Declaration of Human Rights] constitutes a codification of customary international law.'

been examined by this esteemed Court in its *Advisory Opinion on the Separation of the Chagos Archipelago*,[7] where the Court characterised the adoption in 1960 of the General Assembly resolution 1514 (XV)[8] as a 'defining moment' that had clarified the content and scope of the customary law right of self-determination,[9] respect for which is an obligation *erga omnes*.[10] The United Nations is based on the sovereign equality of States which form the basis for rights and obligations in inter-State relations.[11]Article 1(2) of the UN Charter establishes as one of the purposes of the United Nations to 'develop friendly relations among nations based on respect for the principle of equal rights and self-determination of peoples'. As a matter of positive treaty law, the Covenants of 1966 further clarified the status of peoples as the beneficiaries of the right of self-determination, consisting of a range of dimensions reflected in paragraphs 1 to 3 of common Article 1 of the Covenants. Peoples are entitled to invoke that right in respect of the State where they live, or in respect of other States or the international community as a whole. Importantly, the Charter then provides a solid legal basis for a State acting as custodian of the right to self-determination and other human rights of its population or any segment of its population that qualifies as a people for purposes of the two Covenants.

11. Many, if not all substantive human rights are affected by climate change. Arbitrary deprivations of life, many forms of cruel, inhuman or degrading treatment, denial of many economic, social and cultural rights including the rights to health, food and work, many new and old forms of discrimination, destruction of people's homes and possessions, and many other adverse impacts will result from ongoing and forecasted changes in the global climate system. Many of such adverse effects are imputable to action or inaction by States, often also constituting a breach of their obligations under international law.

12. However, only a subset of all these adverse human rights impacts of climate change could be adjudicated under human rights treaty law. Ratification patterns by individual States and the scope of the jurisdiction of the respective treaty body or regional human rights court to receive individual or inter-State complaints, as well as a whole range of admissibility requirements under such procedures, including the

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[7] *Legal Consequences of the Separation of the Chagos Archipelago from Mauritius in 1965,* Advisory Opinion, I.C.J. Reports 2019, p. 95.

[8] *Declaration on the Granting of Independence to Colonial Countries and Peoples*, 14 December 1960, A/RES/1514(XV)

[9] *Legal Consequences of the Separation of the Chagos Archipelago from Mauritius in 1965,* Advisory Opinion, I.C.J. Reports 2019, paras. 150, 152, see also 154

[10] *Legal Consequences of the Separation of the Chagos Archipelago from Mauritius in 1965,* Advisory Opinion, I.C.J. Reports 2019, para. 180.

[11] See UN Charter, Art 2(1), (2).

victim requirement[12] and the requirement of exhausting domestic remedies,[13] further narrow down the subset of adjudicated cases. Furthermore, actual victims of the potential human rights violations that could in principle be adjudicated in respect of a specific State, may be unable or unwilling or lack the resources needed for taking their case to international human rights bodies, usually requiring first the exhaustion of domestic remedies.

13. A graphic illustration of the consequences of jurisdictional and related challenges to adjudicating climate change even where a case might be strong as to substantive human rights obligations, relates to the most sacrosanct of all human rights, the right to life. As will be discussed in the following section, individual cases related to climate change and the right to life have by now reached three of the United Nations human rights treaty bodies but in none of these cases has a violation of that right been established. This does not, however, mean that multiple States would not have acted in breach of their international obligations to respect and ensure the right to life of their inhabitants and other members of humankind in respect of GHG emissions and the effects of climate change, thereby violating their obligations under international human rights treaties or customary norms of international human rights law. To illustrate the wide range of well documented situations where climate change has resulted in loss of human lives some examples are listed below. The fact that these, or other, situations have not been adjudicated before human rights bodies does not mean that there would not have been a breach of positive or negative human rights obligations under the right to life, attributable to one or more States.

- For as early as for summer 2003, it has been shown that anthropogenic climate change increased the risk of heat-related mortality in Central *Paris* by~70% and by~20% in *London*, which then experienced lower extreme heat when respectively, 64 deaths were attributable to anthropogenic climate change in London, and 506 in Paris.[14]
- In June–July 2016, extreme rainfalls in the Yangtze–Huai region of *China*, attributed to preceding 2015/16 El Niño conditions with strong anthropogenic factors, resulted in 833 reported deaths.[15]

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[12] See e.g., *Optional Protocol to the International Covenant on Civil and Political Rights* (GA res. 2200A (XXI), adopted 16 December 1966) UNTS, vol. 999, p. 171 (OP-ICCPR), art 1; *Optional Protocol to the Convention on the Rights of the Child on a communications procedure* (GA res. 66/138, adopted 19 December 2011), UNTS, vol. 2983, p. 135, A/RES/66/138 (OP-CRC), art 5(1).

[13] See e.g., OP-ICCPR, art 5(2)(b); OP-CRC, art 7(e).

[14] Daniel Mitchell et al., Attributing Human Mortality During Extreme Heat Waves to Anthropogenic Climate Change 11 ENVTL. RES. LETTERS 1, 1 (2016), https://iopscience.iop.org/article/10.1088/1748-9326/11/7/074006/pdf.

[15] Qiaohong Sun & Chiyuan Mao, Extreme Rainfall (R20mm, Rx5day) In Yangtze– Huai, China, In June–July 2016: The Role Of Enso And Anthropogenic Climate Change, Bulletin of the American Meteorological Society (January 2018), http://www.ametsoc.net/eee/2016/ch20.pdf and https://www.climatesignals.org/events/china-floods-june-july-2016.

- In August 2017, Hurricane Harvey caused unprecedented rainfalls in parts of the *United States* and over 80 reported deaths.[16]
- In September 2017, *Puerto Rico* was hit by Hurricane Maria, resulting in estimated 5 740 excess deaths.[17]
- A July 2018 heatwave in *Japan* that 'would never have happened without human-induced climate change' caused 1032 deaths.[18]
- In June-August 2022, heavy rains and resulting flooding affected over 33 million people in *Pakistan*, destroyed 1.7 million homes, and nearly 1500 people lost their lives, when the maximum rainfalls over the provinces Sindh and Balochistan were about 75% more intense than they would have been had the climate not warmed by 1.2 C.[19]
- In January and February 2022, the storms Ana and Batsirai caused at least 250 documented deaths across *Madagascar, Mozambique, and Malawi,* with greenhouse gas and aerosol emissions shown in part responsible.[20]
- At a more general level, the World Meteorological Organization has reported that between 1970 and 2019 weather, climate and water hazards accounted for more than two million deaths,[21] and that between 2005 and 2015 only, there were 700 000 deaths.[22]

IV. THE CASE OF *DANIEL BILLY ET AL. (TORRES STRAIT ISLANDERS) V. AUSTRALIA* AND ITS SIGNIFICANCE FOR THE ADVISORY OPINION

14. So far, only a narrow subset of internationally wrongful acts that amount to breaches of the *substantive* human rights obligations of States have been adjudicated

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[16] Geert Jan van Oldenborgh, Attribution of extreme rainfall from Hurricane Harvey, August 2017, Environmental Research Letters 12 124009 (2017), https://iopscience.iop.org/article/10.1088/1748-9326/aa9ef2.

[17] WMO Atlas Of Mortality And Economic Losses From Weather, Climate And Water Extremes (1970–2019), World Meteorological Organization WMO-No. 1267 (2021), https://library.wmo.int/doc_num.php?explnum_id=10989, p. 75.

[18] Yukiko Imada et al., The July 2018 High Temperature Event in Japan Could Not Have Happened without Human-Induced Global Warming, SOLA Volume 15A 8-12 (2019), https://www.jstage.jst.go.jp/article/sola/15A/0/15A_15A-002/_pdf/-char/en.

[19] Friederike E. L. Otto, et. al, Climate Change Likely Increased Extreme Monsoon Rainfall, Flooding Highly Vulnerable Communities in Pakistan, World Weather Attribution (Sept. 15, 2022), https://www.worldweatherattribution.org/climate-change-likely-increased-extreme-monsoon-rainfall-flooding-highly-vulnerable-communities-in-pakistan/

[20] Friederike E. L. Otto et al., Climate change increased rainfall associated with tropical cyclones hitting highly vulnerable communities in Madagascar, Mozambique & Malawi, World Weather Attribution (2022), https://www.worldweatherattribution.org/wp-content/uploads/WWA-MMM-TS-scientific-report.pdf.

[21] WMO Atlas Of Mortality And Economic Losses From Weather, Climate And Water Extremes (1970–2019), World Meteorological Organization WMO-No. 1267 (2021), p. 16.

[22] Idem, p. 71.

as actual human rights violations that pass the various *jurisdictional* preconditions for international human rights adjudication and have materialized as human rights violations in respect of identifiable individuals who meet the 'victim' requirement under respective human rights treaties. Before the landmark case of the *Torres Strait Islanders* decided in July 2022 by the Human Rights Committee,[23] it had in 2021 been established by the Committee on the Rights of the Child that now living children may meet *the victim requirement* in respect of a number of States they call into account under international human rights law, even if their petitions were declared inadmissible for other reasons.[24] Importantly, the Committee also adopted the position of the Inter-American Court of Human Rights in its 2017 advisory opinion on the environment and human rights where the Court recognized the extraterritorial reach of states' human rights obligations in the context of *transboundary harm*,[25] and applied it in the context of climate change. While the *Torres Strait Islanders* case engaged only the territorial state, Australia, the *Sacchi* cases retain their relevance concerning the potential scope of extraterritorial human rights obligations in respect of harmful effects of climate change.[26] Furthermore, the Committee applied the principle of *common but differentiated responsibilities* by stating that the 'collective nature of the causation of climate change does not absolve the State party of its individual responsibility that may derive from the harm that the emissions originating within its territory may cause to children, whatever their location'.[27]

15. In 2019, the Human Rights Committee had declared admissible a petition, *Ioane Teitiota v. New Zealand*,[28] alleging a violation of ICCPR Article 6 (i.e., the right to life) if a person was returned to a Kiribati, as he faced '*a real risk of impairment* to his right to life'[29] under ICCPR Article 6 due to the impact of climate change and associated sea level rise on the habitability of Kiribati and on the security situation on the islands. On the merits, however, the Committee concluded that this real risk of impairment had not (yet) amounted to a violation of Article 6 by New Zealand:

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[23] *Daniel Billy et al. v. Australia* (Communication No. 3624/2019) CCPR/C/135/D/3624/2019.

[24] *Chiara Sacchi et. al. v. Argentina, Brazil, France, Germany and Turkey* (Communication Nos. 104-108/2019), CRC/C/88/D/104/2019, CRC/C/88/D/105/2019, CRC/C/88/D/106/2019, CRC/C/88/D/107/2019, CRC/C/88/D/107/2019. The Committee's establishment of the petitioners meeting the victim requirement was formulated as follows: '… the Committee concludes that the authors have sufficiently justified, for the purposes of establishing jurisdiction, that the impairment of their Convention rights as a result of the State party's acts or omissions regarding the carbon emissions originating within its territory was reasonably foreseeable. It also concludes that the authors have established prima facie that they have personally experienced real and significant harm in order to justify their victim status. Consequently, the Committee finds that it is not precluded by article 5 (1) of the Optional Protocol from considering the authors' communication.' (para 10.14 of *Chiara Sacchi et al v. Argentina*).

[25] Inter-American Court of Human Rights, Advisory Opinion OC-23/17 on the environment and human rights. See, in particular, paras. 95-104.

[26] Paras. 10.5 and 10.7 of *Chiara Sacchi et al v. Argentina.*

[27] Para. 10.10.

[28] (Communication No. 2728/2016) CCPR/C/127/D/2728/2016.

[29] Para. 8.6 (emphasis added)

> 9.12 In the present case, the Committee accepts the author's claim that sea level rise is likely to render Kiribati uninhabitable. However, it notes that the time frame of 10 to 15 years, as suggested by the author, could allow for intervening acts by Kiribati, with the assistance of the international community, to take affirmative measures to protect and, where necessary, relocate its population. The Committee notes that the State party's authorities thoroughly examined that issue and found that Kiribati was taking adaptive measures to reduce existing vulnerabilities and build resilience to climate change-related harms. Based on the information made available to it, the Committee is not in a position to conclude that the domestic authorities' assessment that the measures taken by Kiribati would suffice to protect the author's right to life under article 6 of the Covenant was clearly arbitrary or erroneous in that regard, or amounted to a denial of justice.

16. It needs to be noted that the time frame of 10 to 15 years 'as suggested by the author' had been presented in a submission of December 2016. Hence, the Committee's reference to 10 years only extends to the end of 2026 which at the time of writing this Expert Report is *less than three and a half years ahead*. Equally importantly, the question whether returning the petitioner to Kiribati could already at the time of the Committee's assessment in 2019 qualify as a form of inhuman treatment in violation of ICCPR Article 7 was *not* adjudicated in *Teitiota.* This observation begs the question whether a violation of Article 7 may be triggered earlier in time than a violation of Article 6: returning someone to a known and inevitably approaching threat to their life may be an inhuman act earlier than it constitutes an actual violation of the right to life. Following the approach of the Human Rights Committee in the case of the *Torres Strait Islanders* case, my answer to that question is affirmative.

17. The remaining part of this section will focus on several highly significant features of the case of *Daniel Billy et al v. Australia* (the *Torres Strait Islanders* case), decided on the merits by the Human Rights Committee in July 2022. The first one of such features relates exactly to the issue of whether the adverse impacts of climate change upon different human rights may materialize as adjudicable (justiciable within a specific jurisdiction) human rights violations at different points of time. For the first time, the Human Rights Committee established violations of the ICCPR because of the actions or omissions by a State in respect of the harmful impact of climate change. While the right to life claim was, similarly to *Teitiota*, declared admissible but concluded on the merits as a non-violation with reference to a similar 10-15 years' timeframe in which the State party could take action,[30] the Committee held that certain

[30] See, para. 8.7 of the Views in the *Torres Strait Islanders* case (footnote 23) where the reasons for a non-violation of Article 6 were expressed as follows:'… The Committee takes note of the other adaptation and mitigation measures mentioned by the State party. The Committee considers that the time frame

adverse effects upon other human rights had already materialized as human rights violations. The ICCPR provisions established as violated were Articles 17 (right to privacy, home and family life) and 27 (right to enjoy a minority culture). The Committee's differentiation of how States' actions or omissions in respect of climate change causing human rights harm may materialize as human rights violations at different points of time is of immense significance.

18. The second feature of immense significance of the *Torres Straits Islanders* case is the unprecedented and clear identification of indigenous peoples, as individuals and communities, as victims of adverse impacts of climate change, amounting to actual human rights violations by the respondent State – which in this particular case was both a major emitter of GHGs and the territorial State. Building upon its long line of case law related to the right of members of an indigenous people to enjoy their 'own culture' in community with other members of the group, including the practice of their traditional or otherwise typical nature-based forms of economic livelihood, the Committee held (footnotes omitted):

> 8.13 … The Committee also recalls that, in the case of Indigenous Peoples, the enjoyment of culture may relate to a way of life which is closely associated with territory and the use of its resources, including such traditional activities as fishing or hunting. Thus, the protection of this right is directed towards ensuring the survival and continued development of cultural identity. The Committee further recalls that article 27 of the Covenant, interpreted in the light of the United Nations Declaration on the Rights of Indigenous Peoples, enshrines the inalienable right of Indigenous Peoples to enjoy the territories and natural resources that they have traditionally used for their subsistence and cultural identity. Although the rights protected under article 27 are individual rights, they depend in turn on the ability of the minority group to maintain its culture, language or religion.
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> 8.14 The Committee notes the authors' assertion that their ability to maintain their culture has already been impaired by the reduced viability of their islands and the surrounding seas, owing to climate change impacts. The

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of 10 to 15 years, as suggested by the authors, could allow for intervening acts by the State party involving taking affirmative measures to protect and, where necessary, relocate the alleged victims. The Committee also considers that the information provided by the State party indicates that it is taking adaptive measures to reduce existing vulnerabilities and build resilience to climate change-related harms on the islands. Based on the information made available to it, the Committee is not in a position to conclude that the adaptation measures taken by the State party would be insufficient and therefore represent a direct threat to the authors' right to life with dignity.' Notably, also here the timeline of 10-15 years refers to the petitioners' submission which for instance of the islands of Boigu and Masig was 10 years from September 2020 (see, paras. 5.1 and 5.3).

> Committee notes the authors' claim that those impacts have eroded their traditional lands and natural resources that they use for traditional fishing and farming and for cultural ceremonies that can be performed only on the islands. The Committee further notes their claim that the health of their land and the surrounding seas is closely linked to their cultural integrity. The Committee notes that the State party has not refuted the authors' arguments that they could not practice their culture on mainland Australia, where they would not have land that would allow them to maintain their traditional way of life. The Committee considers that the climate impacts mentioned by the authors represent a threat that could have reasonably been foreseen by the State party, as the authors' community members began raising the issue in the 1990s. While noting the completed and ongoing seawall construction on the islands where the authors live, the Committee considers that the delay in initiating these projects indicates an inadequate response by the State party to the threat faced by the authors….

19. But the Human Rights Committee did not stop here by establishing a violation of ICCPR Article 27 on account of simply relying on its earlier case law on Article 27 and indigenous peoples. Instead, as a third important feature of the case, the Committee took the necessary and logical step of identifying as an aspect of 'the right to enjoy one's own culture', the right *to transmit* a culture inherited from earlier generations to new generations, including both those already living and those yet to be born. The closing part of paragraph 8.14 reads (emphasis added):

> … the Committee considers that the information made available to it indicates that the State party's failure to adopt timely adequate adaptation measures to protect *the authors' collective ability to maintain their traditional way of life and to transmit to their children and future generations their culture and traditions and use of land and sea resources* discloses a violation of the State party's positive obligation to protect the authors' right to enjoy their minority culture. Accordingly, the Committee considers that the facts before it *amount to a violation of the authors' rights under article 27 of the Covenant.*

20. The relevance of the *Torres Strait Islanders* case is not limited to the important specific case of indigenous peoples whose traditional lands and resources, as well as enjoyment and transmission to future generations of their distinct culture, are threatened by rising sea levels or other unprecedented changes caused by anthropogenetic climate change. A fourth immensely significant feature of the case is in the Committee's finding concerning violations of the universally applicable provision of ICCPR Article 17, namely that the petitioners' right to privacy, home, or family life had been disrupted and violated through the adverse impacts of climate change. These were not violations of minority rights, but of rights belonging to any member of society. . These violations had already materialized in respect of the Torres

Strait Islander petitioners, in addition to the violation of their Article 27 right to enjoy their own culture. The Committee held as follows (footnote omitted):

> 8.12 … The Committee also notes the authors' specific descriptions of the ways in which their lives have been adversely affected by flooding and inundation of their villages and ancestral burial lands; destruction or withering of their traditional gardens through salinification caused by flooding or seawater ingress; and decline of nutritionally and culturally important marine species and associated coral bleaching and ocean acidification. The Committee further notes the authors' allegations that they experience anxiety and distress owing to erosion that is encroaching on some homes in their communities and that the upkeep and visiting of ancestral graveyards is associated with the very heart of their culture, which requires experiencing feelings of communion with deceased relatives. The Committee notes the authors' statement that their most important cultural ceremonies are meaningful only if performed on native community lands. The Committee considers that when climate change impacts, including environmental degradation on traditional [indigenous] lands in communities where subsistence is highly dependent on available natural resources and where alternative means of subsistence and humanitarian aid are unavailable, have direct repercussions on the right to one's home, and the adverse consequences of those impacts are serious because of their intensity or duration and the physical or mental harm that they cause, the degradation of the environment may then adversely affect the well-being of individuals and constitute foreseeable and serious violations of private and family life and the home. The Committee concludes that the information made available to it indicates that, by failing to discharge its positive obligation to implement adequate adaptation measures to protect the authors' home, private life and family, the State party violated the authors' rights under article 17 of the Covenant.

21. As the case was brought by indigenous Torres Strait Islanders, it is natural that also the factual basis of the Article 17 violation was closely linked to their distinctive indigenous identity. Irrespective of that, the Committee's finding is of more general significance as it opens the possibility that also non-indigenous groups, communities, families or persons may present their own factual and legal arguments concerning their particular vulnerability, in order to substantiate a claim that their Article 17 rights have been violated. Similarly to the Article 27 finding, this aspect of the case demonstrates that climate change related violations of ICCPR Article 17 may materialize much earlier in time than some other human rights violations, such as violations of the right to life.

22. A fifth and final immensely important feature of the Human Rights Committee's Views in the Torres Strait Islanders case relates to the Committee's

pronouncement on the authors' *right to an effective remedy* under Article 2, paragraph 3, of the ICCPR. Here, the way the Committee addressed the legal obligations of the respondent state under the ICCPR is instructive of how international human rights law addresses the *consequences* of states' breaches of their international obligations in the context of climate change. In particular, the Committee held that Australia was required to make 'full reparation' and, inter alia, to 'provide adequate compensation to the authors for the harm that they have suffered, engage in meaningful consultations with the authors' communities in order to conduct needs assessments; continue its implementation of measures necessary to secure the communities' continued safe existence on their respective islands; and monitor and review the effectiveness of the measures implemented and resolve any deficiencies as soon as practicable.' Australia was also under an obligation to 'take steps to prevent similar violations from occurring in the future'[31].

23. Another Human Rights Committee case where a double violation of Articles 17 and 27 was established in respect of members of an indigenous community, is *Benito Oliveira Pereira et al. v. Paraguay* (Communication No. 2552/2015).[32] While the case was not about the adverse human rights impacts of climate change, it nevertheless addressed the State party's obligations in respect of the destruction of the natural environment and livelihoods of the indigenous group, in this case through large-scale fumigation with toxic agrochemicals. The Committee's two findings of violation were formulated as follows:

> 8.4 In the present case, the Committee notes that the State party did not adequately monitor the illegal activities at the source of the contamination, which have been widely documented (para. 2.7), observed by the State party itself (paras. 2.13–2.23) and even acknowledged by both of the accused farm owners (para. 2.21). By inadequately monitoring the activities, the State party failed to prevent the contamination. This failure in its duty to provide protection made it possible for the large-scale, illegal fumigation, including with banned agrochemicals, to continue for many years, not only causing health problems among community members – including children, as the fumigation was carried out mere metres from the school during school hours – but also contaminating the community's waterways, destroying its subsistence crops, killing its livestock and triggering the mass extinction of fish and bees, all basic components of the members' private life, family life and home. The Committee notes that the State party has not provided an alternative explanation to contradict the alleged causal link between the fumigation with agrochemicals and the aforementioned harm. When contamination has direct repercussions on the right to one's privacy, family

[31] Para. 11.
[32] CCPR/C/132/D/2552/2015

life and home, and its consequences are serious, then the degradation of the environment adversely affects the well-being of individuals and constitutes a violation of privacy, family life and the home. Consequently, in the light of the information that it has before it, the Committee concludes that the events at issue in the present case disclose a violation of article 17 of the Covenant.

8.8 In the present case, the Committee notes that the authors and other members of the community exercise the right to enjoy their culture through a way of life that is closely linked with their territory and the use of the natural resources found therein. The Committee also notes that the large-scale fumigation with toxic agrochemicals presents a threat which the State party could reasonably have foreseen. Not only were the competent State authorities notified of the activities and their impact on the community members, but the prosecutor's office found that the acts fully met the definition of the offence (para. 2.23) and the accused themselves acknowledged their liability (para. 2.21). Yet, the State party did not put a stop to the activities, thus allowing the continued contamination of the rivers in which the authors fish, draw their water, bathe and wash their clothing, the further death of their livestock, a source of food, and the ongoing destruction of their crops and the resources in the forest where they forage and hunt. The Committee further notes that the State party has not provided an alternative explanation of what happened or demonstrated having taken any steps whatsoever to protect the right of the authors and other community members to their cultural life. The Committee accordingly finds that the facts before it disclose a violation of article 27 of the Covenant with regard to the Campo Agua'ẽ indigenous community.

V. WHAT ARE THE OBLIGATIONS OF STATES UNDER INTERNATIONAL HUMAN RIGHTS LAW TO ENSURE THE PROTECTION OF THE CLIMATE SYSTEM?

24. Building upon the *Torres Strait Islanders* case and other case law by the UN human rights treaty bodies, this main section of this Expert Report will now move to a discussion of five distinct but interrelated issues of direct relevance for addressing the questions (a) and (b) put to this esteemed Court by the General Assembly. Here, an effort is made to identify some of the most pertinent *substantive* norms of international human rights law that entail obligations of States 'to ensure the protection of the climate system and other parts of the environment from anthropogenic emissions of greenhouse gases' or that govern 'the legal *consequences* under these obligations for States where they, by their acts and omissions, have caused significant harm to the climate system and other parts of the environment', in respect of *peoples and individuals of the present and future generations* affected by the adverse

effects of climate change, including those *injured* or *specially affected by* or *particularly vulnerable to* the adverse effects of climate change. The following discussion seeks to address some of the most pertinent substantive rights in order to assist the esteemed Court in addressing the questions put to it by the General Assembly, in respect of diverse beneficiaries of human rights obligations of States.

Issue 1: The specific case of indigenous peoples and the human rights obligations of States

25. Anthropogenetic emissions of greenhouse gases have caused rapidly escalating changes in the climate system that entail adverse effects upon human rights protected by international law. Many indigenous peoples are, due to the geographical location of their traditional lands and the total dependency of their distinct economies, livelihoods, communities, cultures, and ways of life upon the natural resources and conditions of specific geographic areas, especially vulnerable to such adverse effects. As the *Torres Strait Islanders* case by the Human Rights Committee demonstrates, these adverse effects may materialize as adjudicable human rights violations by identifiable States much earlier than other negative consequences of climate change in respect of members of the dominant population would in the same countries. This is primarily because of the distinct right, enshrined in Article 27 of the ICCPR, of members of ethnic or other minorities, including indigenous peoples, to enjoy their own culture in community of other members of their group, as well as the jurisdictional availability of the right of complaint under the Optional Protocol to the ICCPR to a large proportion of indigenous peoples in the world.[33] As was established in the *Torres Strait Islanders* case, a violation of ICCPR Article 27 occurs when the elders in an indigenous group are because of climate change unable to transmit its distinct culture, based on local natural resources and traditional or otherwise typical forms of livelihood, to new generations.

26. This important conclusion by the Human Rights Committee in the *Torres Strait Islanders* case is not an isolated finding. As the author of this Expert Report demonstrated in an *amicus curiae* brief in that case,[34] that position is based on multiple legal sources and interpretive practice, including General Comment No. 23[35] and case

[33] The ICCPR-OP has been ratified by 116 States which by far exceeds the number of States that have accepted any other international procedure of complaint under human rights treaties.

[34] Amicus Curiae Brief by Professor Martin Scheinin in the Case of 'Daniel Billy et al. (Torres Strait Islanders) v. Australia' by the UN Human Rights Committee, subsequently published as Bonavero Report No. 2/2022 (November 2022).

[35] See, opening phrase of paragraph 6.2 of General Comment No. 23 which affirms protection for 'the ability of the minority group to *maintain* its culture...' (emphasis added) and final paragraph 9 of the same General Comment is clear in that the protection of article 27 rights 'imposes specific obligations on States parties ... directed to *ensur[ing] the survival and continued development* of the cultural, religious and social identity of the minorities concerned' (emphasis added), a formulation that clearly recognizes the intergenerational dimension of the right, even if not employing notions such as 'to transmit' or 'future generations'.

law[36] by the Human Rights Committee itself, the best known and widely accepted *José Martínez Cobo definition* of the notion of indigenous peoples,[37] and ILO Convention No. 169 on Tribal and Indigenous Peoples.[38] These elements of the intergenerational dimension of indigenous people's rights are also reflected in the United Nations Declaration on the Rights of Indigenous Peoples,[39] academic literature,[40] as well as case law under regional human rights treaties.[41]

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[36] See, *Ángela Poma Poma v. Peru* (Communication No. 1457/2006) CCPR/C/95/D/1457/2006*:* '7.3 In previous cases, the Committee has recognized that the rights protected by article 27 include the right of persons, in community with others, to engage in economic and social activities which are part of the culture of the community to which they belong. In the present case, it is undisputed that the author is a member of an ethnic minority and that *raising llamas is an essential element of the culture of the Aymara community, since it is a form of subsistence and an ancestral tradition handed down from parent to child*...' (emphasis added). For other support for the intergenerational dimension of indigenous peoples' rights in case law, see *Chief Bernard Ominayak and the Lubicon Lake Band v Canada* (Communication No. 167/1984) CCPR/C/38/D/167/1984; *Sandra Lovelace v Canada* (Communication No 24/1997) CCPR/C/13/D/24/1977; and *Ioane Teitiota v New Zealand* (Communication No 2728/2016) CCPR/C/127/D/2728/2016; see further at paragraphs 16-19 in the *amicus curiae* brief mentioned above in footnote 34.

[37] UN document E/CN.4/Sub.2/1986/7/Add.4: 'Indigenous communities, peoples and nations are those which, having a *historical continuity* with pre-invasion and pre-colonial societies that developed on their territories, consider themselves *distinct* from other sectors of the societies now prevailing on those territories, or parts of them. They form at present non-dominant sectors of society and are determined to preserve, develop and *transmit to future generations* their ancestral territories, and their ethnic identity, as the basis of their continued existence as peoples, in accordance with their own cultural patterns, social institutions and legal system.' (paragraph 379; emphasis added)

[38] The intergenerational nature of indigenous peoples' rights and the and importance of cultural transmission to new generations is reflected, *inter alia*, in article 1 (1)(b) ('who are regarded as indigenous on account of their descent... and who ... retain...') and in article 29 ('imparting of general knowledge and skills that will help children belonging to the peoples concerned to participate fully...').

[39] Most importantly, see UNDRIP Article 25 that reads: 'Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to *future generations* in this regard.' (emphasis added) See, also, Articles 11 (1) and 13 (1).

[40] See, James S. Anaya, Indigenous Peoples in International Law (2nd edition, Oxford University Press 2004) pp. pp. 66-67 and 131-141; William Schabas, p. 892 in the 3rd revised edition of *Manfred Nowak's CCPR Commentary* (N.P.Engel 2019); and Martin Scheinin at p. 162 in Francesco Francioni and Martin Scheinin, eds., Cultural Human Rights, Martinus Nijhoff 2008.

[41] See, Inter-American Court of Human Rights, *Case of the Sawhoyamaxa Indigenous Community v. Paraguay* (Judgment of 29 March 2006) paragraph 222; *Case of the Yakye Axa Indigenous Community v. Paraguay* (Judgment of 17 June 2005) paragraph 124, 131 and 203; and *Mayagna (Sumo) Awas Tingni Community v. Nicaragua* (Judgment of 31 August 2001) paragraph 149. Also, see African Court of Human and Peoples' Rights, the case of the *Ogiek Community (Commission v. Kenya)* (Case No. 6/2012, Judgment of 26 May 2017) paragraphs 103, 106, 155, 165 and 179.

Issue 2: The wider case of similarly situated or otherwise particularly vulnerable groups

27. The fact that indigenous peoples often become victims of adjudicable human rights violations related to climate change earlier in time than other individuals or groups, does not mean that the adverse effects of climate change would not have already materialized as human rights violations in respect of anyone else. Indigenous peoples often are in situations of specific vulnerability in respect of changes in the climate system but there may be other groups that share those same vulnerabilities. There is plenty of authority in support of an understanding that on account of the concrete factual circumstances, international law protections typically afforded to indigenous peoples also apply in respect of many other vulnerable groups that do not identify themselves as indigenous peoples or lack one or some of the characteristics on account of which groups may by a State or an international actor be recognized as indigenous peoples, such as the criterion of having arrived on a geographical area earlier in time than another culture.

28. For instance, ILO Convention 169 applies equally to 'tribal' and 'indigenous' groups and assures to them equal rights, even if in its Article 1 only indigenous peoples are characterized through the criterion of being first.[42] More generally, the vulnerability of indigenous peoples to the natural resources of a particular geographical area, as being the foundation of their distinct culture and way of life and its transmission to new generations, may apply also to, for instance, tribal peoples, ethnic minorities, peasants, fisherpersons, mountain communities, lowland farmers, or city dwellers or even the whole population of an island State or other low-lying country. Reference is made to the established understanding of the notion of indigenous peoples in Africa,[43] to the 2018 United Nations Declaration on the Rights of Peasants and Other People Working in Rural Areas,[44] and various policy directives of international financial institutions.[45] All these sources point to the conclusion that States have identical or analogous human rights obligations in respect of many similarly situated groups in addition to indigenous peoples. What matters for those obligations is not the criterion of 'being first' but the *situation of particular vulnerability* to climate change of a people or community with a distinct way of life based on the natural resources of a particular geographical area. Importantly in the context of the current Advisory Opinion proceedings, this conclusion would be applicable to low-

[42] See ILO Convention No. 169, Art 1: 'who are regarded as Indigenous *on account of their descent from the populations which inhabited the country … at the time of* conquest or colonization or the establishment of present state boundaries…'

[43] See, Report of the African Commission's Working Group on Indigenous Populations/Communities (2003). Adopted by the African Commission on Human and Peoples' Rights at its 28th Ordinary Session.

[44] A/RES/73/165

[45] See, for instance, World Bank Operational Policy 4.10 on Indigenous Peoples (2005), paragraph 4, and Performance Standard No. 7 (2012) by the International Finance Corporation, paragraph 5.

lying Pacific Island nations, where the whole population, jointly constituting the people of an independent State or another type or territory, could claim victim status in respect of adverse effects of climate change, and where the Pacific Island State may act as custodian of the human rights of its inhabitants, in adjudication in respect of other States responsible for GHG emissions, climate change and adverse human rights consequences.

29. As the *Torres Strait Islanders* case by the Human Rights Committee demonstrates, the legal basis for the State obligations discussed in the previous paragraph can be found, inter alia, in ICCPR Article 17 on the protection of privacy, family and home, supplementing and expanding the protection afforded by ICCPR Article 27 to minority cultures.[46] Expanding the main rationale of the case of the *Torres Strait Islanders* to tribal peoples, pastoralists, subsistence farmers, fisherpersons or even city dwellers or the whole population of a low-lying State or area should be seen as primarily being a *factual* question concerning the distinctiveness and vulnerability of the way of life of a particular group and the threat climate change constitutes to that way of life and its transmission to new generations, including future ones. As a consequence, communities and peoples in for instance low-lying Pacific Island countries, as well as the States of such countries, acting as custodians of the rights and cultures of their population as a whole, are entitled to invoke the rationale of the *Torres Strait Islanders* case in the substantiation of claims concerning legal obligations of States that, by their acts and omissions, have caused significant harm to the climate system. For instance, they may turn to inter-State adjudication and seek to establish the international *wrongfulness* of the actions or omissions of other States, as pertinent for question (a) by the General Assembly, or to present pursuant to question (b) claims concerning the *consequences* of such wrongfulness, including in respect of cessation, non-repetition and various forms of reparation (restitution, compensation and satisfaction).[47]

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Issue 3: The relevance of the right of all peoples to self-determination

30. Since the *Quebec Secession* case by the Supreme Court of Canada (1998),[48] the Human Rights Committee and other human rights bodies have acknowledged that common Article 1 of the twin Covenants of 1966 on the right of all peoples to self-determination also applies to indigenous peoples. Those interpretive developments paved the way for the adoption in 2007 of the Declaration of the Rights of Indigenous

[46] The application of ICCPR Article 17 in the *Torres Strait Islanders* case is supported by earlier case law, in particular the cases of *Hopu and Bessert v. France* (CCPR/C/60/D/549/1993/Rev.1) and *Benito Oliveira Pereira et al. v. Paraguay* (footnote 32, above).

[47] Reference is made to Articles 30-31 and 34-37 of the Articles on Responsibility of States for Internationally Wrongful Acts, Annex to General Assembly resolution 56/83 of 12 December 2001 (A/RES/56/83).

[48] [1998] 2 SCR 217.

Peoples that confirms the same position. A consequence of these developments is that even if many communities, groups and individuals are entitled to invoke the rationale of the *Torres Strait Islanders* case to substantiate their claims concerning legal obligations of States in respect of climate change, such claims may relate to the right of all peoples to self-determination only in respect of beneficiaries that constitute 'peoples' under international law. Such beneficiaries will include whole populations of independent States as 'peoples', as well as distinct groups within a State that identify themselves as and meet the characteristics of being 'peoples'.

31. As enshrined in common Article 1 of the twin Covenants, the right of all peoples to self-determination includes several dimensions or attributes, including internal and external political dimensions (paragraph 1),[49] a resource dimension (paragraph 2),[50] and a solidarity dimension (paragraph 3).[51]

32. States are entitled to invoke, in relation to other States and the international community as a whole, the right of all peoples to self-determination, acting as custodians of the human rights of the members of their population as a whole, as well as in order specifically to claim and protect the rights of a distinct 'people' within the country. Indigenous or other distinct groups qualifying as peoples under international law are themselves entitled to invoke the right of self-determination in respect of the State that exercises sovereignty over the area where the group lives, be it a multi-ethnic local territorial State or the State of a distant country that retains sovereignty over an overseas territory or a colony. The right of self-determination of peoples is relevant in the context of climate change even if, or precisely because, it is a right of peoples and not of individuals, or any community of individuals.

Issue 4: The question concerning which substantive human rights are most pertinent

33. It is important to note that the question which kinds of human rights violations related to climate change have been successfully and *first in time* been adjudicated at international level is not indicative of the true scope and magnitude of States' breaches of international human rights obligations in respect of anthropogenic climate change. All human rights are interdependent and indivisible, and as was demonstrated in

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[49] '… By virtue of that right they freely determine their political status and freely pursue their economic, social and cultural development.'

[50] 'All peoples may, for their own ends, freely dispose of their natural wealth and resources without prejudice to any obligations arising out of international economic co-operation, based upon the principle of mutual benefit, and international law. In no case may a people be deprived of its own means of subsistence.'

[51] 'The States Parties to the present Covenant, including those having responsibility for the administration of Non-Self-Governing and Trust Territories, shall promote the realization of the right of self-determination, and shall respect that right, in conformity with the provisions of the Charter of the United Nations.'

paragraph 13 above, climate change has by 2023 caused a great number of deaths, many of which most likely entail substantive breaches of the right to life. The right of indigenous peoples to enjoy and transmit their culture is one human right where violations can in some cases already have been established through international adjudication. Furthermore, many 'similarly situated' groups have become subject to the same or analogous forms of human rights violations as indigenous peoples, due to the particular vulnerability of their way of life to the effects of climate change. But these discussions do not justify a conclusion that the most sacrosanct of all human rights, the right to life, would not be pertinent or would not have been violated. Quite to the contrary, as scientific reports, media, social movements and people themselves all point to, ongoing climate change constitutes a real threat to human life and has probably already resulted in two million deaths. International adjudication before human rights treaty bodies or regional human rights courts, or in the form of contentious cases before the International Court of Justice, may follow but by 2023 there should be no reason to doubt that at least a proportion of those two million deaths entail violations by States of their positive or negative human rights obligations under the right to life.

34. Already adjudicated human rights cases themselves point to the relevance of the right to life in the context of climate change. In the *Sacchi, Teitiota and Torres Strait Islanders* cases no violation of the right was yet established as having materialized and proven.[52] Irrespective of that, it was affirmed through these cases that climate change constitutes an ongoing and increasingly severe threat to human life, or life with dignity. States not only have an obligation to refrain from arbitrary deprivations of life, but also an obligation to protect human rights in respect of evolving threats and through active positive measures to maintain and ensure the conditions for human life and life with dignity. Specific positive and negative human rights obligations under the right to life may relate to the elderly, to the young, to people in low-lying areas, to city dwellers, or to people living in poverty.

[52] In *Teitiota*, the Human Rights Committee concluded with a non-violation of Article 6, noting that 'in his comments submitted in 2016, the author asserted that Kiribati would become uninhabitable within 10 to 15 years' (para. 9.10; see also para. 7.1 where the date of the author's submission is given as 29 December 2016) and then itself assessing that 'the time frame of 10 to 15 years, as suggested by the author, could allow for intervening acts by Kiribati, with the assistance of the international community, to take affirmative measures to protect and, where necessary, relocate its population' (para. 9.12). In 2023, soon 7 years of those 10-15 years have passed, and that the actual trajectory presented in 2016 entailed that Article 6 would or might be violated in 3 to 8 years from the submission of this Expert Report.

Issue 5: Operationalizing the rights of 'future generations': from aspirational moral rights to treaty-based legal rights

35. The General Assembly's request for an Advisory Opinion includes, in its question (b)(ii) a reference to the rights of 'peoples and individuals of the present and future generations'. Some commentators may seek to misinterpret the request by claiming that rights of future generations should be constrained to being aspirational and moral in their nature, rather than immediate and legal rights. The *Torres Strait Islanders* case has provided a sound basis for dismissing those views. Under the legally binding treaty provision of ICCPR Article 27, the respondent State was found to have violated the rights of the petitioners '*to transmit to their children and future generations their culture and traditions and use of land and sea resources'*. This finding related to the specific case of the right of members of minorities to enjoy their own culture and the inclusion of transmission of a distinct culture to new and even future generations as an attribute of this right, in the specific context of indigenous peoples. That said, the rationale of this interpretation is sound and can be expanded to other contexts, such as other groups than indigenous ones, or even other treaty provisions than ICCPR Article 27. Even without such an expansion that may prove justified in future cases, the *Torres Strait Islanders case* has provided this esteemed Court with a well-founded foundation for operationalizing the protection of future generations in respect of climate change as a legal obligation of States under international law.

VI. CONCLUSIONS

36. By the end of 2023, very few cases concerning adverse human rights impacts of climate change have been adjudicated before international human rights treaty bodies or regional human rights courts. Importantly, in the *Torres Strait Islanders* case the Human Rights Committee nevertheless established violations of ICCPR Articles 17 and 27, and also the *Sacchi* and *Teitiota* cases demonstrated that human rights claims may be adjudicable. More importantly, this Expert Report has demonstrated that the scope of breaches of States' positive or negative human rights obligations in respect of anthropogenic climate change is much wider than the relatively narrow subset of claims that by now have been adjudicated - narrow because of different ratification patterns of States, various admissibility requirements or other jurisdictional constraints. On the basis of the assessment that the substantive human rights obligations by States are by and large the same and cover, — through States' voluntary ratification of human rights treaties or on account of customary norms of international law — the whole catalogue of human rights enshrined in the 1948 Universal Declaration of Human Rights, it is very likely that many States have violated or are currently in breach of their legal obligations under international human rights law on account of their contribution to GHG emissions or failure to respond to climate change.

37. The international wrongfulness of such conduct, either by actions or omissions, that have occurred in the past, continue as of today, or will occur in the future, may be established through individual complaint procedures under human rights treaties, or through inter-State adjudication before the same human rights *fora*, but also by the International Court of Justice. Consequently, the scope of obligations of States, under international law, to ensure the protection of the climate system and other parts of the environment from anthropogenic emissions of greenhouse gases for States and for present and future generations, as addressed in question (a) posed by the General Assembly, includes the full catalogue of human rights and both negative and positive State obligations.

38. The right of indigenous peoples, individually and collectively, to enjoy their own culture that is based on coexistence with the specific conditions and natural resources of areas they traditionally occupy, and to transmit that culture from generation to generation, including to future generations, was presented as an issue where it already has been established that adverse impacts of climate change have resulted in human rights violations by a State that is in breach of its positive or negative obligations under international human rights law. ICCPR Article 27 has a prime place as a provision of human rights treaty law that is being violated. This was established by the Human Rights Committee in the *Torres Strait Islanders* case.

39. There are numerous peoples, groups, or communities that are situated similarly to indigenous peoples as to the adverse effects of climate change, due to their particular vulnerabilities. They may be, for instance, tribal peoples, ethnic minorities, peasants, fisherpersons, mountain communities, lowland farmers, city dwellers or the whole population of an island State or other low-lying country. Their way of life, or living culture, and its transmission to new generations, may also be disrupted and made impossible because of the effects of climate change. The finding by the Human Rights Committee in the *Torres Strait Islanders* case, that also Article 17 of the ICCPR had been violated, has wide ramifications in expanding the rationale first established in respect of indigenous communities to apply also in respect of many other groups, communities or peoples.

40. A prime example of how the human rights obligations of States are wider than where human rights violations have already been established, relates to obligations of States under the right to life, enshrined in ICCPR Article 6. In the *Sacchi, Teitiota and Torres Strait Islanders* cases no violation of this right was established as having already materialized. Irrespective of that, climate change has reportedly caused already two million deaths and constitutes an ongoing and increasingly severe threat to human life, or life with dignity. States not only have an obligation to refrain from arbitrary deprivations of life, but also an obligation to protect human rights in respect of evolving threats and through active positive measures to maintain and ensure the

conditions for human life and life with dignity. Irrespective of whether violations of State obligations in respect of the right to life have already resulted in internationally adjudicable claims concerning the deprivation of life, States do have obligations under the right to life to prevent loss of human life, since 1945-1948, right now, and also in the future. Those obligations may in specific forms relate to the elderly, to the young, to people in low-lying areas, to city dwellers, or to people living in poverty.

41. The right of all peoples to self-determination is enshrined in common Article 1 of the ICESCR and ICCPR and is relevant as a legal obligation of States, applicable in the context of climate change. This right includes distinct political, resource and solidarity dimensions. It is applicable both to the benefit of the whole population of a country as a 'people' and to the benefit of distinct groups within a State that under international law qualify as 'peoples'. A State is entitled to invoke, in respect of other States or the international community, the right of self-determination as custodian of the rights of its whole population or the rights of a distinct people within a multi-ethnic country. Also, a people within a State are entitled to invoke the right of self-determination in respect of the territorial State, or another State.

42. Having concluded above that the *substantive* scope of the full catalogue of human rights and both negative and positive State obligations in respect of them, gives rise to State obligations under international law to ensure the protection of the climate system and other parts of the environment from anthropogenic emissions of greenhouse gases for States and for present and future generations (question a posed by the General Assembly), it is pertinent to close this Expert Report in respect of question (b). Breaches of those substantive obligations constitute internationally wrongful acts that give rise to claims by individuals, communities of individuals, including indigenous and other peoples, as well as by States acting as custodians of the human rights of their inhabitants. Under general international law such wrongfulness in the past, at present, or in the future gives rise to State responsibility and involves legal *consequences*, including cessation, non-repetition and various forms of reparation (restitution, compensation and satisfaction). The Human Rights Committee's application in the *Torres Strait Islanders* case of ICCPR Article 2, paragraph 3, a provision on a State party's legal obligation to provide an effective remedy for human rights violations demonstrates that the question of legal consequences for human rights violations in the context of climate change can be operationalized, so as to entail full reparation and adequate compensation for the harm suffered, and measures including, but not limited to, meaningful consultations, needs assessments, securing people's safe existence, monitoring and reviewing of measures undertaken, as well as preventing similar violations from occurring in the future.[53]

[53] *Torres Strait Islanders* case (footnote 23), para. 11.

VII. DECLARATION BY THE EXPERT

I confirm that all the matters in respect to which I expressed my opinion are within my competence and professional knowledge. I understand that I have an obligation to assist the International Court of Justice with resolving the matters covered by this Expert Report. I have fulfilled my obligation and will continue to do so in future. I confirm that the conclusions in this Expert Report are unbiased, objective and impartial; they were not led by the influence of the proceedings, nor of any participant thereto.

Signed in London on 31 December 2023,



Martin Scheinin
British Academy Global Professor (Bonavero Institute of Human Rights, University of Oxford); Part-time Professor (European University Institute, Florence)

Annex D

Historical Knowledge and Awareness, in Government Circles, of the Effects of Fossil Fuel Combustion as the Cause of Climate Change

Expert Opinion

Professor Naomi Oreskes
Harvard University

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I. Introduction

1. I have been asked by counsel for the Republic of Vanuatu to provide an expert opinion on the historical knowledge and awareness, in governmental circles, of the effects of fossil fuel combustion as a cause of climate change, particularly in the United States as the largest cumulative emitter of carbon dioxide (CO_2).

2. I provide this expert opinion on the basis of my expertise and research on this specific issue. I am a historian of science who has researched the history of the earth sciences, the role of science in society, anthropogenic climate change, and the role of disinformation in blocking climate action for several decades. I am the Henry Charles Lea Professor of the History of Science at the Department of the History of Science of Harvard University and an Affiliated Professor of Earth and Planetary Sciences at the Department of Earth and Planetary Sciences of Harvard University. I hold a BSc (First Class Honours) from the Royal School of Mines, Imperial College, a PhD from Stanford University (Graduate Special Program: Geological Research and History of Science) and honorary doctorates from Clark University, ETH Zurich, the University of British Columbia, Roskilde University, Colgate University, and the Free University of Brussels. I am the author or co-author of 9 books and over 150 articles, essays, and opinion pieces on these areas of research. I am also the author or co-author of several expert reports on economic geology and the history of science, and I have provided testimonial evidence before the United States Congress and the Belgian Parliament. More information about my qualifications is available at: https://histsci.fas.harvard.edu/people/naomi-oreskes

3. This expert opinion relies on the historical evidence that I have gathered in my decades-long research. Each conclusion is substantiated by reference to a range of sources, encompassing scientific literature, corporate and institutional archives, official governmental communications, and contemporaneous media reports.

II. Summary

4. This expert report demonstrates that, **at least from the 1960s, the United States and other States with high cumulative emissions of greenhouse gases (GHGs),**

including France and the UK, were aware that (i) the release of greenhouse gases into the Earth's atmosphere had the potential to alter the climate system, and (ii) that such interference, if unmitigated, could have catastrophic effects for humans and the environment.

5. There are three main grounds on which I reach this conclusion. First, from the early 1900s, scientists understood that the heightened levels of atmospheric carbon dioxide resulting from the combustion of fossil fuels could significantly alter the Earth's climate system. By the 1960s, this scientific understanding was confirmed by leading scientists on the basis of advances in spectroscopy and CO_2 measurements (Section III). Second, such knowledge was both in public domain and specifically in the power of certain governments, which funded the relevant research and employed many of the scientists who led the decisive studies (Section IV). Third, this knowledge and implications were widely discussed in the context of major domestic conferences, international conferences, and intergovernmental organizations (Section V).

III. The State of Science on the Relationship Between Carbon Dioxide and the Global Climate System Since 1960

6. An overview of scientific academic production shows that by the end of the 1960s leading scientists in Europe and the United States had been working on the foundations of the relationship between CO_2 and the global climate system for more than a century. Crucially, in the 1950s and 1960s, leading scientists concluded (a) that CO_2 in the atmosphere was increasing due to fossil fuel combustion, and (b) that if this increase continued, the increased atmospheric CO_2 would affect the global climate system in potentially catastrophic ways,

7. Since the mid-nineteenth century scientists have known that CO_2 is a 'greenhouse gas', which means that it is highly transparent to visible light but relatively opaque to infrared radiation.[1] In 1859, Irish physicist John Tyndall established the physical basis of what would later be termed the 'greenhouse effect'. The 'greenhouse effect' is the phenomenon by which sunlight reaching the Earth penetrates the atmosphere and warms the planet, and some of that warmth is trapped by greenhouse gases when it is re-

[1] See, generally, James Fleming, *Historical Perspectives on Climate Change* (Oxford University Press 1998); Spencer Weart, *The Discovery of Global Warming* (2 edn, Harvard University Press, 2008).

radiated back to space. In particular, Tyndall measured the infrared absorption and emission characteristics of different gases and vapors and discovered that CO_2 and water vapor absorbed and radiated heat.[2]

8. In the late 19th century scientists building on Tyndall's research provided further insight into how changing atmospheric CO_2 concentrations could alter the global climate system. US geologist TC Chamberlin proposed that fluctuations in CO_2 levels from natural causes could explain the ice ages.[3] Around the same time, Svante Arrhenius, a Swedish chemist and Nobel Laurate, suggested that the burning of fossil fuels, such as coal, could also contribute to changing atmospheric CO_2 concentrations, leading to a net warming effect of the atmosphere.[4] As Chamberlin and Arrhenius were distinguished scientists, their ideas reached a global scientific audience.

9. Ever since Arrhenius' groundbreaking findings were published in the late 1890s and early 1900s, scientists worldwide continued to investigate the potential impact of the heightened levels of atmospheric CO_2 resulting from the combustion of fossil fuels. These scientists repeatedly noted that heightened CO_2 could significantly interfere with the Earth's climate system. Over the years, research on these topics included the works of US Naval Research Laboratory physicist Edward O. Hulburt, British geologist Robert Lionel Sherlock, and British engineer Guy Stewart Callendar.[5]

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2 John Tyndall, 'The Bakerian Lecture —On the Absorption and Radiation of Heat by Gases and Vapours, and on the Physical Connexion of Radiation, Absorption, and Conduction' (1861) 151 Philosophical Transactions of the Royal Society of London 1.

3 TC Chamberlin, 'A Group of Hypotheses Bearing on Climatic Changes' (1897) 5 Journal of Geology 653; TC Chamberlin, 'The Influence of Great Epochs of Limestone Formation upon the Constitution of the Atmosphere' (1898) 6 Journal of Geology 609; TC Chamberlin, 'An Attempt to Frame a Working Hypothesis of the Cause of Glacial Periods on an Atmospheric Basis' (1899) 7 Journal of Geology 751.

4 Svante Arrhenius, 'On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground' (1897) 9 Publications of the Astronomical Society of the Pacific 14; Svante Arrhenius, 'Ueber die Wärmeabsorption durch Kohlensäure' (1901) 309 Annalen der Physik 690; Svante Arrhenius, 'Ueber die Wärmeabsorption durch Kohlensäure und ihren Einfluss auf die Temperatur der Erdoberfläche' (1901) 22(1) Kongl. Vetenskaps-Akademiens Förhandlingar 25; Svante Arrhenius, *Lehrbuch der komischen Physik*. *Teil 2: Physik der Atmosphäre* (Hirzel 1903).

5 See e.g. EO Hulburt, 'The Temperature of the Lower Atmosphere of the Earth' (1931) 38 Physical Review 1876; Robert Lionel Sherlock, *Man as a Geological Agent: An Account of His Action on Inanimate Nature* (H F & G Witherby 1922); GS Callendar, 'The Artificial Production of Carbon Dioxide and Its Influence on Temperature' (1938) 64 Quarterly Journal of the Royal Meteorological Society 223; GS Callendar, 'Variations of the Amount of Carbon Dioxide in Different Air Currents' (1940) 66 Quarterly Journal of the Royal Meteorological Society 395;

10. By the 1960s, scientists had concluded that: (a) atmospheric CO_2 was increasing, and (b) more atmospheric CO_2 would likely have a significant impact on the climate.

11. The establishment of proposition (a) began in the 1930s and 1940s, when Guy Stewart Callendar published a series of papers presenting measurements of atmospheric CO_2, indicating that a measurable increase was already underway.[6] His work was interrupted by World War II, but it was sufficiently well known that when scientists returned to the question in the 1950s and 1960s, the effect of increased atmospheric CO_2 was often referred to as "the Callendar Effect."[7]

12. In the 1950s, oceanographer Roger Revelle, chemist Hans Suess, and geochemist Charles David Keeling undertook further work establishing that atmospheric concentrations of CO_2 were increasing and would likely alter the climate. In 1957, Revelle and Suess were responding to the scientific objection that increased atmospheric CO_2 would not necessarily alter the climate, if the oceans absorbed some or most of the excess CO_2 Revelle and Suess showed that the oceans would not absorb all the excess CO_2 emitted by the use of fossil fuels and that the concentration of the gas in the atmosphere would therefore almost certainly continue to rise.[8] In 1958, Charles David Keeling began the systematic measurement of atmospheric CO_2, under the auspices of the International Geophysical year. By 1965, he had compiled sufficient data to demonstrate that atmospheric concentrations of CO_2 were indeed rising, a conclusion that was cited in a 1965 report by the U.S President's Science Advisory Committee.[9] According to his findings, atmospheric CO_2 had increased by an amount

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6 See e.g. Edward Olson Hulburt, 'The Temperature of the Lower Atmosphere of the Earth' (1931) 38 Physical Review 1876; Robert Lionel Sherlock, *Man as a Geological Agent: An Account of His Action on Inanimate Nature* (H F & G Witherby 1922); Guy Stewart Callendar, 'The Artificial Production of Carbon Dioxide and Its Influence on Temperature' (1938) 64 Quarterly Journal of the Royal Meteorological Society 223; Guy Stewart Callendar, 'Variations of the Amount of Carbon Dioxide in Different Air Currents' (1940) 66 Quarterly Journal of the Royal Meteorological Society 395.

7 See James Robert Fleming, The Callendar Effect: The Life and Work of Guy Stewart Callendar (1898-1694) (American Meteorological Society, 2009)

8 Roger Revelle and Hans E. Suess, 'Carbon Dioxide Exchange between Atmosphere and Ocean and the Question of an Increase of Atmospheric CO2 During the Past Decades' (1957) 9 Tellus 18.

9 Jack Pales and Charles Keeling, 'The Concentration of Atmospheric Carbon Dioxide in Hawaii' (1965) 70 Journal of Geophysical Research 6053; Craig Brown and Charles Keeling, 'The Concentration of Atmospheric Carbon Dioxide in Antarctica' (1965) 70 Journal of Geophysical Research 6077; Charles

of 30 parts per million (ppm) since 1850 – about a 10% increase – with the rate of increase rising in tandem with fossil fuel use.[10]

13. Proposition (b) was demonstrated by Canadian physicist Gilbert Plass in the mid-1950s, who worked in academia and in 1955 moved into the private sector, conducting research at the Ford Motor Company. Plass was responding to the objection that small increases in CO_2 might not alter the global climate because the heat absorption by CO_2 overlapped with that of water vapor, which was far more abundant. Plass showed that the overlap between CO_2 and water vapor was much less than previously believed, and therefore concluded that doubling CO_2 would warm the planet by as much as 3.6°C, a magnitude sufficient to explain past ice ages.[11] However, he also noted that the present warming trend caused by human activity clearly differed from oscillatory past planetary changes.[12] Thus he concluded that if atmospheric CO_2 built up in the atmosphere, it would almost certainly warm the planet; the oceans would slow global warming, but they would not stop it—effectively proving Arrhenius's theory.[13] Plass disseminated his

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Keeling, 'Is Carbon Dioxide from Fossil Fuel Changing Man's Environment?' (1970) 114 Proceedings of the American Philosophical Society 10. Need to add ref to PSAC report.

10 Charles Keeling, 'Is Carbon Dioxide from Fossil Fuel Changing Man's Environment?' (1970) 114 Proceedings of the American Philosophical Society 10.

11 Gilbert Plass, 'A Method for the Determination of Atmospheric Transmission Functions from Laboratory Absorption Measurements' (1952) 42 Journal of the Optical Society of America 677; Gilbert Plass, 'Parallel-Beam and Diffuse Radiation in the Atmosphere' (1952) 9 Journal of Meteorology 429; Gilbert Plass and Danial Fivel, 'Influence of Doppler Effect and Damping on Line-Absorption Coefficient and Atmospheric Radiation Transfer.' (1953) 117 Astrophysical Journal 225; Gilbert Plass, 'Regions of Validity of Various Absorption-Coefficient Approximations' (1954) 11 Journal of Meteorology 163; Gilbert Plass and Danial Fivel, 'The Influence of Variable Mixing Ratio and Temperature on the Radiation Flux' (1955) 81 Quarterly Journal of the Royal Meteorological Society 48; Gilbert Plass, 'The Influence of the 9.6 Micron Ozone Band on the Atmospheric Infra-red Cooling Rate' (1956) 82 Quarterly Journal of the Royal Meteorological Society 30.

12 Gilbert Plass, 'The Carbon Dioxide Theory of Climatic Change' (1956) 8 Tellus 140.

13 Gilbert Plass, 'Carbon Dioxide and the Climate' (1956) 44 American Scientist 302.

work in both specialist and popular scientific journals, and his discoveries were reported by global-reaching media such as *The New York Times* as early as 1953.[14]

14. Throughout the 1950s and the 1960s, the insights from scientists such as Chamberlin and Arrhenius on the problem of carbon dioxide emissions and their impact on the global climate system were confirmed and expanded by scientists such as Plass, Revelle, Suess and Keeling. As a result, by the 1960s, leading scientists had concluded that CO_2 pollution, caused by fossil fuel use combustion, was a problem which, if left unaddressed, would alter the global climate system with major adverse and even potentially catastrophic consequences for humans and the environment.

IV. State Access to Relevant Scientific Knowledge

15. The scientific concern regarding the impending risk of climate change due to increased atmospheric CO_2 from burning fossil fuels was far from insular, resonating well beyond the boundaries of specialized scientific communities. The concern was widely understood by State officials and industry scientists from at least the late 1950s and 1960s.

16. States were not just passive recipients of scientific knowledge; they actively funded the research and employed many of the scientists who led these studies. Shortly after the Second World War, the US government funded projects to study techniques of weather modification.

17. A significant part of this work was financially supported by industry. The reports of a research group at the General Electric Corporation, led by Nobel Laureate Irving Langmuir, Vincent Schaefer, and Bernard Vonnegut[15] contained discussions of a concept their authors termed 'inadvertent weather modification' – what scientists today would call anthropogenic climate change.[16]

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14 WK, 'How Industry May Change Climate' *New York Times* (24 May 1953), available at <https://www.nytimes.com/1953/05/24/archives/how-industry-may-change-climate.html>.

15 James Rodger Fleming, *Fixing the Sky: The Checkered History of Weather and Climate Control* (Columbia University Press 2010), 137-157, 165-187 (2010).

16 Vincent Schaefer, 'The Inadvertent Modification of the Atmosphere by Air Pollution' (1969) 50 Bulletin of the American Meteorological Society 199. For recent use of this terminology, see Philip B Duffy and others, 'Strengthened Scientific Support for the Endangerment Finding for Atmospheric Greenhouse

18. In the early 1960s, President John F. Kennedy authorized government funding for weather modification research through the National Science Foundation (NSF), an agency of the US federal government.[17] The discussions on deliberate weather modification reveals an explicit recognition that 'inadvertent weather modification' could be highly consequential. For example, the NSF's 1962 annual report (released in 1963) cited a 1962 seminar in which the US Weather Bureau meteorologist Harry Wexler had analyzed a variety of factors that could modify Earth's radiation balance, including changing the carbon dioxide content of the atmosphere.[18] The report indicated that this was a cause for concern insofar as Plass had '*suggested that man may already be inadvertently modifying the atmosphere at an alarming rate by burning ever-increasing amounts of fossilized fuel, thus releasing larger amounts of carbon dioxide than ever before in historical times*'.[19] Such warming, if continued, could cause the icepack to '*vanish from the frozen north and frozen tundra would thaw*'.[20]

19. In 1964 the NSF director announced the creation of a Special Commission on Weather Modification to review the state of knowledge and respond to a request from the federal government to analyze potential uses of weather modification and control. The Commission's 1965 report discussed weather and climate modification as already underway and not merely as a local effect: '*Weather and climate modification is becoming a reality ... [T]he inadvertent modification of the weather and climate by such influences as the products of urban development, surface modification for agriculture and silviculture, [and] compositional changes through the combustion of fossil fuels*

Gases' (2019) 363 Science eaat5982. ('One area of scientific progress since the [Endangerment Finding] is the attribution of extreme weather events . . . to human-caused climate change').

17 National Science Foundation Act of 1950, Public Law No. 85-510, 72 Stat. 353 (1958) <https://www.nsf.gov/about/history/legislation.pdf>. This amendment to the National Science Foundation Act of 1950 made NSF the official coordinating agency for weather modification research projects and required that the agency report annually. For a summary of federal laws governing US federal weather modification programs, see Rachel Hauser, 'Using Twentieth-Century U.S. Weather Modification Policy to Gain Insight into Global Climate Remediation Governance Issues' (2013) 5 Weather, Climate, and Society 180.

18 National Science Foundation, *Weather Modification: Fourth Annual Report* (1962), 19, citing Harry Wexler, Seminar on weather control, Department of Meteorology, UCLA (February 1962).

19 National Science Foundation, *Weather Modification: Fourth Annual Report* (1962), 19, citing Gilbert Plass, 'The Influence of Infrared Absorptive Molecules on the Climate' 95 Annals of the New York Academy of Science 61.

20 National Science Foundation, *Weather Modification: Fourth Annual Report* (1962), 20.

and other exhausts are becoming of sufficient consequence to affect the weather and climate of large areas and ultimately the entire planet'.[21]

20. Since at least the late 1950s, CO_2 had been discussed not just as a factor in meteorology, atmospheric physics, and climate science, but also in air pollution science and public health. This included government-sponsored conferences, where leading scientists recognized CO_2 as a pollutant. In March 1963, the Conservation Foundation of New York (which later merged with the World Wide Fund for Nature) held a conference to discuss 'the implications of rising carbon dioxide content in the atmosphere'. A group of seven experts brought together for the discussion included Keeling, Plass, Erik Eriksson of the International Meteorological Institute in Stockholm, biologists from Yale University and the Atlantic Marine Laboratory, and the aerial landscape photographer William Garnett. The report explicitly linked the burning of fossil fuels to global warming and issued dire warnings about consequences such as melting ice caps, flooding coasts, and the potential annihilation of life forms in equatorial regions. It read, in relevant part: '*The present liberation of such large amounts of fossil carbon in such a short time is unique in the history of the earth, and there is no guarantee that past buffering mechanisms are really adequate. It is not a cause for complacency that nature seems to have a lot of checks and that these checks seem thus far to be controlling any artificial imbalances. There may be processes presently going on which are due to man's activities and which will eventually be alarming*'.[22]

21. By 1968, in France, policymakers and scientists at a prominent international symposium on technological forecasts and economic planning organized by the Interministerial Delegation of Land Planning and Regional Attractiveness were similarly discussing whether they should '*systematically focus on these micro-pollutions that are today's urban pollutions, or, on the contrary*, […] *think about pollution of a global character, that is to say the increase in the rate of carbon dioxide in the entire atmosphere, which*

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21 National Science Foundation, *Weather and Climate Modification: Report of the Special Commission on Weather Modification* (1965), 8, available at <https://www.nsf.gov/nsb/publications/1965/nsb1265.pdf>.

22 Conservation Foundation, *Implications of Rising Carbon Dioxide Content of the Atmosphere* (1963), 5, available at <https://babel.hathitrust.org/cgi/pt?id=mdp.39015004619030>.

could perhaps, in a decade or half a century, begin to pose problems of global climate change?'[23]

22. In the 1960s, the relation between CO_2 pollution and interference with the climate system became well known to political leaders worldwide. In 1965, under President Lyndon Johnson, the US President's Science Advisory Committee issued a now-famous report in which they predicted that '[b]*y the year 2000 there will be about 25% more CO_2 in our atmosphere than at present. This will modify the heat balance of the atmosphere to such an extent that marked changes in climate, not controllable through local or even national efforts, could occur*'.[24] Revelle and Keeling served on the Committee, which was then the most important channel by which scientific information and advice was transmitted to the White House.[25] The channel was clearly in operation, as suggested by a special message by President Johnson to the Congress on Conservation and Restoration of Natural Beauty, of 8 February 1965, where he noted that '*Air pollution is no longer confined to isolated places. This generation has altered the composition of the atmosphere on a global scale through radioactive materials and a steady increase in carbon dioxide from the burning of fossil fuels*'.[26]

23. By 1968, a US Congressional Committee observed that '*our power to disturb or alter the ponderous forces and rhythms of nature by man-induced manipulations has increased to the point where mistakes or unknown effects may be profound and*

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23 Collège des techniques avancées et de l'aménagement du territoire (CTAAT), *Colloque international sur l'aménagement du territoire et les techniques avancées* (1968), 51, available at <https://www.terrestres.org/wp-content/uploads/2021/10/1968_1er-coll-int-sur-lamenagt-du-terr-et-les-tech-avancees_pages-cle-1.pdf>, cited in Christophe Bonneuil, Pierre-Louis Choquet and Benjamin Franta, "Early Warnings and Emerging Accountability: Total's Responses to Global Warming, 1971–2021" (2021) 71 Global Environmental Change 102386, 3.

24 Environmental Pollution Panel of the President's Science Advisory Committee, *Restoring the Quality of Our Environment: Report of the Environmental Pollution Panel* (The White House, 1965), 9, available at <https://books.google.it/books/about/Restoring_the_Quality_of_Our_Environment.html?id=mdXanDtshX8C&redir_esc=y>.

25 Zuoyue Wang, *In Sputnik's Shadow: The President's Science Advisory Committee and Cold War America* (Rutgers University Press 2009); American Institute of Physics, 'United States. President's Science Advisory Committee', American Institute of Physics (archived at The Internet Archive), available at <https://web.archive.org/web/20220815054423/https://history.aip.org/phn/21612015.html>.

26 Lyndon B. Johnson, Special Message to the Congress on Conservation and Restoration of Natural Beauty, 8 February 1965 (emphasis added), available at: <https://www.presidency.ucsb.edu/documents/special-message-the-congress-conservation-and-restoration-natural-beauty>

irreversible'.[27] A year later, in 1969, a British Lord, the 2nd Viscount St Davids, became one of first politicians to raise climate change in the UK's Houses of Parliament, when he asked: '*My Lords, can my noble friend say whether he and British Railways have taken account of the fact that what were abnormal temperatures last summer may not be abnormal if we continue to discharge carbon dioxide into the air by the burning of various fossil carbons, so increasing the greenhouse effect?*'.[28]

24. In 1968, the NSF issued its tenth annual report on the topic of weather modification, and in 1969 US President Richard Nixon and his staff drafted a two-page, impassioned message to Congress on the 'special interest' of this report in the aftermath of Hurricane Camille. Nixon's message was vivid: '*In recent months many American communities were ravaged by storms that were among the most violent and destructive in our history … Swept away by wind and water were families, homes, businesses, and dreams for the future*'. Writing two months after the hurricane, Nixon linked the storm wreckage to '*mounting concern with the quality of the environment generally*' and emphasized to Congress the importance of a research program in '*facing the issue of air pollution, including the possible effect on weather and climate*'.[29]

25. In November 1969, Nixon appointed a Task Force on Air Pollution to evaluate the effectiveness of existing air pollution control efforts. The task force included representatives of the United Steelworkers of America, the US Steel Corporation, Ford Motor Company, an array of prominent scientists, and Princeton statistician John Tukey. The resulting report, Cleaner Air for the Nation, was transmitted to the President in June 1970 and publicly released in August. In a section on 'Climatic Effects of

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27 'Is Mankind Playing a Game of Environmental Russian Roulette?' Conservation Foundation Letter (23 February 1968) at 1, s. V.A.6, b. 598, f. 5, Edmund S. Muskie Archives and Special Collections Library, Bates College, quoting from *Subcommission on Science, Research and Development, Report to the H. Comm. on Science and Astronautics, 89th Cong., 2d Sess., Environmental Pollution: A Challenge to Science and Technology* (Comm. Print 1966), 3.

28 'Railways: Use of Continuous Welded Rail', House of Lords Debate, 5 November 1969, vol 305, cols 335-9335, available at <https://api.parliament.uk/historic-hansard/lords/1969/nov/05/railways-use-of-continuous-welded-rail>.

29 Richard Nixon, Letter of Transmittal to the Congress of the United States 2 (27 October 1969), f. Atmos. Sci. [Oversized Materials, 1969-70], b. 4, Edward E. David papers (WHCF:SMOF), RNPL. For the full report see, National Science Foundation, *Weather Modification: Tenth Annual Report for Fiscal Year Ended June 30, 1968* (1969), available at <https://hdl.handle.net/2027/uc1.31210025052638>.

Pollutants', the report concluded that: '*the greatest consequences of air pollution for man's continued life on earth are its effects on the earth's climate*'.[30]

26. As scientists grew increasingly concerned about the destructive potential of greenhouse gases, they communicated this concern to governmental bodies throughout the globe, as well as to industry leaders and the general public, increasing the scope of awareness. As early as 1959, physicist Edward Teller sounded an alarm to petroleum industry leaders, cautioning them about the looming consequences of CO_2 accumulation – namely, a discernible rise in global temperatures and sea levels before the end of the century.[31] In 1965, Frank Ikard, president of the American Petroleum Institute (API), discussed the President's Science Advisory Committee 1965 report at the organization's annual meeting, concluding that the '*substance of the report is that there is still time to save the world's peoples from the catastrophic consequence of pollution, but time is running out*'.[32]

27. As a result of extensive communication of scientific knowledge to the general public, global environmental matters rose to public prominence.[33] In this context, the scientific concern about impending climate change found an echo in activists and artists of the era, underlining an often-overlooked cultural uptake of climate issues during the 1950s and 1960s. This shows how much of the available scientific knowledge was generally known and disseminated at this time. For instance, in 1958 Frank Capra, a prominent US filmmaker, produced a film entitled *The Unchained Goddess* about weather, weather modification, and climate change for The Bell System Science Series. In the film, the protagonist, Dr. Research, explains that even a few degrees of temperature rise could melt the polar ice caps, creating a future sea level rise that was so great that an '*inland*

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30 US President's Task Force on Air Pollution, *Cleaner Air for the Nation: The Report of the President's Task Force on Air Pollution* (1970), 34, available at <https://babel.hathitrust.org/cgi/pt?id=mdp.39015002760075&seq=1>.

31 Benjamin Franta, 'Early Oil Industry Knowledge of CO2 and Global Warming' (2018) 8 Nature Climate Change 1024. See also E Robinson and RC Robbins, 'Sources, Abundance, and Fate of Gaseous Atmospheric Pollutants. Final Report and Supplement' Stanford Research Institute Proj. No. PR-6755 105 (1968) (prepared for the American Petroleum Institute), available at <https://www.osti.gov/biblio/6852325>; Bonneuil, Choquet, and Franta (n 23).

32 FN Ikard, 'Meeting the Challenges of 1966' (1965) 45 Proceedings of American Petroleum Institute, 12-13, available at <https://archive.org/details/5348130-1965-API-Proceedings>.

33 See Yannick Mahrane, Marianna Fenzi, Céline Pessis, and Christophe Bonneuil, 'From Nature to Biosphere: The Political Invention of the Global Environment, 1945-1972' (2012) 113 Vingtième Siècle. Revue d'histoire.

sea would fill a good portion of the Mississippi Valley [and] tourists in glass bottom boats would be viewing the drowned towers of Miami through 150 feet of tropical water'. This could happen, he added, because of industrial CO_2: '*Even now, man may be unwittingly changing the world's climate through the waste products of his civilization. Due to our release through factories and automobiles every year of more than six billion tons of carbon dioxide, which helps air absorb heat from the sun, our atmosphere seems to be getting warmer*'.[34] The Bell Science Series has been described as '*among the best known and remembered educational films ever made'*, and *The Unchained Goddess* was broadcast on television and also shown in classrooms around the United States.[35]

28. In 1967, anthropologist Gregory Bateson discussed global climate change in his lecture at the Dialectics of Liberation Congress held in London between July 15 and 30 of 1967. Remembered as a 'now legendary' event in the 'expression of the politics of dissent', the Congress was attended by prominent intellectuals, activists, and artists from around the world, including William S. Burroughs, Thich Nhat Hahn, C.L.R James, Angela Davis, and Kwame Ture (née Stokely Carmichael).[36]

29. In March 1969, US Senator Henry Jackson received a letter from an angry constituent in Seattle. The constituent had watched a recent episode of the popular television show – the *Merv Griffin Show* – where the Beat poet Allen Ginsberg told an alarming story of planetary demise. Ginsberg claimed that '*the current rate of air pollution brought about by the proliferation of automobiles*' could cause '*the rapid build-up of heat on the earth*'. This would '*melt the polar ice caps, causing a flooding of the greater part of the globe*'. The constituent was sure that the eccentric poet was wrong, but he wanted the powerful Senator to do something to stop Ginsberg from spreading disinformation.

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34 *Unchained Goddess* (Warner Brothers Pictures 1958), available at <https://www.youtube.com/watch?v=sqClSPWVnNE>. Discussion of weather modification begins around 47:30.

35 Geoff Alexander, *Academic Films for the Classroom: A History* (McFarland 2010), 66.

36 See James McKenzie, 'An Interview with Allen Ginsberg' in Michael Schumacher, *First Thought: Conversations with Allen Ginsberg 70-71* (University of Minnesota Press 2017); Gregory Bateson, 'Lecture at Dialectics of Liberation: Consciousness versus Nature' (17 July 1967) (transcript at Villon Films Archive, available at <https://villonfilms.ca/archive/vf_avtacrcbfp>); David Cooper (ed.), *The Dialectics of Liberation* (Verso 2015). The quote is from the book description at Verso: <https://www.versobooks.com/products/89-the-dialectics-of-liberation>.

'*After all, quite a few million people watch this show, people of widely varying degrees of intelligence, and the possibility of this sort of charge – even from an Allen Ginsberg – being accepted even in part, is dangerous*', he wrote. The constituent was particularly concerned that Ginsberg had attributed this information to a presidential science advisor. Jackson did not know whether Ginsberg's claims were true or false, so he forwarded the letter to Lee DuBridge, the former President of Caltech who had become science advisor to President Richard Nixon that year, asking for clarification. DuBridge replied with a long, detailed letter describing current knowledge of CO_2 and the greenhouse effect. He affirmed that Ginsberg was broadly correct. The '*greenhouse effect*' – caused by atmospheric CO_2 – was real, and it was also true that '[w]*e are indeed filling the atmosphere with a great many gases and in very large quantities from our automobiles, from industry, and from the burning of fossil fuels*'.

30. These examples, while by no means exhaustive, suffice to make the point: scientists working in the 1950s and 1960s on climate change were not isolated in ivory towers, their work unbeknownst to others. On the contrary, by the late 1960s concern about CO_2 and climate change had been communicated both to politicians at the highest levels and to school children and teachers, conservationists, and ordinary people though film, television, and articles in popular magazines such as *Fortune* and *Sports Illustrated.*[37]

31. Thus, throughout the 1960s, leaders and policymakers in States with high greenhouse gas emissions, including the United States, were well-versed in the potentially serious implications of climate change due to the increased levels of atmospheric carbon dioxide from fossil fuel use. Moreover, this vital knowledge had been extended beyond political and scientific circles to inform the general public.

V. Awareness in Major International Conferences and Intergovernmental Organizations

32. The international efforts in the 1960s and 1970s to address global environmental crises demonstrate a widespread global awareness of the carbon dioxide problem. The question of air pollution due to changes to climate introduced by human activity and the

[37] See, e.g., Edmund Faltermayer, 'A Fortune Proposition: We Can Afford Clean Air' *Fortune* (November 1965); Tom Alexander, 'Some Burning Questions about Combustion' *Fortune* (February 1970); Lord Ritchie-Calder, 'Mortgaging the Old Homestead' *Sports Illustrated* (2 February 1970).

need for an international plan of action were being discussed within the United Nations and other international organizations in the late 1960s. The preparations for the landmark 1972 UN Stockholm Conference on the Human Environment (UNCHE), which started in the late 1960s, provide strong evidence of this international awareness.

33. By the mid-1960s, numerous international organizations were discussing global environmental crises and CO_2 as air pollution, including the International Labour Organization (ILO), the World Health Organization (WHO), and the World Meteorological Organization (WMO).[38]

34. For example, in 1968, the Secretary-General of the United Nations described the work of the WMO in this area as follows. '*Application of meteorology to the protection of the atmosphere is mainly related to the problem of increasing air pollution*'. He expressly mentioned in this context that '*the increase of the carbon-dioxide in the earth's atmosphere which may change our climate*' was a '*large scale air pollution problem*', which explained the WMO's global approach to the matter.[39]

35. The groundwork for convening the UNCHE began in 1968. The Permanent Representative of Sweden in New York proposed that the United Nations Economic and Social Council address the topic of human environment by organizing a conference.[40] The explanatory memorandum accompanying this request specifically referred to the prior work of international organizations on the issue of air pollution.

36. Further key preparatory steps were taken during an intergovernmental meeting organized by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) to address the subject of conservation and the environment. This meeting, known as the International Biosphere Conference, brought together approximately 320 experts from 63 different countries and 23 international organizations. These experts collectively adopted a report that unequivocally identified atmospheric carbon dioxide

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38 'Activities of United Nations Organizations and programmes relevant to the human environment: Report of the Secretary-General' (11 July 1968) E/4553, available at <https://digitallibrary.un.org/record/729430>.

39 'Activities of United Nations Organizations and programmes relevant to the human environment: Report of the Secretary-General' (11 July 1968) E/4553, para 78, available at <https://digitallibrary.un.org/record/729430>.

40 Letter dated 20 May 1968 from the Permanent Representative of Sweden addressed to the Secretary-General of the United Nations, E/4466/Add.1, available at <https://digitallibrary.un.org/record/729874>.

as a major pollution concern resulting from the '*technological developments of man as shown by his achievements in industry, transport, communications and urbanization*'.[41] The report emphasized the need for international action as '*many of the changes produced by man affect the biosphere as a whole and … these problems cannot be solved on a regional, national or local basis but require attention on a global scale*'.[42] Moreover, the report urgently called for approval of a United Nations Conference on the Human Environment at the upcoming UN General Assembly session, wherein States could deliberate on the advisability of a Universal Declaration on the Protection and Enhancement of the Human Environment.[43]

37. On 3 December 1968, the United Nations General Assembly unanimously adopted the resolution to hold the UNCHE in 1972. The resolution was tabled by Sweden and co-sponsored by 51 other nations, including the United States.[44] The Resolution 2398 noted that modern scientific and technological developments '*involve*[d] *great dangers if not properly controlled*'.

38. The groundwork for the UNCHE was not only the province of State representatives; it was a collaborative effort involving various stakeholders. International non-governmental organizations, such as the International Council of Scientific Unions (ICSU), also began to address the topic, which heavily relied on the findings of the academic community. An example of this collaboration is the ICSU Scientific Committee on Problems of the Environment (SCOPE)'s reliance on the *Study of Critical Environmental Problems* conducted under the direction of the Massachusetts Institute of Technology. The report, which included participation of US federal departments and agencies, private foundations, and corporations, found that the human-induced increase

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41 'Intergovernmental Conference of Experts on the Scientific Basis for Rational Use and Conservation of the Resources of the Biosphere (Paris, France, September 4-13, 1968), Recommendations' (1 October 1968), 2, available at <https://files.eric.ed.gov/fulltext/ED047952.pdf>.

42 'Intergovernmental Conference of Experts on the Scientific Basis for Rational Use and Conservation of the Resources of the Biosphere (Paris, France, September 4-13, 1968), Recommendations' (1 October 1968), 2, available at <https://files.eric.ed.gov/fulltext/ED047952.pdf>.

43 'Intergovernmental Conference of Experts on the Scientific Basis for Rational Use and Conservation of the Resources of the Biosphere (Paris, France, September 4-13, 1968), Recommendations' (1 October 1968), 24, available at <https://files.eric.ed.gov/fulltext/ED047952.pdf>.

44 UNGA 'Resolution 2398: The Problems of the Human Environment' UN GAOR 23rd Session A/RES/2398(XXIII) (3 December 1968), available at <https://digitallibrary.un.org/record/202554>. The draft resolution and its sponsoring states are available at <https://digitallibrary.un.org/record/657791>. See projects A/L.553 and Add.1-4.

in atmospheric CO_2 could lead to the '*long-term warming of the planet*'.[45] The report further added that '*the consequences for the human condition and human endeavor could be enormous. They could threaten man's agriculture and food supply, his warmth in winter and his cooling in summer, and could throw his entire transportation system out of gear*'; addressing the problem, therefore, could involve a '*radical curtailment of man's consumption of fossil fuels*'.[46]

VI. Conclusion

39. For the foregoing reasons, I reach the conclusion that at least from the 1960s, the United States and other States with high cumulative emissions of greenhouse gases, including France and the UK, were aware that (i) the release of greenhouse gases into the Earth's atmosphere had the potential to alter the climate system, and (ii) that such interference, if unmitigated, could have catastrophic effects for humans and the environment.

Professor Naomi Oreskes
29 January 2024

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45 Study of Critical Environmental Problems and Massachusetts Institute of Technology (eds), *Man's Impact on the Global Environment: Assessment and Recommendations for Action; Report* (MIT Press 1970), 10-12, available at <https://archive.org/details/mansimpactonglob0000unse/page/12/mode/2up?q=warming>.

46 Study of Critical Environmental Problems and Massachusetts Institute of Technology (eds), *Man's Impact on the Global Environment: Assessment and Recommendations for Action; Report* (MIT Press 1970), 245, available at <https://archive.org/details/mansimpactonglob0000unse/page/12/mode/2up?q=warming>.

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Annex E

Pacific Community
Communauté du Pacifique

INTERNATIONAL COURT OF JUSTICE

Request for an Advisory Opinion on Obligations of States in respect of Climate Change

Expert Report for the Government of Vanuatu
prepared by the Pacific Community (SPC)

Authorised by the Director-General of the Pacific Community,
Dr Stuart Minchin

Compiled and authored by Johanna Gusman, M.Sc., J.D.

12 March 2024

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I. INTRODUCTION AND EXPERTISE

The Pacific Community (SPC) supports Pacific countries and territories with scientific and technical solutions to address the region's greatest challenge, climate change. SPC is one of the Pacific region's scientific and technical intergovernmental organisations working alongside its Pacific Island country and territory (PICT) members[1] to understand and develop effective solutions to the challenges they face. In this case, SPC's core technical abilities to provide the objective science behind observed impacts of the adverse effects of climate change will help provide further expertise for Vanuatu's state submission.

SPC's mandate and work programme addresses the many facets of climate change and its impacts on the region, including but not limited to marine ecosystems, fisheries,[2] coastal hazards, and human rights protections.[3] Additionally, SPC is the regional lead for the implementation of many climate–change mitigation and adaptation programmes, including those on sea-level rise as well as loss and damage, and it sustainably manages Pacific maritime zones, ecosystems, and resources from 'ridge to reef' for current and future generations.[4] Its expertise in global and regional analyses of the impacts of climate change on the marine environment led to its inclusion in the advisory opinion proceedings at the International Tribunal for the Law of the Sea in Case No. 31.[5]

Finally, SPC is a consultative and advisory body to participating governments in matters affecting the economic and social development of the territories within its scope of the Pacific Community and the welfare and advancement of their peoples.[6] SPC sustainably manages the social and environmental risks and impacts of all its activities in an inclusive manner, with a people-centred approach to maximise whole-of-society benefits. SPC is committed to openness and transparency, maintaining the highest ethical standards, and, as such, the statements contained in this report are factually correct and materially complete.

II. METHODOLOGY

Vanuatu requested this expert report to include the full scope of climate-related losses and damages experienced, including environmental, human health, socio-economic, and cultural impacts. From this

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[1] SPC has 27 members, including 22 PICTs: American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Kiribati, Guam, Marshall Islands, Nauru, New Caledonia, Niue, Northern Marianna Islands, Palau, Papua New Guinea, Pitcairn Islands, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu and Wallis and Futuna.

[2] Note that, under the United Nations Convention on the Law of the Sea (UNCLOS), fishing is singled out among the legitimate uses of the sea that are negatively affected by pollution (*'pollution of the marine environment means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities)*, UNCLOS, 10 December 1982, 1833 United Nations Treaties Series (U.N.T.S.) 397 (entered into force 1 November 1994) at Article 1(1)(4).

[3] Article IV, §§ 6-10, of the Canberra Agreement establishing the South Pacific Commission (U.N.T.S., vol. 97, p. 227).

[4] For the full range of SPC's implementation for mitigation and adaptation programming, *see* Pacific Community Strategic Plan 2022-2031 (available at: https://purl.org/spc/digilib/doc/uzzya).

[5] *See* Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law (Request for an Advisory Opinion submitted to the Tribunal, Intergovernmental Organizations invited to submit written statements pursuant to the Rules of the Tribunal.

[6] *Supra* note 3 at para. 6.

request, several of SPC's largest and most relevant divisions provided the necessary science to put together this report, compiled by an international lawyer with a scientific background to ensure proper competencies.[7]

The science captured in this expert report builds upon the best available science, including the Sixth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC).[8] It covers climate impacts that have already been observed as well as those currently occurring, such as cyclones and other natural disasters, extreme weather events, marine environment degradation, and others.

It concludes that (i) Vanuatu has experienced significant harm as a result of anthropogenic climate change; and (ii) future losses and damages are bound to occur, with the extent of future harm depending on actions taken to avert, minimise, and address such losses and damages.

III. CLIMATE CHANGE–RELATED IMPACTS

Small island developing states, due to their geographical circumstances and level of development, are specially affected and particularly vulnerable to the adverse effects of climate change. For Vanuatu, these well-documented harms include but are not limited to extreme weather events; sea-level rise; coastal erosion; ocean warming, acidification, and deoxygenation; and adverse effects on pelagic and coastal fisheries; coral reefs and biodiversity; temperature rise; drought and water security; agriculture; and food security.[9] These impacts are described under the progression of time and corresponding increased temperature projections, and where possible, including climate impacts likely to occur at 2.8°C, the level of warming projected to occur if nationally determined contributions submitted under the Paris Agreement are fully implemented.

Extreme weather events: Increased frequency and intensity of extreme weather events, including cyclones

According to the World Risk Index 2021, Vanuatu has been classified as the country most exposed to the risks of natural disasters,[10] meaning that current climate change–related harm is likely to only worsen. Global evidence shows that the economic damage caused by cyclones is long-lasting and cumulative.[11] Countries never quite recover from the impact of one cyclone, let alone a series of them.

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[7] SPC's relevant divisions include Geoscience, Energy and Maritime (GEM), Fisheries, Aquaculture and Marine Ecosystems (FAME), Land and Resources Division (LRD), and Human Rights and Social Development (HRSD). The Climate Change and Environmental Sustainability programme also agrees with the following report. The profiles of these divisional directors as well as the author's curriculum vitae for this expert compilation can be found packaged at the end of this report.

[8] United Nations Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the United Nations Intergovernmental Panel on Climate Change, Cambridge University Press, 2022 (also available at: https://report.ipcc.ch/ ar6/wg2/IPCC_AR6_WGII_FullReport.pdf).

[9] *See mainly*, McGree, Simon, Grant Smith, Elise Chandler, Nicholas Herold, Zulfikar Begg, Yuriy Kuleshov, Philip Malsale, and Mathilde Rittman, SPC. *Climate Change in the Pacific 2022: Historical and recent variability, extremes and change.* Chapter 16 'Vanuatu'. https://purl.org/spc/digilib/doc/7wifz; and Gillett, Robert and Mereselita Fong. 2023. Fisheries in the economies of Pacific Island countries and territories (Benefish Study 4). Noumea, New Caledonia: Pacific Community. 704 p. https://purl.org/spc/digilib/doc/ppizh. SPC also received data on *Coral Reefs* and on *Biodiversity* from experts at the Secretariat of the Pacific Regional Environment Programme (SPREP) in consultation with the Government of Vanuatu.

[10] *See* World Risk Index 2021 available at https://www.preventionweb.net/publication/world-risk-report-2021-focus-social-protection.

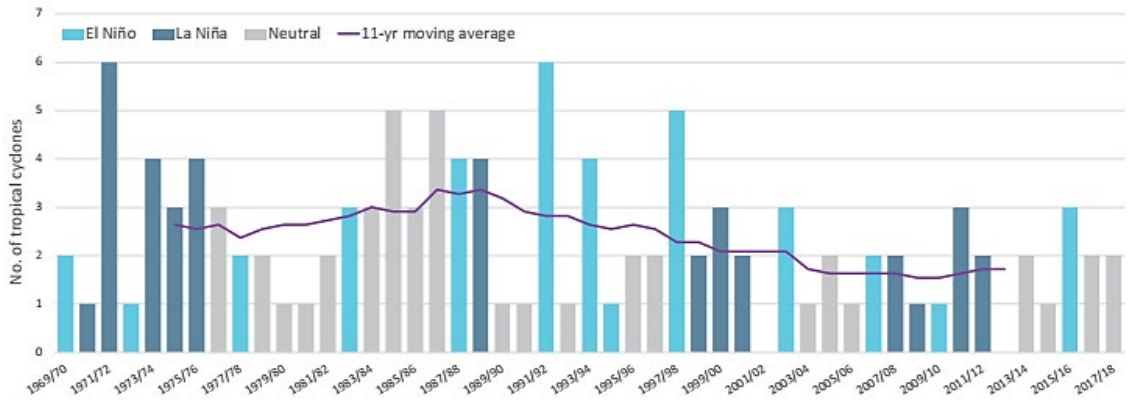
[11] United Nations Capital Development Fund (2020) at 5.

While current statistics for Vanuatu indicate an average annual loss of 20% GDP,[12] the impacts due to sea-level rise further reduce arable area, and hence agricultural and forestry production lags. GDP loss due to the frequency and intensity of cyclones occurring will certainly increase and adversely affect vulnerable aspects of nature and community into the future.

Tropical cyclones usually affect Vanuatu during the southern hemisphere tropical cyclone season, which is from November to April, but also occasionally occur outside the tropical cyclone season. The Southern Hemisphere Tropical Cyclone Archive indicates that between the 1969/70 and 2017/18 seasons, 117 tropical cyclones passed within the Vanuatu exclusive economic zone (EEZ) (see Figure 1).[13] This represents an average of 24 cyclones per decade. Tropical cyclones were most frequent in El Niño years (28 cyclones per decade), followed by La Niña years (26 per decade), and least frequent in neutral years (20 cyclones per decade).

Interannual variability in the number of tropical cyclones in the EEZ is large, ranging from zero in some seasons to six in 1971/72 and 1991/92, and five in 1984/85, 1986/87, and 1997/98. High interannual variability and the small number of tropical cyclones occurring in the EEZ make reliable identification of long-term trends in frequency and intensity difficult.[14] However, extensive data does exist for the loss and damages caused by previous extreme weather events that have had lasting impact on Vanuatu. For example, Cyclone Pam—a category 5 tropical cyclone struck Vanuatu killing 11 people, destroying and/or damaging over 17,000 buildings, and displacing 65,000 people—hit the island in 2015. The economic damages alone were estimated to be equivalent to 64% of Vanuatu's total gross domestic product (GDP).[15]

Figure 1. Number of tropical cyclones passing within Vanuatu EEZ per season.[16]



While the predictions for cyclones for the country are expected to decrease, there is likely to be an increase in the wind speed of between 2% and 11% and an increase in rainfall intensity of about 20%

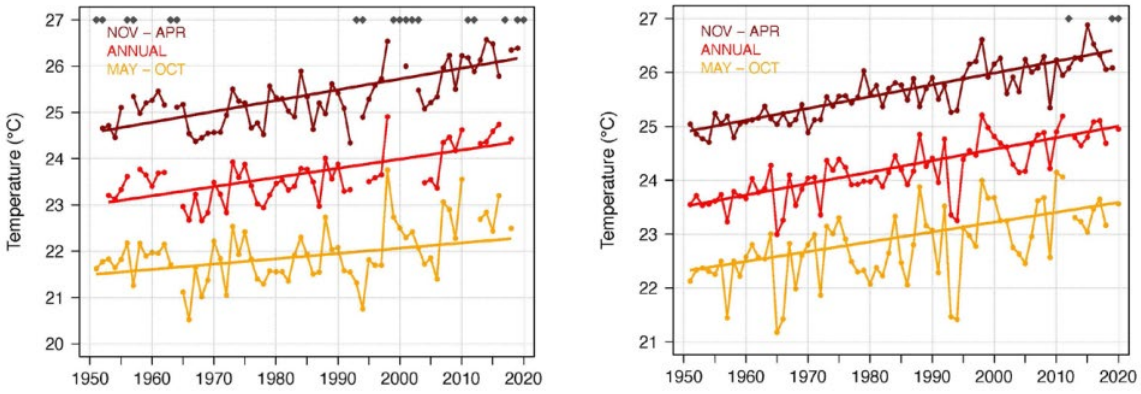
[12] United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), *Vanuatu twin cyclones underscore the Pacific's vulnerability to compounding climate disaster risks*, available at https://rb.gy/ay1pol (accessed 12 December 2023).
[13] McGree et al. *Climate Change in the Pacific 2022,* 205.
[14] Records of tropical cyclones exist from the late 1800s in some countries in the Southwest Pacific, but trends in tropical cyclones have only been presented from 1981/82. Satellite-based observations began in the Southwest Pacific in the early 1970s, but consistent coverage and reliable intensity estimates have only been available since the early 1980s. Confidence in tropical cyclone trends is moderate as the definition of a tropical cyclone has changed and satellite observation methods have continued to improve over the last 40 years.
[15] The World Bank Group, Climate Risk Country Profile: Vanuatu (2021), available at https://climateknowledgeportal.worldbank.org/sites/default/files/country-profiles/15825-WB_Vanuatu%20Country%20Profile-WEB.pdf
[16] Figure from McGree, S. et al. *Climate Change in the Pacific 2022*, 205.

within 100 km of the cyclone centre.[17] In the year 2023 alone, Vanuatu was impacted by three cyclones. The impact of the March cyclones to the economy of the country was estimated at 20% of its GDP.[18]

Temperature Rise

Average annual and seasonal temperatures are increasing in Vanuatu (see Figure 2). All temperature trends are statistically significant for the two sites SPC has measured, and November to April temperatures have increased faster than the May to October temperatures, with maximum temperatures increasing faster than minimum temperatures, especially outside Port Vila.[19] Seasonal temperature changes in Vanuatu are strongly connected to changes in the surrounding ocean temperature, so as one rises, it will influence the other.[20] SPC analysis determined that there is a clear shift towards warmer average monthly temperatures between the climatology periods of 1961–1990 and 1991–2020.

Figure 2. Average annual and seasonal temperature rise in Aneityum (left) and Port Vila (right).[21]



Water security, including floods and drought

Past droughts have caused significant impacts in Vanuatu affecting water security and agricultural production.[22] In the coming decades, droughts are projected to become longer and more intense, with a higher proportion of events in the extreme drought category, with little change in annual average rainfall projected.[23] At the same time, annual average temperature is projected to increase (see above), with more heatwaves and increased climate variability, through more extreme El Niños and La Niñas in the future, impacting water security.[24]

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[17] Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP), *Current and future climate of Vanuatu* (2015), available at https://www.pacificclimatechangescience.org/wp-content/uploads/2013/06/15_PACCSAP-Vanuatu-11pp_WEB.pdf.
[18] UNESCAP, *Vanuatu twin cyclones.*
[19] McGree et al., *Climate Change in the Pacific 2022*, 208.
[20] *Ibid*.
[21] Figure from *Climate Change in the Pacific 2022*, 208. Diamonds indicate years with insufficient data for one or more variables.
[22] Iese, Viliamu, Anthony S. Kiem, Azarel Mariner, Philip Malsale, Tile Tofaeono, Dewi GC Kirono, Vanessa Round et al. "Historical and future drought impacts in the Pacific islands and atolls." *Climatic Change* 166, no. 1 (2021): 19.
[23] Kirono, D., et al., National and sub-national climate projections for Vanuatu. 2023. CSIRO: Melbourne, Australia (accessed restricted).
[24] CSIRO and SPREP (2023), *Climate change impacts on water security in Vanuatu.* Info byte prepared for the Vanuatu Meteorology and Geo-hazards Department as part of the Van-KIRAP project. CSIRO: Melbourne, Australia. Given that access to clean drinking water is a fundamental human right, water security is identified in

In Vanuatu, major droughts occurred in 1982–1983, 1997–1998, and 2015–2016, with their frequency and intensity differing over space and time.[25] The latest drought occurred in the aftermath of Cyclone Pam, which had already caused considerable damage to agricultural production. Throughout the drought, most water tanks were empty or severely depleted. Villagers in 20% of households walked more than 30 minutes to collect water for cooking and washing.[26]

With extreme droughts becoming potentially longer and more intense under some emissions scenarios, the impacts on water security may worsen. Such impacts will likely include limitations in the supply of domestic and industrial water, including urban, peri-urban, and rural areas with deleterious consequences for public health, commerce, and overall economic productivity.[27] As has already been seen (see below), the agriculture sector impacts are especially affected and include reduced productivity, loss or reduced output of crops and livestock, deleterious consequences for food security for local communities, and reduced exports affecting the economy more broadly. For example, research conducted in the western region of Ambae has revealed a concerning vulnerability in the boreholes situated near the shoreline. These crucial water sources, relied upon by local communities for potable water, are prone to salinization during extended dry spells that will be further impacted by more extreme El Niño events in the future.[28]

While data shows no significant predicted change in the trend of annual rainfall, extreme daily precipitation is predicted to increase. On average, across the country, daily extreme rainfall events are expected to produce an average of 6.5% more precipitation by 2050 under RCP4.5 projections. However, 95th percentile estimates indicate precipitation on any given event could be as high as 77.5% higher than baseline observations, indicating individual events over a season or year could cause dramatically higher precipitation events. This is also correlated to the predicted increase in tropical cyclone intensity and rainfall. Damage to water and sanitation infrastructure caused by extreme wind and flooding events can lead to overflows in pit latrines or makeshift structures, reducing access to safe facilities and increasing the health burden of exposed communities.

Agriculture

The agriculture and forestry sectors of Vanuatu are highly prone to the impacts of climate change, especially concerning extreme weather events like cyclones. An impact assessment carried out in 2020 after Tropical Cyclone Pam estimated that the economic loss to the agriculture sector was 8% of the country's GDP. The crop damage was around 69% of the total agricultural damage with forestry estimated at 16%. The populations most impacted were also those most vulnerable, including farming communities operating at the subsistence levels.[29]

Studies carried out by SPC in the northern province of Vanuatu documented several climate change-related harms to agriculture in these communities, including a relatively high exposure and sensitivity to climate change impacts and lower abilities to adapt to such changes. For example, some of the identified climate-related impacts on agriculture production involved changes in behaviour of plants and livestock, resulting in reduced productivity. Weather patterns also closely correlated with increased

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the Vanuatu National Sustainable Development Plan (NSDP) as an important issue, particularly in a changing climate.

[25] *Ibid*.

[26] Vanuatu Government, Post-Disaster Needs Assessment Tropical Cyclone Pam, March 2015. 2015: Port Vila, Vanuatu, available at https://www.dfat.gov.au/sites/default/files/post-disaster-needs-assessment-cyclone-pam.pdf.

[27] CSIRO and SPREP (2023), 3.

[28] SPC Recovery Support for Tropical Cyclone Pam: Groundwater Investigation, West Ambae, Vanuatu (2017) (access restricted).

[29] UN Capital Development Fund (2020), Economic impacts of natural hazards on vulnerable populations in Vanuatu, available at https://www.uncdf.org/article/6318/climate-risk-insurance-literature-reviews.

incidence of pests and disease problems.[30] Other impact assessments projected the climate change as causing significant damage to the infrastructure and equipment needed for a productive agriculture sector.[31]

Food security

These climate change–related harms compound and contribute to increased food and nutrition insecurities, especially for rural communities. With more than 50% of the household's dietary energy consumption purchased, the increase in prices of food after natural disasters puts them at greater risk. It is estimated that 29% of children in Vanuatu are stunted, which is higher than the Pacific average of 20%, around 4% of children are wasted and 11% are underweight.[32] While the statistics for wasting and underweight children are below the average rate for the Pacific average, this is not to say that as communities become more impacted by climate change, the prevalence of these food insecurity issues will increase.

The compounding nature of the climate crises is also found in the fisheries industry. Nearly three-quarters (71%) of the population enjoy free access to marine resources including fish, shellfish, and more. Just under one-third (31%) of households in Vanuatu have members actively engaged in fishing and 29% of households consume free fish from home production at least once a week. Fish, shellfish, and their products contribute to only 4% of the average dietary energy consumption,[33] meaning that more than half of the dietary energy consumed is purchased, despite free access to marine resources.[34]

For Pacific Islands like Vanuatu, climate change–related impacts significantly affect ocean and coastal areas. While the ocean covers two-thirds of the planet, the Pacific Ocean is the largest, occupying the most surface area, carrying nearly one-third of the world's marine resources, and comprising 20% of the global exclusive economic zones (EEZ).[35] Ocean and coastal ecosystems host vast biodiversity and modulate global climate systems by regulating heat, water, and elements like carbon. Marine systems are also central to Pacific cultures, providing food, minerals, energy, and employment to its peoples, of which Vanuatu is no exception.

Sea-level rise

Sea level observations from satellite altimetry over the last 30 years show a positive trend (increase) across the western tropical Pacific, and in many countries, the rate of sea-level rise is higher than the global average over that same period.[36] Sea level in Vanuatu, measured by satellite altimeters since 1993,[37] has risen between 3.5 millimetres (mm) and 5 mm per year across the EEZ, with a confidence

[30] SPC, Climate change vulnerability assessments for communities in six Pacific Island countries: Fiji, Kiribati, Samoa, Solomon Islands, and Vanuatu (2016), available at https://ccprojects.gsd.spc.int/wp-content/uploads/2016/04/Web_whole_Climate_change_Vulnerability_Assessments.compressed.pdf.
[31] *Ibid*.
[32] UNICEF, *Situational Analysis of Children in Vanuatu* (2017) available at https://www.unicef.org/pacificislands/media/1281/file/Situation-Analysis-of-Children-Vanuatu.pdf.
[33] Vanuatu National Statistics Office (VNSO), Food and Agriculture Organization of the United Nations (FAO), and SPC, 2021. *The Vanuatu Food Security Profile* available at https://www.fao.org/3/cb3785en/cb3785en.pdf.
[34] *Ibid*.
[35] Seidel, Henrike and Padma N. Lal, *Economic value of the Pacific Ocean to the Pacific Island Countries and Territories*, IUCN, 2010 (available at: https://www.iucn.org/sites/default/files/import/downloads/economic_value_of_the_pacific_ocean_to_the_pacific_island_countries_and_territories_p.pdf).
[36] McGree et al., *Climate Change in the Pacific 2022*, 207.
[37] SPC has completed lidar imagery acquisition for selected islands in Vanuatu. Lidar data is high-resolution topography and bathymetry imagery that can be used for multiple applications such as ocean modelling, hydrographic mapping, infrastructure development, planning, etc. including capturing climate change–related impacts and corresponding damage over time.

interval of ±0.4 mm in the south and up to ±1.0 mm in the north. Most of the EEZ exhibits sea-level rise that is larger than the global average of 3.1 ± 0.4 mm per year.[38] For example, Nguna-Pele Islands already faces coastal inundation and erosion, water salination, and land degradation exacerbated by sea-level rise. These impacts are exacerbated by other adverse effects of climate change including disrupted precipitation patterns, soil nutrient loss, and hillside erosion. While Vanuatu has implemented adaptation plans to address these effects, most of the impacts appear to be irreversible, amounting to losses.[39]

Sea-level rise is expected to continue to rise in Vanuatu in all emission scenarios. By 2030, under a high emissions scenario, an average of 12 centimetre (cm) is projected (see Table 1).[40] The projection for the intermediate emissions scenario paints an even more harrowing picture for small island developing states like Vanuatu because the sea level would rise by approximately 67 cm by 2100 and even about 26 cm as early as 2050 (see Figure 3). As the ocean encroaches upon the land, it is not merely the physical landscape that faces changes; it is the essence of how people live and thrive. As coastal areas become increasingly uninhabitable, communities face the heart-wrenching prospect of abandoning ancestral homes. This upheaval not only severs ties to land and heritage but also disrupts social structures, community cohesion, and cultural identity, and makes people deeply vulnerable.

Table 1. Decadal increments for projections of sea-level rise in metres for Vanuatu relative to the 1995–2014 mean sea-level rise.[41]

Year	*Low* SSP1-2.6	*Intermediate* SSP2-4.5	*High* SSP3-7.0	*Very High* SSP5-8.5	*Very High – Low* SSP5-8.5 H+
1995–2014	0.00	0.00	0.00	0.00	0.00
2020	0.07 (0.04–0.10)	0.07 (0.03–0.11)	0.07 (0.03–0.10)	0.07 (0.04–0.10)	0.07 (0.04–0.11)
2030	0.12 (0.08–0.17)	0.12 (0.08–0.17)	0.12 (0.08–0.17)	0.13 (0.10–0.17)	0.13 (0.10–0.20)
2040	0.18 (0.12–0.24)	0.18 (0.13–0.25)	0.18 (0.13–0.25)	0.20 (0.15–0.27)	0.21 (0.15–0.33)
2050	0.24 (0.18–0.32)	0.26 (0.20–0.34)	0.27 (0.20–0.35)	0.29 (0.22–0.38)	0.30 (0.21–0.48)
2060	0.30 (0.22–0.40)	0.33 (0.25–0.43)	0.35 (0.27–0.45)	0.38 (0.30–0.49)	0.40 (0.29–0.68)
2070	0.37 (0.28–0.49)	0.41 (0.31–0.55)	0.45 (0.35–0.59)	0.49 (0.38–0.65)	0.52 (0.38–0.92)
2080	0.43 (0.32–0.59)	0.50 (0.38–0.68)	0.56 (0.43–0.74)	0.61 (0.47–0.82)	0.67 (0.47–1.21)
2090	0.49 (0.37–0.68)	0.59 (0.44–0.80)	0.67 (0.52–0.90)	0.76 (0.59–1.01)	0.85 (0.59–1.53)
2100	0.56 (0.40–0.79)	0.67 (0.47–0.94)	0.81 (0.61–1.10)	0.93 (0.71–1.25)	1.06 (0.71–1.89)
2110	0.65 (0.44–0.92)	0.76 (0.51–1.09)	0.92 (0.64–1.27)	1.04 (0.74–1.46)	1.26 (0.74–2.23)
2120	0.71 (0.48–1.02)	0.85 (0.57–1.22)	1.05 (0.73–1.46)	1.19 (0.84–1.67)	1.50 (0.84–2.55)
2130	0.77 (0.51–1.12)	0.93 (0.62–1.35)	1.17 (0.81–1.64)	1.33 (0.94–1.87)	1.75 (0.94–3.34)
2140	0.84 (0.55–1.21)	1.02 (0.68–1.48)	1.30 (0.90–1.82)	1.46 (1.03–2.07)	2.03 (1.03–4.41)
2150	0.89 (0.59–1.30)	1.11 (0.73–1.61)	1.42 (0.98–2.00)	1.59 (1.11–2.26)	2.34 (1.11–5.59)

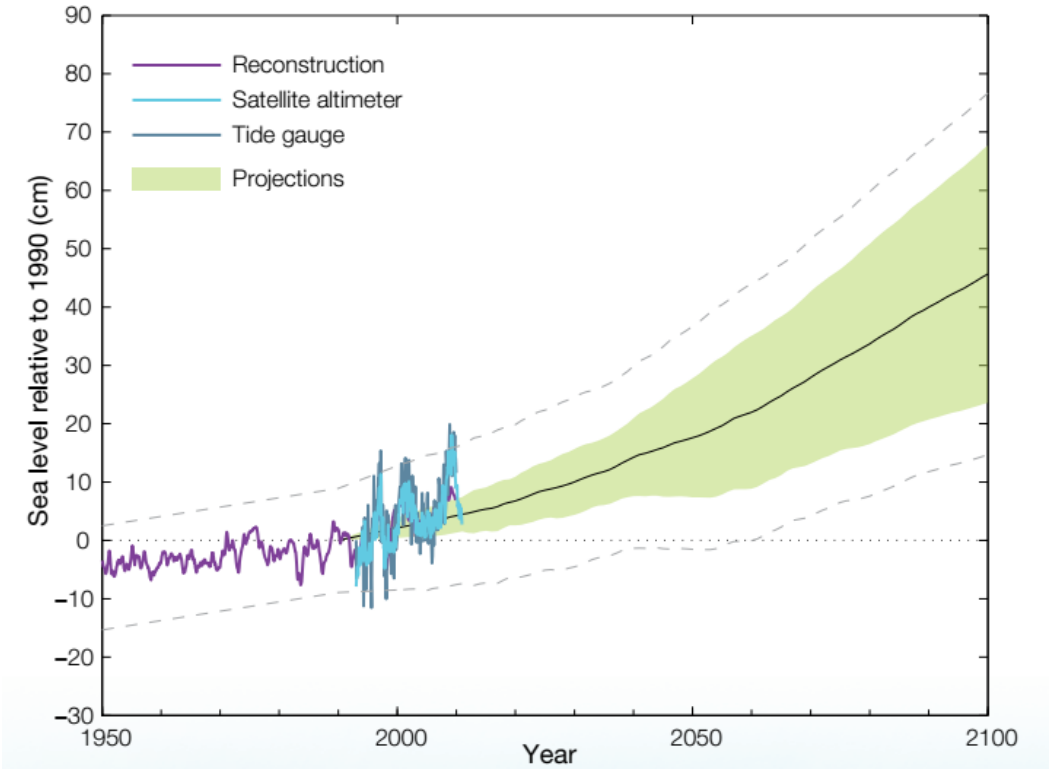
[38] von Schuckmann, Karina, Pierre-Yves Le Traon, Neville Smith, Ananda Pascual, Samuel Djavidnia, Jean-Pierre Gattuso, et al. 2021. Copernicus Marine Service Ocean State Report, issue 5. *Journal of Operational Oceanography*, 14, 1–185. doi: 10.108 0/1755876X.2021.1946240. This rise is partly linked to a pattern related to climate variability from year to year and decade to decade. Trend estimates at the Port Vila tide-gauge over a similar time span to the altimetry observations from January 1993 to July 2020.

[39] Nguna-Pele Islands is one of two pilot sites for implementing climate change adaptation measures under SPC's Coping with Climate Change in the Pacific Islands Region (CCCPIR) programme.

[40] International Climate Change Adaptation Initiative, Vanuatu Meteorology and Geo-hazard Department, Australian Bureau of Meteorology, and Commonwealth Scientific and Industrial Research Organisation (CSIRO) Pacific Climate Change Science Program, *Current and future climate of Vanuatu* (2011), available at https://www.pacificclimatechangescience.org/wp-content/uploads/2013/06/15_PCCSP_Vanuatu_8pp.pdf.

[41] Table from *PRIF (2021): Guidance for managing Sea Level Rise Infrastructure Risk in Pacific Island Countries*, published December 2021, available at https://www.theprif.org/sites/default/files/documents/PRIF_SLR-Report_Digital_0.pdf. Projections based on IPCC (2021) sourced from AR6 and interpolated to nearest decade and adjusted for the upper bound of the most *likely* vertical land movement defined by Fox-Kemper et al. (2021).

Figure 3. Observed and projected relative sea-level change near Vanuatu.[42]



Coastal inundation

Studies have documented significant harm caused by climate change across Vanuatu's islands and waters (see Image 1). For example, Teouma (South Efate) has suffered losses and damages due to rainfall variability, soil nutrient loss, high wind exposure, and excessive temperatures.[43] These climate change–exacerbated environmental impacts have forced many communities to abandon their ancestral lands and important traditional food sources and relocate to safer areas, often resulting in the loss of cultural heritage, cultural identity, cultural practices, social cohesion, and economic stability, causing insecurity. The displacement of these communities poses significant challenges in terms of safeguarding human rights, ensuring access to basic services, and maintaining community structures. There are also many implications for receiving communities and the ability of nations to effectively relocate communities where there are limited land resources and highly complex land tenure systems.[44]

[42] Graphic from *Current and future climate of Vanuatu* (2011), 7. The observed sea-level rise records are indicated in dark blue (relative tide-gauge observations) and light blue (the satellite records since 1993). Reconstructed estimates of sea level near Vanuatu since 1950 are shown in purple. The dashed lines are an estimate of 90% of the range of natural year-to-year variability in sea level.

[43] Teouma (South Efate) is the other pilot island under CCCPIR.

[44] *See e.g.,* Pacific Climate Change Migration and Human Security (PCCMHS) Programme*, Regional policy dialogue: Summary Report, 2022* (available at https://www.preventionweb.net/publication/pacific-climate-change-migration-and-human-security-pccmhs-programme-regional-policy).

Image 1. Projected inundation for extreme sea levels with an average recurrence of 10 years, 50 years, and 100 years for the Vanuatu coast.[45]



The inundation projections are calculated through extreme-value analysis from a 40-year SCHISM-WWMIII simulation[46] of the ocean around Vanuatu, which accounts for sea-level variations due to tides, waves, storm surge, and background variability combined with projected sea-level rise from the Next Generation Climate Projections for the Western Tropical Pacific. Data is available for the periods of 2020–2039, 2040–2059, 2060–2079, and 2080–2099, for emissions scenarios at representative concentration pathway (RCP) 2.6 (lower emissions) and RCP 8.5 (higher emissions) as well as for the baseline period representing near-current sea-level extremes. Noting that over 90% of Vanuatu's population lives within 5 kilometres of the coast, critical infrastructure is found in locations where there are varying degrees of exposure and vulnerability to such climate hazards.[47]

Damage has already been documented under current climate conditions (see Image 3). For the period of 1980–2020, regions of 10-, 50-, and 100-year coastal inundation (from light to dark blue) include roads that are inundated under current climate conditions.[48] With the sea-level rise observed over the western tropical Pacific of about 10–15 cm on average since 1993, the compounding issues have caused consequences for Vanuatu, particularly in low-lying coastal areas that are the most vulnerable to flooding and erosion. While vertical land motion due to earthquakes has offset some of the effects of

[45] Image from the Vanuatu Climate Futures Portal available at https://www.vanclimatefutures.gov.vu/dashboard/home.
[46] Recent technological advances have allowed for a high-resolution numerical model capable of analysing ocean dynamics to better understand how storms will impact local beaches on a Vanuatu-wide scale. The advanced, high-resolution (in the coastal zone ~100 m) 3D finite element hydrodynamic model (SCHISM) coupled with the state-of-the-art WWMIII wave model is capable of two-way information exchange between the hydrodynamic model and wave model to provide the most advanced simulations to date.
[47] CSIRO and SPREP (2023). Current and projected coastal inundation affecting roads in Vanuatu. Infobyte prepared for the Vanuatu Meteorology and Geo-hazards Department as part of the Van-KIRAP project. CSIRO: Melbourne, Australia.
[48] *Ibid*.

sea-level rise on relative sea level in some locations[49] (and can sometimes explain differences in long-term sea level trends between land-based tide gauges and satellite altimetry), at the national scale, Vanuatu remains vulnerable to the long-term effects of sea level rise.

Image 3. Coastal inundation of the road running between Kauwenu sport field and the coast (left) and a coastal road in Luganville, Santo (right).

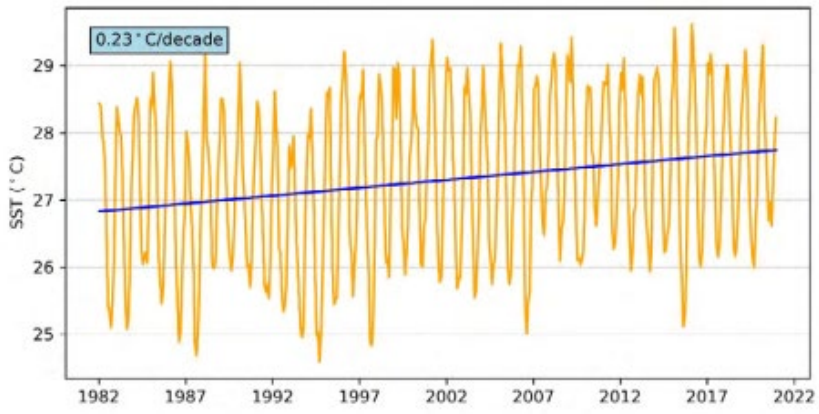


Ocean warming, acidification, and deoxygenation

Ocean warming, acidification, and deoxygenation will continue to increase this century at rates dependent on future emissions of carbon dioxide and greenhouse gases.[50] Since 1993, the rate of ocean warming (and thus heat uptake) has more than doubled and is attributed to anthropogenic forcing, or human-caused changes in concentrations of greenhouse gases despite climate variations that naturally occur. Anthropogenic change has been detected in surface temperature with very high significance levels, a conclusion strengthened by the detection of anthropogenic change in the upper ocean with a high significance level. In Vanuatu, surface-level ocean warming is in line with the conclusion against upper ocean warming being due to natural internal processes (see Figure 4). Observed change is very large relative to climate-model simulated internal variability.[51]

[49] Brown, N.J., A. Lal. B. Thomas, S. McClusky and J. Dawson, G. Hu and M. Jia. Vertical motion of Pacific Island tide gauges: Combined analysis from GNSS and levelling. Geoscience Australia, 2020. doi: 10.11636/Record.2020.003.
[50] Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2022*.
[51] Intergovernmental Panel on Climate Change (IPCC), *Combining Evidence of Anthropogenic Climate Change*.

Figure 4. Sea surface temperature from satellite observations averaged across the Vanuatu EEZ.[52]



In terms of sea surface temperature rise in Vanuatu, existing harm can best be captured in what is known as marine heat waves (MHWs), defined as 'discrete, prolonged anomalously warm water events which last for five or more days, with sea surface temperatures warmer than the 90th percentile relative to climatological values. Across Vanuatu historically there has been an increasing frequency of MHWs (1982–2021), mostly in the 'Moderate' to 'Strong' category.[53]

Broadly speaking, northern Vanuatu has experienced more frequent, longer duration and higher intensity MHWs than southern Vanuatu for the period 1982–2021.[54] Across all sites, historically the typical number of MHWs is around 25 days per year (20-year average centred on 1995). Under the low greenhouse gas emissions scenario (SSP126), this is projected to increase to about 80–150 days per year by 2050. Under the high emissions scenario (SSP585) this increases to about 170–310 days per year by 2050, with many days in the 'Strong' and 'Severe' MHW categories.[55]

There may also be broader biological, hydrological, physical, and chemical processes (e.g., fish spawning and recruitment, food web and critical habitat relationships, diurnal feeding and distributional patterns, nutrient cycling, etc.) sensitive to MHWs in winter.[56] Winter MHWs on top of long-term warming can also enable the establishment of invasive species in some instances where previously cool winters would have killed them off. The existing issues and projected changes to the key features of the tropical Pacific Ocean surrounding Vanuatu relative to the long-term averages are expected to result in increases to sea surface temperatures, sea level, and ocean acidification (see Table 2).[57]

[52] Image taken from *Climate Change in the Pacific 2022*, 206. Satellite observations are shown as the orange lines and the blue line shows the linear regression trend depicting the rise in temperature over time.
[53] CSIRO, SPREP and VMGD (2023). *Historical, current and future marine heatwave climatology for Vanuatu*. A report to the Van-KIRAP project. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Secretariat of the Pacific Regional Environment Programme (SPREP) and Vanuatu Meteorology and Geo-hazards Department (VMGD), CSIRO Technical Report, Melbourne, Australia.
[54] *Ibid*., 3.
[55] *Ibid*.
[56] Shanks, Alan L., Leif K. Rasmuson, Jenna R. Valley, Marley A. Jarvis, Carly Salant, David A. Sutherland, Eleanor I. Lamont, MacKenna A.H. Hainey, and Richard B. Emlet, "Marine heat waves, climate change, and failed spawning by coastal invertebrates." *Limnology Oceanography*, 2020. 65(3): 627-636.
[57] Bell J.D., Johnson J.E., Ganachaud A.S., Gehrke P.C., Hobday A.J., Hoegh-Guldberg O., Le Borgne R., Lehodey P., Lough J.M., Pickering T., Pratchett, M.S. and Waycott M (2011), *Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change, Summary for Pacific Island Countries and Territories*. Secretariat of the Pacific Community, Noumea, New Caledonia.

Table 2. Current and projected changes in ocean features over time.[58]

Ocean feature	1980–1999 average	Projected change			
		B1 2035	A2 2035	B1 2100*	A2 2100
Sea surface temperature (°C)	27.1[a]	+0.6 to +0.8	+0.7 to +0.8	+1.2 to +1.6	+2.2 to +2.7
Sea level (cm)	+6 since 1960				
IPCC **		+8	+8	+18 to +38	+23 to +51
Empirical models ***		+20 to +30	+20 to +30	+70 to +110	+90 to +140
Ocean pH (units)	8.08	-0.1	-0.1	-0.2	-0.3
Currents	Increase in South Pacific gyre	SEC decreases at equator; EUC becomes shallower; SECC decreases and retracts westward			
Nutrient supply	Decreased slightly	Decrease due to increased stratification and shallower mixed layer			< -20%

* Approximates A2 in 2050; ** projections from the IPCC-AR4; *** projections from recent empirical models (Chapter 3, Section 3.3.8); a = average for EEZ derived from the HadISST dataset; SEC = South Equatorial Current; EUC = Equatorial Undercurrent; SECC = South Equatorial Counter Current.

Under all emissions scenarios, the acidity level of sea waters in the Vanuatu region will continue to increase over the 21st century, with the greatest change under the very high emissions scenario. The impact of increased acidification on the health of reef ecosystems is likely to be compounded by other stressors including coral bleaching, storm damage, and fishing pressure,[59] with many of those systems already showing large-scale bleaching.

About one quarter of the carbon dioxide emitted from human activities each year is absorbed by the oceans. As the extra carbon dioxide reacts with sea water it causes the ocean to become slightly more acidic. Due to closely linked changes in seawater chemistry, less oxygen remains available; a process known as ocean deoxygenation. This impacts the growth of corals and organisms that construct their skeletons from carbonate minerals. These species are critical to the balance of tropical reef ecosystems. Data show that since the 18th century, the level of ocean acidification has been slowly increasing in Vanuatu's waters.[60]

Pelagic fisheries and tuna stock

Pelagic fish inhabit the water column (meaning not near the bottom or the shore) of coasts, open oceans, and lakes.[61] Oceanic pelagic fish, such as tuna, are highly adept at long-distance migration, can travel with ocean currents, and inhabit the pelagic zone—the largest habitat on earth.[62] The Pacific Island Forum Fisheries Agency's (FFA) 'Tuna Report Card' for 2022 estimates Vanuatu's average annual tuna export during the period of 2018–2020 at USD 91 million. It also indicates that over that same period, an annual average of 560 people in Vanuatu had tuna-related employment encompassing the harvest, processing, and ancillary service sectors, observers, and government employees (artisanal/cultural

[58] Image taken from *Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change, Summary for Pacific Island Countries and Territories*, see note 57, at 265 (projections for AR6 forthcoming).
[59] Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP). *Current and future climate of Vanuatu*, 9, available at https://www.pacificclimatechangescience.org/wp-content/uploads/2013/06/15_PACCSAP-Vanuatu-11pp_WEB.pdf (updated versions forthcoming).
[60] *Ibid*. at 5.
[61] *See* the National Oceanic and Atmospheric Administration (NOAA) definition—What are pelagic fish? available at https://oceanservice.noaa.gov/facts/pelagic.html.
[62] *Ibid*.

sector not included).[63] All in all, pelagic fish constitute a major nutrient source for the people of Vanuatu, as collected from household surveys and village-level data on women's food consumption (see Table 3).

Table 3. Mean daily per capita consumption of aquatic foods in Vanuatu.[64]

Aquatic food group	National	Rural	Urban
Pelagic fish	14.4 (0.63)	18.0 (0.82)	4.4 (0.49)
Reef fish	7.2 (0.49)	7.6 (0.58)	6.1 (0.88)
Canned fish	14.1 (0.30)	13.3 (0.30)	16.3 (0.68)
Shellfish	1.6 (0.08)	2.0 (0.11)	0.44 (0.05)
Mixed fresh/frozen fish	1.4 (0.11)	1.7 (0.14)	0.58 (0.16)
Aquatic food (total)	38.8 (0.99)	42.6 (1.23)	27.9 (1.40)

Source: Farmery et al. (2020); Units: Edible portion in grams ± standard error

The scarcity of natural resources and limited private sector development in the Pacific makes the tuna industry vital to island economies. If emissions continue to rise throughout the twenty-first century (highest baseline emissions scenario), there will be a statistically significant redistribution of tuna by 2050.[65] As they shift east, the local decline in tuna fish means they will move from coastal states' EEZs to the high seas or international waters. This results in an average annual loss of revenue from fishing access fees that is upwards of USD 90 million.[66] For Vanuatu, this impact on communities is unsustainable.

Coastal fisheries

Coastal commercial fisheries production for Vanuatu is estimated to produce Vanuatu vatu (VT) 572.4 million.[67] With two-thirds of Vanuatu's population living along the coast, Vanuatu people depend on fish and other marine resources for food and income. In times of hardship—when natural disasters strike, or yields fail—Vanuatu turns to the sea for sustenance. With increasing pressures (e.g., population growth, natural disasters, and climate change), managing coastal fisheries is crucial now and for generations to come.[68]

Climate change impacts on marine ecosystems and their services put key cultural dimensions of lives and livelihoods at risk, including through shifts in the distribution or abundance of harvested species and diminished access to fishing or areas. This includes potentially rapid and irreversible loss of culture,

[63] Forum Fisheries Agency, Tuna Fishery Report Card (2022), Honiara, available at https://www.spc.int/DigitalLibrary/Doc/FAME/Brochures/FFA_2022_Tuna_Fishery_Report_Card.html.
[64] Table from Farmery Anna K., Jessica M. Scott, Tom D. Brewer, Hampus Eriksson, Dirk J. Steenbergen, Joelle. Albert, Jacob Raubani, Jillian Tutuo, Michael K. Sharp and Neil L. Andrew. 2020. "Aquatic Foods and Nutrition in the Pacific." *Nutrients*, 12, (2020) 3705. doi:10.3390/nu12123705.
[65] Bell et al., "Pathways to sustaining tuna-dependent Pacific Island economies during climate change", *Nature Sustainability*, 4, 2021, 900-910 ('could reduce total annual fishing access fees earned by the ten Pacific SIDS by an average of US$90 million (range = –US$40 million to−US$140 million) per year compared with the average annual revenue.') (available at: https://www.nature.com/ articles/s41893-021-00745-z).
[66] *Ibid*., 901. Additionally, recent review work across SPC's 22 member countries and territories has highlighted that the volume of fishery production between 2007 and 2021 increased by 20.3% (*Ibid.*), denoting further importance of fisheries as significant income generation in the Pacific.
[67] Gillett and Fong*, Benefish Study 4* (*see* note 9), 284.
[68] Vanuatu Fisheries Department (2019) *Vanuatu National Roadmap for Coastal Fisheries: 2019–2030. Noumea, New Caledonia: Pacific Community*, adapted from the Forward by Honourable Hosea NEVU (MP), Minister of Agriculture, Livestock, Forestry, Fisheries and Biosecurity.

traditional practices, and Indigenous knowledge as well as negative impacts on traditional diets and food security.[69]

Coral reefs and biodiversity

Significant losses of area and local extinctions of warm-water coral reefs have been observed across Vanuatu, especially as regards annual severe bleaching events when water temperature increases. This is compounded by severe cyclones that reduce the structural complexity of coral reef habitat. Structurally complex fast-growing branching corals tend to be more susceptible to bleaching and they die when temperature stress persists. Once dead, algae and other bioeroders colonise the skeleton, which then breaks up into rubble under typical wave forcing, especially during heavy seas caused by cyclones. Structurally complex coral colonies also have greater surface area and therefore are more susceptible to wave damage during cyclones.[70]

Data from the Millennium Coral Reef Mapping Project shows that Vanuatu's corals are damaged and at risk.[71] Many of the reef locations in Vanuatu have historically been refugia—defined as an area where coral species can survive during periods of adverse conditions where corals would die elsewhere—from thermal stress that causes coral bleaching. Reef locations that represent historical refugia are Tanna, Southern Efate, Ambrym, North Pentecost, and West Maewo Islands.[72] These historical refugia were less frequently exposed to severe thermal stress in the past 30 years and had relatively low rates of change in warm season temperatures and relatively high warm season variability – especially around Epi, West Pentecost, and West Maewo Islands. Climate model projections for Vanuatu suggest that some of these historical refugia are also temporary refugia from future severe thermal stress.[73] That is, they are projected to experience annual severe bleaching seven or more years later than the average for Vanuatu in 2040. This is especially true for the reefs of Tanna, Epi, and West Maewo Islands. Worldwide, almost all warm-water coral reefs are projected to suffer significant losses even if global warming is limited to 1.5 °C.[74]

Regarding biodiversity, Vanuatu has different reef types including fringing, platform and oceanic ribbon reefs, and atolls. The reefs contain significant biodiversity with records of 295 hard corals, 469 reef fishes, and 18 species of sea cucumbers. Seismic events and cyclones periodically cause significant

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[69] *See* SPC written submission to International Tribunal for the Law of the Sea (ITLOS) at https://www.itlos.org/fileadmin/itlos/documents/cases/31/written_statements/2/C31-WS-2-5-SPC.pdf.

[70] Maynard J, Heron S, van Hooidonk R, and D Tracey (2018) *Past and projected future impacts of coral bleaching on the reefs of Vanuatu*. Report to the Secretariat of the Pacific Regional Environment Programme (SPREP), Apia, Samoa (19 pp) (reference provided by SPREP).

[71] Andréfouët, S., F. E. Muller-Karger, J. A. Robinson, C. J. Kranenburg, D. Torres-Pulliza, S. A. Spraggins, and B. Murch (2005). *Global assessment of modern coral reef extent and diversity for regional science and management applications: a view from space*. Y. Suzuki, T. Nakamori, M. Hidaka, H. Kayanne, B. E. Casareto, K. Nadaoka, H. Yamano, M. Tsuchiya, and K. Yamazato, Editors. Tenth International Coral Reef Symposium. Japanese Coral Reef Society, Okinawa, Japan. CDROM. Pages 1732-1745.

[72] *See* Note 70, *Past and projected future impacts of coral bleaching on the reefs of Vanuatu*, 3.

[73] *Ibid*.

[74] Hoegh-Guldberg, Ove, Daniela Jacob, Michael Taylor, Marco Bindi, Sally Brown, Ines Camilloni, Arona Diedhiou, Riyanti Djalante, Kristie L. Ebi, Francois Engelbrecht, Joel Guiot, Yasuaki Hijioka, Shagun Mehrotra, Antony Payne, Sonia I. Seneviratne, Adelle Thomas, Rachel Warren, and Guangsheng Zhou, 2018: *Impacts of 1.5ºC Global Warming on Natural and Human Systems*. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T.Maycock, M.Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 175-312. doi:10.1017/9781009157940.005.

damage to Vanuatu's coral reefs. This is due to Vanuatu's location on the western margins of the Pacific plate. Of Vanuatu's 16 volcanoes, nine are active, and earthquakes and eruptions occur regularly.

Figure 5: Timeline of major events causing significant harm in Vanuatu.[75]

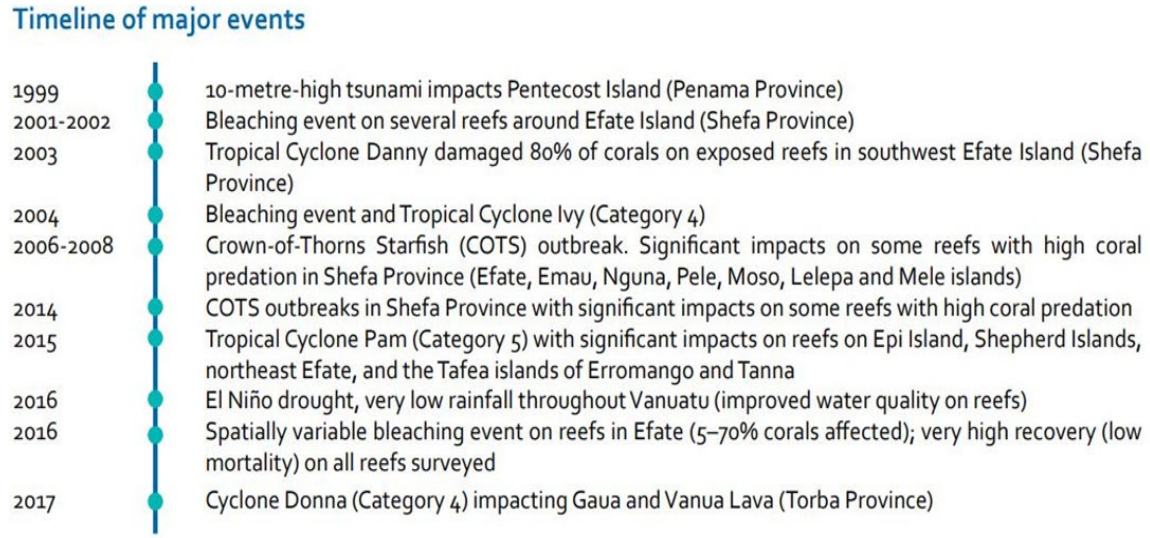


Figure 5 is a timeline of major events that outlines a selective list of local events (natural and anthropogenic) affecting coral reefs and local management as well as major conservation efforts that occurred in Vanuatu.

IV. CONCLUSION

Climate change is causing significant harm to Pacific Island countries, including Vanuatu. This harm materialises in the form of increasing ocean temperatures, sea level rise, ocean acidification, disrupted weather patterns, extreme weather events, prolonged drought, and other impacts.[76] Projections indicate that these impacts are bound to intensify, threatening to render some or all land territory of these countries uninhabitable. The extent to which this existential threat materialises will heavily depend on actions taken to curb anthropogenic greenhouse gas emissions—the vast majority of which is generated outside of its borders—as well as measures to adapt to climate change and respond to the loss and damage it causes.

[75] Moritz, Charlotte, Jason Vii, Warren Lee Long, Jerker Tamelander, Aurélie Thomassin, Serge Planes (eds.). (2018) Status and Trends of Coral Reefs of the Pacific. Global Coral Reef Monitoring Network, 212, available at https://gcrmn.net/wp-content/uploads/2022/06/Status-and-Trends-of-Coral-Reefs-of-the-Pacific-2018.pdf.
[76] *See also* note 69.

Annex G

I, Werry Narua, from Port Resolution, Tanna, Vanuatu solemnly affirm and declare:

Background

1. I am a Vanuatu national and I live in Port Resolution on the island of Tanna in Vanuatu. The Kastom (custom) name for Port Resolution is Irepao.

2. I provide a statement to the International Court of Justice on the changes to the weather patterns that I have observed and experienced in Port Resolution and the impacts that this is having on my Kastom and on my home.

3. I speak Nafe, as my local language, and French, Bislama and English. I have given my testimony in English.

4. I have provided some photos to the lawyers and the lawyers took some photos when they visited my village and my place. I would have liked to have attached them to this statement, but there are no printing facilities for the photos and they will be provided to the Court in another way.

5. My testimony is based on my direct knowledge and my knowledge based on Kastom, which has been passed down to me from my parents, grandparents and great grandparents and my ancestors.

6. I am 45 years old. I have 4 children. My eldest daughter is Esdher, who is 14, the next eldest is my son Nowar, who is 13. Mary, another daughter is 8, and my youngest daughter Elizabeth is 5.

7. I come from two Chiefly lineages. My younger brother is the High Chief of Irepao, who makes the decisions for our village. My older brother is a Tupunis, which is a special type of Chief with special knowledge. His special knowledge is about the banana. In our tradition, I assist both brothers in their roles. My lineage provides me with a special status within the village, including entitlements related to yam and special knowledge and privilege related to banana.

8. I am a farmer. I grow all kind of bananas and other crops. My family and I have traditional and specialised knowledge about all aspects of the banana, including using it for traditional medicine.

9. I am also a manager of the Yacht Club at Port Resolution, which is owned by the five Tribes that live around the bay of Port Resolution.

Port Resolution and Irepao

10. Port Resolution has a lot of history and is very beautiful. It is a peninsula, where there is a curved inlet which is a Bay, and on the other side is the coast, including beaches. My village and my land is on a cliff, which overlooks the Bay of Port Resolution.

11. Port Resolution was named after the ship Resolution, which was the ship that Captain Cook was voyaging on when he anchored there in 1774. When Captain Cook came ashore, my ancestors met him. Captain Cook picked up the soil and asked the name. My ancestors told him it was Tanna, which means soil in my language. Tanna is now the name of the whole island.

12. Port Resolution was also the first place that the missionaries landed when they came to Tanna in around 1938/39.

Signed (Werry Narua):

Prepared and signed on 12/01/2024 at Lanakulu, Tanna, Vanuatu.

Witness:
Senior State Counsel
Office of the Attorney General

Kastom crops

13. We still live strong in our Kastom at Port Resolution. I am also a farmer and I rely on my crops for my subsistence as well as for my cultural living. Ninety percent of what I eat and what my family eats is from the garden. We do not rely on things in the shops. If we want to get something from the shops, we have to go to Lenakel which is 2 hours each way on difficult roads, which often flood or are damaged by the rainfall. The roads are flooding more now because of the heavier rains.

14. In my Kastom, there are specialised farmers who have a special role and specialised knowledge about growing certain Kastom crops. We call these Tupunis. These are Yams, Taro, Kava, Kumala (sweet potato), Cassava, Banana, Breadfruit and other fruit trees. We also call these knowledge holders Tupunis, which mark how special they are in my local language and refers to a kind of sacred medicine. Anything that is important in my kastom is Tupunis, like certain birds, fish, chicken and pig are also included. My older brother is the Tupunis for the banana and I assist him and I have special knowledge about the banana.

15. Bananas and other Tupunis crops are used for ceremony because they are sacred. For kastom weddings, the husband pays a bride dowry to the bride's family which will consist of mats, pigs and the Tupunis crops. All the extended family and village of the bride will put in crops, mats or pigs to support the Kastom wedding. This binds both families and villages together, which is also a basis for social cohension and peace.

16. For male circumcision, my first-born son must be circumcised around 6 to 8 years old. My extended family and village will provide Tupunis crops, mats and pigs for the circumcision ceremony. This ceremony is so important, that we start to prepare 1 to 2 years before the date of the ceremony to ensure we have enough Tupunis crops, mats and pigs. Again, this binds the families and villages together and I will also pitch in when someone else in my village needs crops, pigs and mats for their Kastom ceremonies.

17. Yam is considered the King of all foods in our Kastom and it is offered to the high status people in our village and around the island when it is first harvested on 1 April. Because I am from a Chiefly line and my high status, my family and I are offered the first harvest Yams. 1 April is a major date in our kastom, where we celebrate the first harvest of the Yam, with a traditional feast including dance.

The Banana

18. I know how to plant banana, which is based on a seasonal calendar and traditional knowledge that was passed down to me. We used to have many varieties. For example, we have *Nariram*, *Taiketoga*, *Sarawei*, *Kwankun*, *Nparius*, Finger, *Yatir*, and *Kawiren*. We ended up using an English name for the Finger variety of the Banana, but in our tradition all of these Bananas are my Ancestors and are extremely important to me. These Bananas are either eaten raw or are cooked. For example, the Finger Banana is eaten raw as a fruit, whereas the *Nariram* and *Kwankum* are cooked green. Both the Nariram and Kwankum are used in laplap, which is a savoury traditional food in Vanuatu.

Signed (Werry Narua):

Prepared and signed on 12/01/2024 at Ipnakulu, Tanna, Vanuatu.

Witness: Senior State Counsel, Office of the Attorney General

19. We have a story about the first Banana from Port Resolution. I will only tell part of the story because it is very long. The story of the Banana is linked with origin of living. We believe that at the very beginning the people who lived in the very old days were not humans but were the birds or other living creatures. There was the sea snake, which is black and white. The sea snake ended up marrying a local bird, but I do not know the name in English. In my language it is *Piray*. That bird used to live on the side of the mountain, called Enkahi. The sea snake was from another place, but it married the bird and they lived together in that area and they had two children.

20. Those two children grew up and then they were playing around with other children, but the other creatures in the village were jealous about sea snake and bird. They wanted to kill the sea snake and this is the origin of jealousy. The sea snake actually knew that there was something going on and suspected that there was hatred between him and other creatures. He warned his wife and two children that if anything happened to him, they would have to cut off his head and bury his head close to his house. He told them to build a fence around it and they were to make sure that they cleared and cleaned the area every morning. You can see that this story is related to our everyday life, building a fence is about building gardens and clearing it and cleaning it everyday, is about our need to visit the gardens daily.

21. The other creatures wanted to kill the sea snake and they went to the Nakamal where Kava drinking happens, even to this day. They put a poison in the Kava and invited the sea snake to come. They gave the Kava to him and then he died. After he died in the Nakamal, the other creatures sent a message to his wife and children about his death. The bird and her two children went to the Nakamal to collect him and, following his instruction, they took him back to their home and cut off his head and buried it and built a fence around it, at the side of their house. They looked after the burial site in the the way that he instructed them to do. So they looked after the burial area every morning. Then crops began to grow. The first is the coconut.

22. The reason that the Coconut comes first is the promise that the sea snake made to the bird that he would he would "still be on your side." When the wife opened up the coconut, it looked like a head with a mouth and two eyes, which she kisses to drink.

23. Then comes the Banana, which is closely related to the Coconut. This is why it came second. The Coconut trunk and the Banana trunk are similar. The Coconut is male to us, and the Banana is female.

24. Next is the ocean, as there was no ocean at the time, so the ocean forms at this time. And then the sand, the coral, and the fish, and all the creatures and things from the ocean come up.

25. The Banana grew up and the mother (the bird) started to harvest the Banana and used the dried Coconut flesh to make milk to have with the green and the ripe Banana. At one time, while the mother went to her garden, she told the two sons if they are going to play with other children, they much not show them all the things that had grown in the fenced area - it was sacred and only for them. It is still the case that our gardens are to be secret. She prepared the Banana and the Coconut cream and showed them when they were hungry how to make it.

26. When the two children were playing with the others, they went to get the ripe Banana and took it out to the playing ground. They started to share. The other children did not have Banana at the time or creamy Coconut milk and the other children wanted to know what it is and how it was prepared. They start telling the whole story about what is secret inside the fence. And then they disobeyed what their mother said ,and they took the other children inside the fence.

Signed (Werry Narua):

Prepared and signed on 12/01/2024 at Ipnakulu, Tanna, Vanuatu.

Witness:
Senior State Counsel
Office of the Attorney General

27. All the children went inside and started to play around the ocean and started to destroy the reefs and the fish, and they were getting all the coconuts down. The mother came back in the afternoon and she saw that everything inside the fence was not in order. She was very disappointed and told her two sons that this property was meant to be for their private use, but because they had allowed everyone to be a part of it, she broke the fence.

28. This allowed the ocean to run and break down the land and created the Bay at Port Resolution, where I live. The mother took other Bananas and crops and sent them out, even Coconut. All these crops were bigger varieties. Only some things were left at Port Resolution and these were smaller varieties. The only things we have left are a few bBnanas and other Tupunis crops, such as the Coconut, Yam, a nut, and fruits and a few things from the ocean. That is why Bananas are very important to us.

29. This is also why the name of our village Irepao, which means the land of the child. When the mother broke the fence, the two children tried to prevent all the things inside the fence from leaving, but they were unsuccessful and were only able to keep some of the crops and ocean foods in Irepao.

30. As part of my special status and relationship to Banana, my family and I can decide when to plant Banana and others in the community must wait until we have first planted the Banana, then they can grow Bananas too. No one can plant Banana until my family and I do. When it comes to harvesting, no one can harvest Banana until my family and I harvest the Banana. This is the same for the other Tupunis or kastom crops, though there are others within our village and all of Tanna with specialised knowledge and status related to these other crops.

31. I normally plant Banana in March. I harvest them in the following February. By March, we start to plant the shoots, which starts the new process again. I have been doing this since I was a teenager. However, my parents used to take me out to their gardens from when I was really young, when they would transfer the knowledge to me about how to grow Bananas and other crops. I would watch them, and I would copy them and they would also talk to me about the Banana. The garden was an education.

Changes in weather, decline of our varieties of Banana and Yam

32. I have seen a lot of changes to the weather. I grow Banana and, as I said above, there were many varieties of Banana and I gave the name of eight varieties above. Since I have been growing Banana I have noticed major changes in the weather. The weather is more extreme. It rains more or it is drier and hotter than what it used to be. It has gotten worse over the last five to six years. This confuses the Banana and it fruits outside its season. The fruit is not as good quality now that the weather patterns have changed and become confused.

33. Some varieties do not grow anymore in my area. They stopped growing around 7 years ago, but I noticed these varieties were in decline for about 10 years beforehand. This more extreme heat stops the banana from fruiting successfully. I tried to find these varieties from other parts of the island to regrow them in my area, but this did not work. The varieties that have disappeared and that I can no longer grow include the Sarawei, Finger and Yatir. These is a deep spiritual loss because these Bananas are my ancestors and are part of the origin of my place.

34. Further, the cyclones are more intense than they were before and the Banana is very vulnerable to cyclone damage. We have always had a cyclone season, which is between December and

Signed (Wery Narua): Prepared and signed on 12/01/2024 at Ipnakulu, Tanna, Vanuatu. Witness: Senior State Counsel Office of the Attorney General

March, but cyclones are much stronger than they were before and last year a cyclone came in the offseason in November 2023.

35. For the Yam, when they were offered to my family as part of the first harvest, they used to be massive. Some were as tall as a metre and a half. Now, the Yams are much smaller. They are tiny, around 50 to 70cm. I grow Yams too. I think the problems is that there is too much rain now and too much humidity. The Yam can only take a little bit of sun and a little bit of rain, which is why we plant close to the dry season, when it is cooler. This is all changed and there is no balance now in the rain or the sun, which is why the Yams are not like before. All the other crops are suffering too.

Loss of traditional medicine

36. Our Bananas also have traditional medical uses. The medical uses are an important part of my specialized and traditional knowledge about the Banana, particularly the use of the different leaves, fruit, the trunk and roots. Each variety has different medicinal uses. The loss of the Sarawei, Finger and Yatir Bananas meanwe can no longer access the medicine they provide.

37. Traditional medicine is still very important in my village and the whole of Tanna. If someone is sick, a person will visit a traditional doctor and that doctor will say what medicine is required. The Banana is one of the medicines. Because my family and I have a special relationship to and knowledge about the Banana, they will come to us to ask for the medicine. There is a whole Kastom exchange that accompanies this request. They will take the traditional medicine, which will cure their sickness.

38. The loss of the varieties of banana means that we are unable to fulfil this traditional and important function as custodian of the Banana and this means that without the traditional medicine, the sickness cannot be cured.

Our gardening traditions ensured continuing abundance of fish on the coral reefs

39. We have a season for fishing in our traditions, which is from April until September/October. The fishing seasons are also connected to our Yam season, which also starts in April. The fishing seasons stops when we plant Yam (which is in around September/October). At that time, we apply restrictions on our method on catching fish.

40. In our knowledge systems, we know that after November it is the breeding season for the fish, so we restrict fishing at that time, and, as I said, this coincides with Yam planting. We call this a seasonal calendar, where the seas and our lands are linked through the seasons and our traditions. This is our traditional way, which is how our ancestors did it, our great grandparents did it, our grandparents did it, and how my parents did it and how we still maintain it.

41. We have different types of fishing methods, which relate to the fishing season (April to September/October). During the fishing season, people can fish with a net or diving speargun. From around September/October, people are prohibited from using those fishing methods and are restricted to using a fishing line, traditional spear and a poison arrow. This restricts how many fish any one person can catch and ensures that the fish are able to breed and repopulate during their breeding season, which keeps our seas and reefs sustainable. It is a Kastom form of resource management and harvesting which has been passed down to us from the generations.

Our reefs are dead and the fish are almost gone

Signed (Werry Narua): Prepared and signed on 12/01/2024 at Iapakulu, Tanna, Vanuatu. Witness: Senior State Counsel Office of the Attorney General

42. Fish is one of our main sources of protein and is very important to us as a coastal village.

43. When I was a child, I remember that the reefs were close to the shore, only around 3m from the beach. The coral was colourful and living. There were different shaped coral and a lot of fish.

44. One of the important eating fish is the Blue Parrott fish, which we call Makum in local language. There were plenty of these around the reef when I was a child and a teenager. I used to hunt the Makum with a spear when I was a teenager.

45. We used to also have the Trocar, which is a very large green sea snail. It is a delicacy for us and is very yummy.

46. I have been swimming and exploring the reef all my life, I can see the changes and know when coral is living and dead. The coral now is either severely damaged, but mostly dead. This is from the cyclones, the sun and the soil runoff from the landslides, which have become more frequent in recent years. I really started to notice the changes in the reefs in my early twenties.

47. I know the land. I know the sea. I have been learning about the land and the sea and observing both since I was a child. My grandparents and my parents passed on their knowledge about the land and sea to me as well. This is special knowledge that I have, so I am confident that what I am observing is happening and is different to what I saw and experienced before my twenties.

48. Because we are getting more frequent cyclones, the coral never has time to recover, though the bleaching from the sun and the soil runoff are also major factors in the ill health of our reefs.

49. The reef is not coming back. It is slowly disappearing. It is dying.

50. I have noticed that there are less and less fish. When I was a teenager there are plenty of fish and lots of different types of fish. There are no longer any Makum or Trocar near the shore on our reef.

Creation of Community Conservation Areas

51. The village decided to create some marine conservation areas using the Government's community conservation area (CCA) laws, which we did about 2 years ago. I am the chairperson of the committee that looks after the (CCA).

52. We decided to act because we were concerned about the loss of marine species and the damage to our reefs. We also wanted to ensure that we could enforce the restrictions in these CCAs because people were coming from outside our area to fish and they are not respecting the traditional calendar and traditional resource management, where we place restrictions through our customary law on fishing and harvesting seafood.

53. The marine conservation areas are protected by national law. Some of the CCAs are 'no take zones', where no fishing is allowed at all. Some of the CCAs are regulated, to ensure sustainable fishing.

54. I saw some species returning, such as the Trocar but not in the same numbers.

55. We are trying our best to see if we can have our resources recover, but if the reefs cannot recover from the damage caused by the sun, run-off, and cyclones, our marine areas will remain

Signed (Werry Narua): Prepared and signed on 12/01/2024 at Ipnakulu, Tanna, Vanuatu. Witness: Senior State Counsel Office of the Attorney General

impoverished. This makes me upset, because I know what our reefs were like when I was a teenager, when they were colourful, alive and full of life.

56. I have observed the coral in all of the CCAs for the last two years and the reefs are not recovering as they should. This is because they do not have enough time to recover before a cyclone hits. I am also concerned that coral bleaching is a factor and this might also mean that the reefs are unable to recover at all if it keeps getting hotter.

Relationship Tapunis

57. Our crops and seafood are very important in building and maintaining connection to extended family, Tribes and friends. Before, I had a lot of Banana, which I could contribute to traditional feasting, Kastom ceremonies or funerals. When my crops are destroyed, I can't help or contribute. This makes me ashamed. I have been struggling to meet my obligations for the last 3-4 years.

58. It also means that I can't go and visit relations or friends, as I should go with something in my hand in our tradition. Without food, it is hard to do that.

59. Not being able to fulfil my obligations and relationships through food affects the relationship and undermines the entire fabric of our society - our traditional connections and obligations.

60. Exchange of food also helps to keep the peace between our different villages and Tribes. Our traditional trading partners (Tribes) are inland. For example, we are meant to take something from the ocean, because these inland tribes cannot otherwise get access to seafood. But Banana is also very important, because it grows better in the coastal areas. We get Taro and Kava from these inland Tribes, which we can't grow well on the coast and which is very important to our Kastom.

61. Kava is an important drink for the governance of our village, where it is drunk in the Nakamal. The Nakamal is the traditional parliamentary house in the Tribe. We still use the Nakamal today and Chiefs can pass traditional laws for the governance of the village. Kava is a central part of all business of the nakamal, which is why this trading system is so fundamental to our law and governance.

62. This trading system is now collapsing. This is due to the death of the reef and the slow decline of our crops, including the Banana. The impact that the change in weather is having on the inland crops, is also a factor in this collapse.

Cyclones

63. I said above that the cyclones are getting more intense since Cyclone Pam in 2015. This affects more than my Banana crops and the reef. They can cause big waves, from the storm surge. I have noticed this getting worse as the sea rises, which I have also observed over my life. The waves are bigger. During Cyclone Judy and Kevin, the waves were around 5 metres high.

64. During Cyclone Pam most of the traditional houses in my village were destroyed. I was in Australia at the time, and my wife and children where inside the house. They survived and my house was fine. But it was devastating for the village. I came home two weeks later, and I saw the destruction. I could not figure out where the homes used to be, so much of the village had been destroyed.

Signed (Werry Narua):

Prepared and signed on 12/01/2024 at Ipakulu, Tanna, Vanuatu.

Witness:
Senior State Counsel
Office of the Attorney General

The Yacht Club

65. The cyclones have also destroyed our yacht club, which is an important institution in Port Resolution.
66. Because of its history, Port Resolution is an icon for Western sailors, and it is also close to Yasur, the name we call the active volcano on Tanna, which Cook writes about sighting in his journal. We also had a local Dugong, a very important cultural species for us, living in the Bay, because there was a lot of seagrass. Many yachts come to visit between April to November. We also have a lot of boat rallies, which might include up to 20-30 boats.

67. My dad and his cousin set up a Yacht Club in Port Resolution in 1990, when I was still at school. When my dad and cousin first built the club house, it was one simple round hut. It had a sleeping hammock for visitors if they wanted to stay in, and we also started to sell beer. It became a much-loved place for the sailors to come.

68. My dad and my cousin also built some simple bungalow for guests to sleep in. All up, we had 9 bungalows.

69. In 1999, I built a new club house, which included a restaurant, with the Port Resolution community. Part of my decision to do so, was because I noticed that the cliff had become less stable because of landslides. This was because the rain has gotten heavier, and because the cyclones are stronger now, and cause big waves to hit the cliff. It took us many years to build the new Yacht Club because we did not have much money to buy all the materials, and we had to ship materials from Port Vila, which is on another island in Vanuatu.

70. The Yacht Club is very important for the five Tribes living on the Peninsula of Port Resolution. I have permanent staff and I have temporary staff. The temporary staff are rotated around the different Tribes. This helps them to get some income, as there are few other cash employment opportunities on the island.

71. Some of the Bungalows were destroyed by Cyclone Pam.

72. In 2019, we took another hit because of Covid and the Vanuatu Government had to shut the borders. We did not get any visitors during this time. On 1 July 2022, the Government reopened the border and a few yachts started to visit us again that season, but not very many. However, the numbers started to gradually build up.

73. In February 2023, just before the yachting season was to begin, the two Cyclones Judy and Kevin hit Port Resolution and destroyed the Yacht Club. This was from the strong winds. Cyclone Judy was Category 4 when it hit Tanna at midnight on 1 March 2023. Cyclone Kevin was also Category 4 when it made landfall on 4 March 2023.

74. All the remaining Bungalows were destroyed too.

75. I built a basic temporary structure made of wood for the Yacht Club so I could still cater to the 2023 season. We have not been able to rebuild the Yacht Club to where it was or with restaurant facilities. We had 200 boats visiting from April to November last year. There were also four different rallies in 2023.

76. I estimate that it will take 6-7 million VATU to rebuild the Yacht Club, which is around $70,000-$80,000 Australian dollars.

Signed (Werry Narua):

Prepared and signed on 12/01/2024 at Iqnakulu, Tanna, Vanuatu.

Witness:
Senior State Counsel
Office of the Attorney General

Landslides and coastal erosion

77. As I said above, there are more landslides than before. The more intense cyclones and heavier rainfall causes landslides. We did not have landslides when I was younger.

78. We've also experienced more coastal erosion due to the rising seas. When I was a teenager there were many trees along the coast in the Bay and on the other side of the peninsula, including the Banyan tree. These coastal trees have been destroyed by the rising sea. They get rooted out by the water. This causes more coastal erosion too because the roots held the soil together.

79. This soil is also ending up in the sea and affecting the reef.

80. The cliff where I live has had many landslides. It used to go down to the sea as a gentle slope. Now it is a sheer drop. It is a cliff. This cliff keeps receding and I am worried that this will not stop.

Passing on my kastom to my children and the collapse of our way of life

81. My children attend school. On the holidays and weekends I will take them to the ocean and show them how to fish. I tell them that things are different now and that I used to fish differently. I also take them to the garden, and teach them about Bananas and growing other crops. They still learn, but not what I learnt because our environment has changed so much.

82. Because some of our traditional varieties of Banana has disappeared, they will never see them or know them. They will not know how to grow them, to look after them or their medicinal uses. This makes me extremely sad, because this is a knowledge that has been passed down through the generations and I am unable to pass this onto my children. I am frustrated because it is beyond my control and I have been unable to continue to grow these bananas, despite sourcing these varieties from other parts of the island to attempt regrow them. This failed.

83. I am worried about the future for my children, even my grandchildren as they will live a very difficult life compared to what I am living now. We have a name for Tanna, which is Tanauta, which means the land of plenty. I saw the abundance when I was a teenager, with our healthy reefs and crops but that has changed now. I believe I am seeing the slow collapse of our gardens. This also means the fabric of our society is slowly declining due to the change in the weather. We live close to the land, we know when things are not well. Everything is at risk.

84. I am also worried about Port Resolution and its historical significance, which covers our Kastom, Captain Cook and the early missionaries. We are at risk of losing this.

Message to the Court

85. My message to the International Court if Justice is that I am concerned about my future, and for future generations. I have been seeing all these changes and the impact over the course of the 45 years of my life, I recently realised that all of the changes are gradually building up and it will get worse. My concern is about the livelihood of my children that are alive and their unborn children. If you are able to stop it, to keep our culture alive and our future generation - stop it.

Signed (Werry Narua):

Prepared and signed on 12/01/2024 at Ipnakulu, Tanna, Vanuatu.

Witness:
Sonia
State Counsel
Office of the Attorney General

Statement taken at Isanakulu, Tanna, Vanuatu on 12 January 2024.

Signed:

Witness:

Signed (Client):

Prepared and signed on 12/01/2024 at Isanakulu, Tanna, Vanuatu

Witness:

Annex H

I, Mangau Iokai, from Yakel Village, Tanna, Vanuatu solemnly affirm and declare:

Background:

1. My name is Mangau Iokai, I am 78 years old. I was born in 1946 in Yakel Village on the island of Tanna, Vanuatu.

2. I am a Vanuatu national and I provide a statement to the International Court of Justice on changes to the weather and cyclones, the loss of the Yam, and what these changes mean for my Kastom.

3. My testimony is based on my direct knowledge and my knowledge based on Kastom, which has been passed down to me from my parents, grandparents, great-grandparents, and ancestors.

4. I speak *Nahvwaal* as my local language. I have given my testimony in Nahvwaal through a translator, John Kalwas. This written statement has been read back to me in its entirety in *Nahvwaal*. I have confirmed that the content of the statement is accurate.

5. This statement uses italics for words in my local language.

6. I have lived in Yakel Village all of my life. I have 14 grandchildren and seven great-grandchildren. All of them are living in Yakel Village.

7. Yakel Village is a Kastom village. This means we have chosen not to adopt Western ways of living but maintain our traditional ways. The center of our community is the *Imalul*. It is a place for the community to gather and also a place where we commune with the spirits. It is our place of governance and law. It is an open area surrounding by large Banyan trees. The *Imalul* was not made by man, it was put there by our Supreme God, *Kalbapeng*.

Changes in the weather

8. I've seen big changes in the weather over my lifetime. Before, I knew the weather pattern. But now, even though I am living in my homeland, it feels like I am living in a foreign land. It is strange. I don't know my place anymore.

9. In the past, we had a balance of rain and sun, and when I went to the garden to harvest, the crops always gave me enough. But now things are out of balance. We have too much rain and too much sun, and we don't get enough harvest. I have noticed this change more since Cyclone Pam in 2015.

10. From when I was young, I made the garden at the same time each year, and after the planting the rain would always come at the same time and help the plants to grow. But now, the rain is coming at the wrong times. For instance, it is already coming when I am planting. It is unpredictable.

Signed: Mangau Iokai -

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Senior State Counsel
Office of the Attorney General, Republic of Vanuatu

11. The rain that came used to be a good rain, it gave my garden just enough water. But now, the rain that comes is a bad rain. It gives too much water and rains for too long. It washes away my garden and causes the crops to rot.

12. Before, we had good sun. When the crops were growing it was sunny and the crops were growing very well. But now, the sun is too strong and it is too hot. Because of the bad sun we have, the crops and the trees are dying. The sun is too strong. It is too hot for our crops to survive.

13. Because of these changes to the weather, our crops do not produce enough to eat. Due to food shortages, we are mostly eating Taro and the *Nimahnim* leaves, which are special leaves that only people on Tanna eat. Sometimes we have other crops, but it was not like before. Because of the food shortages, our health is not good like it was before.

14. When I was a little boy, I used to follow my father to the garden. My father did the real gardening, and I copied what my father was doing. That's how I learned how to do the gardening. By the time that I was a young man, I started to garden on my own. That's how we've always passed on our knowledge of gardening from generation to generation all the way back to our ancestors.

15. In my time, when I was young, I could follow our traditional pattern for gardening. Now with the weather change, I am seeing it is very difficult for my children, my grandchildren, and my great-grandchildren to learn or follow our gardening traditions, and to pass on the same knowledge.

The Yam is central to our Kastom

16. The Yam is the most important crop in our Kastom. I can plant all other crops, including Taro, Taro Fiji, Kumala (sweet potato), but out of all of the crops, Yam is the most important. We consider it to be the King of all crops. Of all the crops that I have in my garden, I need to have the Yam.

17. *Kalbapeng*, our Supreme God, gave us all of the Crops. The Crops first came to us as spirits that took the shape of Stones and these Stones also sometimes took the shape of human beings. The story is that when the spirits came to us, they came to the Eastern side of Tanna first, and then they traveled to the Western side of the island. The Yam spirit is male and all other Crop spirits are female. The Yam spirit and the Taro spirit are like husband and wife.

18. While the Spirits were traveling over to the West, they stopped and had a meeting at *Ianapik* this is at a creek which is a boundary between two areas. While the Spirits were there, two others came into the meeting. The first was *Nuwing* who is male, and who is the Spirit of the Wildcane. *Nuwing* is the Chief of the Yam because Wildcane is needed for Yam to grow. The other was *Nukia* who is female. *Nukia* is the Spirit of the entire garden, and is also the Chief of the Taro.

Signed: Mangau Iokai -

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19. At the meeting, *Nuwing* and *Nukia* decided to split the Taro and the Yam. Taro went to the south of Tanna, following the land downwards, and Yam came to our region, which is known as *Tanna Azul*. *Tanna* means the soil or the ground and *Azul* means big, so in English the name of the is region is big land, it also means rich soil, because our land has always been so fertile.

20. After the Taro and Yam were separated, the Taro and all the other Crops left Tanna and went across the sea as far as the Americas. But the Yam stayed here, it was our only crop.

21. The Taro and all of the other Crops stayed in the Americas for a long time. But eventually, Taro began to miss her husband, the Yam. The Taro started to cry and wanted to come back to Tanna.

22. The Taro and all of the other Crops journeyed back to Tanna. Two different types of Taro were captain of the ship on the way back. The *Tahveta* Taro captained the ship when the seas were rough and the *Nawanwalah* Taro captained the ship when the seas were calm.

23. After their journey, the Taro and the other Crops landed on Tanna at a passage called *Iakilkaak*, which is down at the coast on the black sand beach. *Iakilkaak* means "the place where they disappeared," because this is where they left Tanna when they went to the Americas. It is also the place where they came back.

24. When the Taro and all the crops came ashore, they looked at the land and saw the mountains. They were talking among themselves about who would go to live on the mountains, because up there it is cold. The Taro responded that she would be the one to go and live in the mountains, and two other crops followed her up there: the *Wrurpei*, which is a type of banana, and *Kauvnak*, which is island cabbage. They followed the Taro up the mountains because they knew one day in the future when we are doing the ceremonies, Taro would be part of the ceremonies and, if they followed her, they would be too. And so, for ceremonies there has to be Taro, *Wrurpei*, and *Kauvnak*. The ceremonies are a time for husband (Yam) and wife (Taro) to meet.

25. So now, taking the story to our time, you can see why the Yam is our most important crop: because he stayed. When all of the other crops went to the Americas, he was the only one who stayed on Tanna. That is why the Yam is the King of the crops and the most special one.

26. This is also why Yam is essential to our Kastom and ceremonies. We include Taro and other types of crops in ceremonies, but Yam is always essential and is the only crop in our most important ceremony, the *Toka*.

My Spiritual Relationship to the Yam

27. In my village we have special people called *Tupunis* who have a special relationship with a particular crop, species, or element, and hold sacred knowledge about that the thing. For

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example, we have a *Tupunis* for Taro, a *Tupunis* for Kava, and a *Tupunis* for the Weather. A *Tupunis* is also like a Chief. In other parts of Tanna, there are also *Tupunis*.

28. In my village, Yakel, I am the *Tupunis* for the Yam. I am responsible for looking after the Yam. I hold this position because my family is spiritually connected to the Yam through a Chiefly lineage. The spirit of Yam flows through my ancestors, my family and me.

29. The first *Tupunis* were spirits, as I explained in our story of the Yam, Taro and other Crops given by *Kalbapeng*. When the spirits were traveling, they took the form of Stones, but when they reached our place, they manifested as human beings. These were the first Tupunis. My first ancestor was the spirit of the Yam. He manifested as a human being in Yakel and my family has been here ever since, taking care of the Yam crop. I am also the custodian of the sacred Stones. I have these ancient Stones from way back.

30. As *Tupunis*, I am responsible for ensuring we get a good crop of Yam. I use sacred Stones to commune with the spirits, and to ask them to look after the crop and make sure that my community has enough harvest. The Stones are hidden in a secret place. The ritual that I perform is too sacred to talk about and I am unable to share it. It is only my family that can perform the ritual because the spirit of the Yam is in us and we have the Stones.

31. The Stones were given to my ancestors from *Kalbapeng*. The knowledge of how to use the Stones was also given to my ancestors from *Kalbapeng*. The knowledge has been passed down through my family. I learned about the Stones and how to use them from my father.

32. Only I can commune with the spirit of the Yam in this way, but all men confer with the spirits when they are planting yam. The men perform a ceremony called *Tamafah* at the *Imalul* every time we plant Yam. The ceremony is performed with a chicken and Kava. You kill the chicken and drink the Kava and that is how you make a connection to the spirits to ask for a good harvest. Kava is the gateway to the spirits. The knowledge of how to perform this ceremony is passed on from father to son. I have taught my sons how to do it.

The Yam has disappeared

33. The Yams we harvest have been getting smaller and smaller. I noticed this slowly happening before Cyclone Pam, but afterward the change happened much faster. Before, they were the size of a house post (approximately 3m). But they shrunk to the size of my hand and wrist (approximately 20cm). Four years ago, the Yam vanished altogether. We have been trying to plant each year, but no Yams come.

34. I think the changes of the weather I have observed have caused the Yam to vanish. I have been gardening all my life and I know the weather. Especially the rain has changed. Since Cyclone Pam in 2015, we have been getting too much rain and at the wrong times. It is causing the Yam to shrink and die. Yams do not like too much rain. The rain that is coming now is too heavy. It causes the leaves of the Yam to fall off, and the crops are turning bad.

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There is something special about rain. In the past we had good rain, which the Yams drank and used to grow strong. But now we have bad rain that is killing the Yams.

35. I have been farming my whole life. I have been following the same practices I have always used. These practices were passed down from our ancestors. I learned these farming practices from my father, who learned them from his father.

36. When I plant Yam, the first thing that I do is clearing the bush. Then I leave the cleared land there for some time so that it will get dry. Next, I use fire for burning dry trees and dry leaves and then I do the plowing. After that I start planting Yam. The process for planting is that I have to dig into the ground, dig further, further down. When I plant Yam, my intention is that the Yam tuber will reach the bottom of the hole. But because of the changes in the weather and, especially because we are getting too much rain, the Yam tubers have not been filling the holes. They've been getting shorter and smaller until they vanished.

37. Even though the Yam has vanished, we are still trying to plant it. But our gardens are not like before. We used to plant Yam in very big mounds almost as tall as a man. Now we have very small Yam mounds. They are no bigger than 10cm. This is because each year we use the tubers from the last season to plant, and each season the yams grew tinier and tinier. It is not what it used to be.

38. Each season, I change the location where I plant the Yam. I also use a local plant *Lilahng*, which enriches the soil. Despite these efforts, the Yam doesn't grow. No matter where I plant or what I try, it won't grow.

39. The stem of the Yam needs a support to grow. They cannot grow on the soil because it is too hot for them and they die. We use Wildcane to build beds for the Yam. This is why, in our stories, Wildcane is the Chief of the Yam—because the Yam needs it to grow. The beds used to be much bigger and much longer because the Yam stems would creep along the beds, back and forth, to and fro, and when you harvest it you have big crops. Now, the Yam stems are much smaller and won't grow. We've had to make our beds much smaller. In some cases, we don't build a bed for the Yams at all. When we plant, all we get is a single, shriveled stem. It won't grow, so there is no point in building a bed. Even when we plant the Yams on the same day, some grow a little bit and we can make a small bed, and some don't grow at all. But no matter what, we don't get a harvest.

40. In recent years, because of the cyclones, we've been experiencing a shortage of Wildcane. Even with our much smaller gardens, we don't have enough Wildcane to build the beds. When we don't have Wildcane, we just go cut sticks and use them to prop up the Yam plant. It doesn't work as well. Wildcane is the chief of the Yam. It is for the Yam. But now Wildcane is nowhere to be found and we are just using wood. It isn't right. This is also a spiritual wound because it severs the connection between the Wildcane and the Yam. Likewise, the disappearance of the Yam has left the Taro all alone. She doesn't have her husband anymore

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41. In the past, we had very big Yam gardens. And when we built them, we would get the entire village to help plow and build the mounds. The mounds were so big it would require the entire village to help. Our gardens now are so small, planting them is the work of one person, or two persons at most.

42. The size of a person's Yam garden reflects their status. It is a matter of respect. An elder of the village or the Chief should have the biggest garden, and young people who are just beginning to garden should have gardens that are much, much smaller. But now everyone's gardens are the same size: the size of a beginner's garden. It's sad to see the size of the Yam gardens. This effects relationships and doesn't give the elders the respect they are entitled to.

43. Now that the Yam has vanished, my heart is broken. My connection with the Yam spirit is broken. Before, through my family and my ancestors, I was able to lean on the spirit when I needed it. But now I don't have anything to lean on. It just feels like empty space. Because the spirit is no longer there, I feel empty. I am walking around like an empty shell. I feel that I have failed in my duty that has been passed down from my ancestors, to my grandfathers, to me.

44. Even though the Yam is gone, I will continue doing the ritual with the sacred Stones as it is my duty. The Stones are part of me, my connection to the spirit. If I don't continue the ritual, I will get sick.

45. Even though the Yam is gone, I keep trying to grow it. I will try to pass the knowledge that has been passed down to me to my sons. I will teach them how to plant the Yam and how use the Stones and commune with the spirit. But because the yam is already vanished, I don't know if they will continue the practice. It is not the same without the Yam.

46. When I had the big Yams, and brought them to the *Imalul* in my heart I was very happy. Now I feel empty.

Use of the Yam in Kastom

47. There is only one spirit of the Yam, but he has given us many different varieties of Yam. Some Yams are big, including *Mtuak*, *Norahvamua*, and *Neuksugar*, which is a sweet yam. There are several varieties of *Neuksugar*, including *Neuksugar Nalmeta* and *Neuksugar Haowon.* These Yams grow to be around 3m. Some other Yams are smaller, like the *Naupi*, *Namiau*, *Naklak*, which are round Yams. We also have the *Kalaka, Yati*, *Se Kuaseramoni*, *Magras*, *Matuk*, *Kulanlulah*, which are little but long yams. Some of these names are also used for the names of men. This is because the Yam is inseparable from us. It is our identity.

48. We plant some Yams for eating. Other yams are essential for our important Kastom ceremonies. Our most important ceremonies include male circumcision ceremonies, wedding ceremonies, the *Niel*, and, most important of all, the *Naukial*. *Norahvamua* and *Neuksugar* are the most important for ceremonies because they are the biggest Yams. They

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are the King of Kings. When the Taro went to the Americas and was crying it was because she missed these Yams, because they were her husband.

49. Male circumcision is an important ceremony for us. The Yam and other crops are used for this too, where there will be a celebration. The young boy, around the age of 6 will stay in the *Imalul* with other men from the village for 3 months. During this time, they are unable to see women. They will learn a lot of Kastom, undergo the circumcision (which is conducted by special knowledge holders) and heal there.

50. We have Kastom marriage. We are unable to marry within our village. It is Kastom for the bride to come to the village through marriage through the Kastom roads. The Kastom roads are a mutual relationship between two villages. Kastom marriages are essential for maintaining those relationships, At around the age of 20 to 25, a decision will be made for marriage with another village and the Chief of the other village will decide on whether it is a good match. There is a large gift given to the family of the bride. This must include Yams.

51. The *Niel* is a ceremony of giving. We have the *Niel* when we have an abundant harvest with lots of surplus crops. During the *Niel* we give any leftover crops from our garden that we don't need as a gift to someone else, maybe another family or another village. It is an important way that we maintain and strengthen relationships. It also shows our status as a gardener. When the harvest is not good, there is no *Niel*.

52. The *Naukial* is our most important ceremony. It is performed only every four or five years. It is a ceremony of dance. The ceremony itself involves four days of dancing and feasting. Everyone wants to be there for the whole four days because it is our most important ceremony.

53. Like how there are many different events performed during the Olympics, there are many different dances performed during the *Naukial* -- *Nao*, *Kaausascivah*, *Nasal*, *Napan*, *Ninimouio*, and *Toka*. Of these, the *Toka* is the most important because it's a male dance. It is essential to our governance. It is during the *Toka* that we decide who is *Ialmalu*, who is the high chief of our village. The *Ialmalu* is a symbolic leader, like a monarch. To perform the *Toka*, we must have Yam. It is only the Yam that is used in the *Toka*, this is how important it is. The practice for the *Toka* takes a full year. All of the other *Nikaowar* are female, so we eat the Yam but also can eat any other crops. The *Toka* is male and we must eat the Yam.

54. The Yam plays a vital role because the Yam is the chief of the crops and the *Toka* is the dance to decide the *Ialmalu*. The Yam also gives us the energy to us to dance for all four days.

55. During the *Toka*, if there is a dispute about who should be *Ialmalu* we do a test to determine who it should be by deciding who should wear huge feather (*Kweria*). The people who are dancing the *Toka* hold up the *Kweria*, and when it passes over the candidates, they can feel

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whether they are worthy or not. It is a spiritual test. If you are not the real *Ialmalu* and you are crowned with the *Kweria* you will get very, very sick.

56. Now that the Yam is gone, the *Naukial* is not being done as much anymore. I am not sure if it can survive into the future.

57. Since the Yam has vanished, I am still doing the Kastom ceremonies, but I am using a different crop, Taro. It isn't right. When I am doing Kastom rituals it is very important that I have Yam. When I did the Kastom ceremony with the Yam, it was good and right. When I brought Yams to the *Imalul* to perform the ceremonies my heart felt happy. But now, although I am still performing the ceremony, it doesn't feel right in my heart. The ceremonies are worthless without the Yam.

58. The Kastom I am practicing is here. It is for this place. It is connected to the *Imalul* which was put here for us by *Kalbapeng*. I can't go get Yams from another place to use in the Kastom ceremonies. It wouldn't be connected to our place or our spirits.

59. We have stayed with our beliefs, even though other religious beliefs have come to Tanna. Now it is hard for us without the Yam.

60. Before, we also used the Yam to trade with people from the coast. I traded Yam for fish. But since the Yam has vanished, we don't do any trade with the coastal villages anymore. Those relationships are broken. Instead, when I want to eat fish, I have to buy it with money from the shop. I get money by selling Taro at the markets.

61. As I said, the Yam is our most important crop. Now that the Yam has disappeared, the spirit is telling me that the other crops will disappear in the near future too. I can see the changes happening to them now, I am worried for the future of my village, and for my grandchildren and my great-grandchildren. I am worried they will have nothing in their gardens and will not be able to maintain our Kastom. In some ways, as I have said, there has already been a severing because we cannot grow Yams and our Wildcane is hard to find.

Cyclones have become more destructive

62. In my lifetime, I have seen big changes in the cyclones.

63. Like I am a *Tupunis* for Yam, we also have *Tupunis* for the Weather. They are responsible for looking after the Weather. They used to be able to stop the cyclones from hitting us, but they can no longer. Whenever we have a cyclone coming, they go inside a special hut and do a sacred ritual with the sacred Stones for the Weather that would stop the storm from coming. It used to work, but now the rituals are not working anymore. The power is broken.

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64. The cyclones have grown more intense. The winds are stronger and the rains are heavier. I observed the cyclones becoming more intense starting with Cyclone Uma in 1987, but the worst was Cyclone Pam in 2015.

65. Before, when the cyclones came, they didn't damage the houses. But now the cyclones that are coming are doing a lot of damages to our houses.

66. During Cyclone Pam, my house fell down. All of the houses in the village fell down. Everyone had to go to Iepkisip, which is another village, to seek shelter in a "Tanna House." The Tanna House is a special type of house that is built to withstand cyclones. It was difficult to get to Iepkisip because so many trees were fallen all over the road.

67. While Pam was raging, there were so many people inside the Tanna House that we all had to stand. There was no room to sit. The house didn't fall over and we survived the night, but everything else was destroyed. During the twin cyclones, Kevin and Judy in 2023, the same thing happened again.

68. Our ordinary houses are made out of local materials. We use Wildcane stalks for the structures and Wildcane leaves for the thatched roof. Before, both our houses and the Wildcane would survive the cyclone, but now it is just the opposite. The cyclones not only destroy the houses but also destroy the Wildcane we need to build them back. We have to use axes and knives to cut materials from the fallen plants, but there are not enough materials to build what we need.

69. The cyclones are also damaging the trees that we need to build the Tanna Houses. We need a specific type of tree that has a curved trunk. Before the cyclones would pass and the trees would survive, but now they've all been destroyed.

70. Before when the cyclones came, they were beneficial to us in a way. The cyclones would prune the overgrown fruit trees. The trees would get twisted together and the cyclones would straighten them out. After the cyclone passed, the trees would still be growing, and because of the pruning, more fruit trees would be able to grow. But now, the cyclones are destroying all of the fruit trees.

71. It takes about a full year for fruit trees to grow back and bear fruit now after these bigger cyclones. I wait to eat the fruit, but just when they are about to bear fruit, another cyclone comes and destroys them again. The fruit trees cannot recover. This is not how it was before. This is a big loss for my village because we are spiritually connected to the fruit trees and they provide staple foods for us – Breadfruit, Coconut, *Namanmbe*, *Nantau*, and Banana. After the twin cyclones Kevin and Judy in 2023, all of the banana plants were destroyed. I haven't tasted a banana since. The banana plants are growing back but it's not too healthy. At least they are still giving a little bit of fruit, but they aren't nearly as big as before.

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Office of the Attorney General, Republic of Vanuatu

72. It's the same for the crops in our gardens. Before, some crops would survive the cyclone. For example, even after Cyclone Uma, we still had crops growing. But after Cyclone Pam, it is just the opposite. Pam destroyed all of the gardens and all of the crops.

73. Starting with Cyclone Uma, a lot more rain comes with the cyclones and this causes landslides. Before Uma, we never experienced a landslide. But whenever we have cyclones now, we get landslides. The landslides damage our gardens.

74. My entire garden was destroyed by a landslide last year, during the twin cyclones, Kevin and Judy in February and March 2023. We used to get landslides only during major cyclones like Pam and Uma. But now we get landslides during smaller cyclones like Kevin and Judy too. This is because Cyclone Pam in 2015 cleared the whole area. It was just something waiting to happen. The trees that were on the slope helped to hold the soil together, but after Pam destroyed them, the garden became vulnerable to landslide. With the trees gone, the soil gets washed away easily.

75. Ever since Pam, the crops have never grown back as well. I think this is also related to the landslides, because when there is a landslide, they take all of the rich soil away and leave only the tough bedrock to garden on.

76. In the past, once the cyclone passed, we still had enough to eat. But now, when the cyclones come, they damage all of the food and we have to wait for the government to give us aid. We have to wait for about 3 months.

Visit to the United States of America

77. In 2008, I visited the United States of America. I went to New York, Montana, and Illinois. When I was in Illinois, I saw factories. I saw smoke going up from them that was very thick, the same as clouds.

78. When I saw the smoke, I knew it was bad. I knew it was affecting the gardens in my area. I knew my place was affected more than in the United States. In the United States, the products from the factory are going into the houses and are protected. But here we depend on our gardens which are outside. They are directly affected by the smoke. When it goes up into the atmosphere, its effect comes down here and harms us.

79. I'm very happy to be sharing my story with the International Court of Justice. Now our living has gone very differently and we are suffering. We have to say something to the world in order for things to get better. I want to tell the Court that they have to do something good for the people. If they do something good, I would be happy about that. I don't want them to do something bad that will harm our people.

80. I have asked the lawyers to come back and tell us the decision of the Court.

Signed: Mangau Iokai - Prepared on January 12, 2024 Witnessed: 10

Senior State Counsel, Office of the Attorney General, Republic of Vanuatu.

Tour of the gardens

81. I took the lawyers and the Attorney-General of Vanuatu on a tour of my gardens and other gardens in the village. I showed them different things. They took photos and videos and said that they will include them in the information that will be before the Court.

Signed:
Mangau Iokai

Witness:

Christine Lava
Senior State Counsel, Office of the Attorney General

Data:
12 January 2024

Senior State Counsel
Office of the Attorney General, Republic of Vanuatu

Annex I

We, Linet Iawain, Yalitea Iakaho, Sera Nawahata, Nelly Pilia, Nau Iaho, Nancy Iacitan, Sera Naburam, Yoba Mearangi, and Jenny Toata from Yakel Village, Tanna, Vanuatu solemnly affirm and declare:

Background

1. We are women from Yakel village. Our names and ages are: Linet Iawainn (51), Yalitea Iakaho (58), Sera Nawahata (48), Nelly Pilia (53), Nau Iaho (62), Nancy Iacitan (42), Sera Naburam (56), Yoba Mearangi (58), and Jenny Toata (61).

2. We have been asked to give testimony to the International Court of Justice about how the weather is changing and the impacts of this on our lives and our Kastom. We gathered together to share our views. Some of us have given individual statements. We are a community, and we feel more comfortable and more confident giving a statement together. We have chosen to share our voices as a group.

3. We speak our language, Nahvwaal. We have given our statement through an interpreter John Kalwas, who can speak Nahvwaal. He read this statement to us in Nahvwaal and we agree with the content of it.

4. Our testimony is based on our direct knowledge or our knowledge based on Kastom, which has been passed down to me from my parents, grandparents and my ancestors.

5. We do not know how to write so we have each signed this statement by marking an "X".

Impacts of changing weather on the duties of Women

6. As women, our Kastom duty is to do *Nahunu*. It is a big word with a big meaning. We will try to explain it in English as best as we can. *Nahunu* means bringing food and water to the Nakamal for the men to drink Kava there. The Nakamal is the centre of our village life. The men go there every evening when the sun is in a certain position to commune with the spirits and ask them for a good crop. The women bring the water that the men need to prepare the Kava. We bring the food because the Kava is bitter and it is needed to clear the throat of the bitter taste. The *Nahunu* is a duty that women owe to the Nakamal.

7. As women, we have to do the *Nahuna* every night. Before, it was easy for us to perform our duty because our gardens were close by and full of food. But after Cyclone Pam in 2015, landslides have destroyed our gardens. We can no longer garden close by. Instead we have to cross a ravine to get to another valley on the other side. We have to walk

Signed –
Linet Iawain
Yalitea Iakaho
Sera Nawahta
Nelly Pilia
Naus Iaho

Signed -
Nancy Iacitan
Sera Naburam
Yoba Merarangi
Jenny Toata

Signed: Witness
Senior State Counsel
Office of the Attorney General

down a steep mountain to the river at the bottom of the ravine and then walk back up the other side. It takes almost the whole day to get there and back.

8. The trip is so long to get to the garden and back that sometimes we cannot make it back to the village in time to do the *Nahunu*. When we are not able to perform our duty. We are feeling unhappy and sad that we are not doing those duties for the Nakamal.

Impacts of changing weather on food shortages

9. On top of that, the changing weather is causing our crops to shrink. The rain is too much and the sun is too strong. They are killing the crops. The repeated landslides and cyclones also destroy the crops. As a result of all these changes, we don't have enough food. Some of us have observed these changes since Cyclone Uma in 1987 but things have gotten much worse since Cyclone Pam.

10. The Yam is our most important crop. Because of all of these changes to the weather, especially the rain, the Yam has vanished entirely. It's been four years now with no Yam.

11. Before, we were thinking that we would be able to live in the same way as our grandparents and perform our duties. But it is hard for us to perform those duties because of the weather we are getting now, which is leading to a shortage of food from the gardens.

12. One of the roles of women in our community is to go down to the river to get fish and prawns.

13. Before, we could go down to the river whenever we wanted prawns and we got lots of them. But now, we can start in the morning and go until the afternoon and we are trapping maybe five prawns total. That's it.

14. The prawns have washed away due to landslides and floods, which happen when we get cyclones and when the rain is too heavy.

15. Prawn is a staple of our diet and we must have prawns to eat. When we don't have prawns, it affects our health. It is affecting the growth of both our children and adults. We are getting smaller. We are afraid that if we continue without having our staple foods, it will make us sick.

16. The heavy rains and landslides have also washed away all the fish and eel from the river. The flooding has washed away the stones from the riverbed that the fish use for

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breeding, so the fish population can't recover. Now we can't get fish at all. There is nothing.

17. Starting from Uma up until now, that's when all the prawns and fish have washed away. After Uma, some of the prawns and fish were washed away, but still they were coming back. They weren't gone entirely. From 2015, they disappeared quickly because of the rain and cyclones. We were waiting for the fish and the prawns to grow to a size that we could eat, but they weren't able to because the other cyclones came through and washed them away before they could grow.

Impacts of food shortages on community cohesion and gender-based violence

18. Because of the shortage of food, the community has changed a lot. Before we lived together peacefully, but now we have lots of quarrelling among men because of the shortage and the children are not having enough to eat.

19. The shortage of food and the cyclones are also disrupting the harmony between husbands and wives. And sometimes things get violent. Because of the stress of the shortages, men shout at us and swear at us and threaten us.

20. We want to go back to the way things were before. We were living in a different environment back then and there was harmony between us. We want that to come back.

21. The food shortages are also affecting our health. Our lifespans are getting shorter. The women are dying younger and they are not reaching the age when they are supposed to die.

22. These times are very hard. We are trying to do our best but things are only getting worse.

Impact of food shortages on Kastom

23. The food shortages are also impacting our ability to perform Kastom ceremonies.

24. Before, we had a hunting area where we could go for wild chicken and pigs. But now we don't have that anymore. The cyclones have destroyed the hunting places for chickens and pigs. During Cyclone Uma, we had little landslides. But the landslides that occurred during Cyclone Pam were much bigger and destroyed the entire place. We can't hunt there anymore.

25. With that place gone, we don't have any source of meat. If we want to eat meat, we have to eat the pigs and chickens we are raising in the village for use in ceremonies.

Signed –
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Naus Iaho

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Jenny Toata

Signed: Witness
Senior State Counsel
Office of the Attorney General.

26. Because of the disappearance of prawns and fish, the destruction of our gardens and hunting grounds, and the decline of our crops, we have very little food. We have very few options.

27. Because of the shortages, we are eating the ceremonial pigs and chickens. These animals are meant to be used for Kastom ceremonies at the Nakamal.

28. For this reason, we cannot perform our Kastom ceremonies until we have money to buy a pig or can find one. But often we cannot get the animals we need. We are avoiding doing the ceremonies when we are supposed to do them, and with each one we miss this is building up, it is causing us a lot of worry. We are thinking, where will we get the meat for the ceremony? Because we are not performing the ceremony, we feel like we owe something to the Nakamal. We are feeling bad.

29. We are feeling very depressed and worried. Some women in the community have become so worried about the Kastom ceremony they are supposed to be doing that they are having strokes.

30. When we are not able to do the Kastom ceremony, we feel shame. We feel like we are are isolated from the rest of the community. We feel wrong. But we can't help it.

31. This affects our husbands too, because the ceremonies belong to both men and women. But the worry is greater for women. Women marry into Yakel from other villages, and when we perform custom ceremonies, especially the male circumcision ceremony, we are supposed to give back to our fathers and brothers in the other village. For the woman, it is for their family, their brothers they are giving back to. The burden is falling on them really strongly, because they want to make sure they are pleasing their family. The ceremonies are about relationships. The male circumcision is a way of paying respect and giving thanks to the woman's family for sending her to the village.

32. It is a must for us to do the male circumcision ceremony, especially for the first born boy. If a women doesn't do it, that is a source of shame for her. She will feel very bad inside. She will be unhappy, worried, and depressed because she wasn't able to perform that ceremony.

33. The Yam is our most important crop and is essential for all of our Kastom ceremonies. Now that we have no Yam, if we want to do the ceremony, we try our best to get Yam from our families living in other villages. But if we can't get Yam from our families, we perform the ceremony without the Yam. Starting from Cyclone Pam until now, that is when we have been forced to perform the ceremonies without the Yam.

Signed –
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Sera Nawahta
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Naus Iaho

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Jenny Toata

Signed: Witness
Senior State Counsel
Office of the Attorney General

34. Performing the ceremony without the Yam doesn't feel good. It doesn't right. We have a word to describe the way it feels to do the ceremony without the Yam, but there is no English translation. The best way we can describe it is to say the ceremony is devalued. But that doesn't really capture the depth of our feeling or the meaning of doing the ceremony without yam.

Impacts of changes on transmission of culture

35. For us in the village, we are practicing what are grandparents taught us. We are doing it. We are also telling our children, especially the women and the girls, to do the same. But due to Western influences, it is getting harder. Because of the food shortages due to the changing weather, life is getting hard. Our children are looking elsewhere for a different life. They are leaving the village. As mothers, this makes us feel so sad, because we want them to keep our Kastom and our way of life.

Message for the Court

36. Today, the lawyers have come here to ask us questions and to get our views and about what we have to happen. What we want is to go back to the way things were so we can live a better life.

37. Seeing the changes in the climate has given us a lot of worries and we want to tell the Court to put a stop to this and how this is affecting us. If the Court can make it stop, it will make us more happy in the way that we will be living.

Prepared at Lenakel, Tanna, Vanuatu on 12 January 2024.

Signed –
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Yalitea Iakaho
Sera Nawahta
Nelly Pilia
Naus Iaho

Signed -
Nancy Iacitan
Sera Naburam
Yoba Merarangi
Jenny Toata

Signed: Witness
Senior State Counsel
Office of the
Attorney General

Annex J

I, Jenny Toata, from Yakel Village, Tanna, Vanuatu solemnly affirm and declare:

Background

1. My name is Jenny Toata. My Kastom name is Narua. I am a national of Vanuatu. I live in the village of Yakel on the island of Tanna in Vanuatu. I moved to Yakel in around 1986.

2. I was born in 1967.

3. I have eight children. Seven boys and a girl and 19 grandchildren.

4. I have been asked to give a testimony to the International Court of Justice about how the weather is changing, how my garden and my life in the village is affected by these changes.

5. I speak my language Nahvwaal. I have given my statement through an interpreter John Kalwas, who can speak Nahvwaal. He read this statement to me in Nahvwaal and I agree with the content of it.

6. My testimony is based on my direct knowledge or my knowledge based on Kastom, which has been passed down to me from my parents, grandparents and my ancestors.

Changes to my garden

7. When I was young, I used to see my mother go to the garden and when my mother comes back, she had plenty of food to come back and it was shared among us and many other people. The food that we have from those days could sustain us for quite a long time.

8. Before moving to Yakel, I lived in Lankuengah village, which is the same language group as Yakel and is an inland village in the same region as Yakel.

9. I started a garden as soon as I moved to Yakel and it gave good crops and plenty of crops. It was like my mothers garden.

10. Around 1987, I started to see the changes happening over time. I remember because this is when Cyclone Uma was. Anyway, even after Uma, it was a slow change but I am noticing it more in recent years.

11. I saw the changes in my yams, taros, kumula and the produce of those crops were starting to get smaller.

12. The food that I am harvesting now, it is getting smaller and it is not the same as before. It used to sustain us for a long time, but now it just lasts for a day.

13. The things that are affecting the crops are the rain and the sun. When the rain comes, it is supposed to be good for the crops and help them to grow, but now the rain is too heavy for the crops to survive. The sun shining is also supposed to help the crops grow, but now it is too strong and too hot. The crops do not grow as well as before.

Senior State Counsel
Office of the Attorney General

14. The weather pattern before was predictable, But now the rain comes when it is unexpected and same as the sun. The sun comes when it is supposed to rain. Before the weather had a pattern. I assumed the weather pattern would be the same as before and now it is different. It is bad for the crops.

15. Before when I do the gardening, the rain comes, it is a normal rain and now it is more heavy. Now when it rains, I have soil erosion and it is effecting my gardening. When it rains, due to soil erosion, the soil buries the crops and they cannot breathe and you cannot get a good harvest.

16. Now there are a lot of landslides too. I started to see them happen over time also from Cyclone Uma onwards and now there are more.

17. When I was doing the gardening, I used to plant crops, and plant fruit trees such as oranges. But my garden was destroyed by a landslide during Cyclone Pam in 2015. This has affected me and my children.

18. At that time, during that landslide I was sad, because it was time for the praying for the yam and we could not do that ceremony. At the time, during the landslide, I was expecting that we would do the ceremony for the yams, but then the landslide damaged the garden for the yams, I just took the kava to the Nakamal without yam. It felt wrong.

19. After Cyclone Pam, we had a lot of hunger. Yam is part of my day-to-day food and I also couldn't eat it. We depended on what was left, such as cassava, but this cassava was also not good and was rotten and I could only eat some of it. I also had a little bit of Kamala and our special leaves. It was not enough and I was hungry. So were my children.

20. The crop that I love most is the yam. The yam is completely gone from Yakel. I am so scared that there is no more yam. I am not happy that the yam is gone.

21. The yam was much harder to grow after Cyclone Pam in 2015, but now it has been gone for about 4 years.

22. I like yam so much, because I do most of the kastom ceremony with yams, like Niel, circumcision and other ceremonies.

23. I am still doing the yam garden, but it is so small. I am trying to keep it going but I am unable, I do not want to lose it, which is why I keep trying. It is the bad rain. It is so rainy. Also with the sun, it is not a good sun because it is shining on the crops.

Changes to my garden location

24. Before I was a healthy person, because my gardening was close by.

25. After the landslide destroyed my garden, everything changed. I can no longer garden close by. Instead, I have to cross a ravine at the bottom and climb all the way to the other side of the valley. I have to go way down the ravine, where I have to cross a

Senior State Counsel
Office of the Attorney General

river at the bottom of the ravine and then go all the way back up the other side of the valley. The walk is very steep. It takes me almost a full day to go there and come back I only have 30 minutes to 1 hour to garden. I must load the produce on my back and walk back with it and that effects my knees and my hurts my back also.

26. My daily routine when I go to the garden is I must do some chores at home, whether doing the dishes or feeding the pigs. When I am done, I have to walk to the garden which takes a long time, only to be able to garden for a short time. I have to be back in the village before 4pm when the men start to drink kava in the Nakamal.

27. I used to go to the garden daily, but now sometimes I feel too tired and cannot go up anymore. This is affecting my ability to feed myself and my families.

28. If there is something that is very important at the Nakamal, I will have to prepare myself a day or two beforehand. Before, I used to walk short distances. It is not like that anymore. It is a hardship on me.

29. The weather is making it hard to get to the garden too. Because of the heavy rains the river often floods. When the river floods, I cannot go to the garden.

30. When the heavy rain comes, that is when the river floods. When it rains, I am unable to go. For an example, the day before yesterday and yesterday, there was rain. When it rains that hard, I cannot get across.

31. I do not know what to do. When this happens and I do not go to the garden, I need to look for something to eat and to feed my family. But there is nothing to eat. We will only have leaves.

32. I have a husband and he has a garden. I used to depend on him to get food from the garden. Now he is getting old, too old to get food from the garden. My husband is relying on me.

33. Sometimes, my children will feed me when I am too tired to walk to the garden and back and sometimes my children will cook for me too.

34. I would like to tell that Court that they have to put a stop on the gas emissions that are ruining our gardens. They are living in continents and we are living on tiny islands. When they are doing these things, it effects my village, me, my family, my children and my grandchildren.

Signed: Jenny Toata

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Witness:
Okalu
Senior State Counsel
Office of the Attorney General

Date: 12 January 2024.

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Okalu
Senior State Counsel
Office of the Attorney General

Annex K

I, Johnny Loh, from Yakel Village, Tanna, Vanuatu solemnly affirm and declare:

Background

1. My name is Johnny Loh and I am a national of Vanuatu. I live in the village of Yakel on the island of Tanna in Vanuatu. I have been living in Yakel all my life.

2. I was born in 1963.

3. I have 16 grandchildren and eight great-grandchildren. All of them live in Yakel.

4. Gardening is a key part of life at Yakel. I am a gardener. I eat what I produce. My crops provide most of the food that I eat. Crops are also essential to my Kastom. I grow crops for the many important ceremonies that we have in the *Imalul*, which is a central meeting place in the village. Our cultural life, politics, governance, and religious beliefs centres on the *Imalul*.

5. I have been asked to give a testimony to the International Court of Justice about how the weather is changing and how many of our crops are affected by these changes.

6. I speak my language *Nahvwaal*. I have given my statement through an interpreter John Kalwas, who can speak *Nahvwaal*. He read this statement to me in *Nahvwaal* and I agree with the content of it.

7. Where I use terms from my local language in this statement, it is in italic.

8. My testimony is based on my direct knowledge or my knowledge based on Kastom, which has been passed down to me from my parents, grandparents and my ancestors.

Gardening

9. I have been gardening by myself since I was 15. Before that, I would go to the gardens with my mother and father and they taught me how to garden.

10. I grow Taro, Kava—which we call *Nikkaowah* in my language, Banana, Kumala, and, before now, Yam.

11. Each growing season, I move my gardens to different areas, to allow the last area where I had my gardens time to rest, before I use it again.

12. I also use a cutting from a local plant, which acts as a fertiliser. In my language, we call it *Lilahng*. I will use this plant when I notice that weeds do not grow in the soil, I know that the soil is not good. I must go and take the plant and use it on the soil so that it can enrich the soil. This has been our tradition for generations. It worked for my parents and my grandparents.

13. At the time that I started to do my garden, that was when I was 15 years old, I was harvesting big Yams. Recently, the Yam started getting smaller and smaller. About four years ago, the Yam vanished altogether.

Signed: Johnny Loh

JOHNNY

Prepared on January 12, 2024

Witness: 1

Senior State Counsel
Office of the Attorney General

14. Every other crop that I grew too, was big.

15. All of my crops have started to get smaller and smaller.

16. I took the lawyers and the Attorney-General and the translator for a tour of my gardens and other gardens in the community. I talked to them about my crops and some of the other crops in the gardens and showed them the different crops. They took photos and video of me showing them the different crops and the problems I and others are having. They told me that they will do a statement that will show these photos and some of the videos.

17. For example, the Banana. The Banana plants used to give much more fruit. Before, when I planted Banana, the bunches of Banana would be much bigger and there would be many more fruits. The branches would be full of Bananas and would hang down much lower. It is not healthy if it does not drop from the top to the bottom. Now, only a few Bananas grow at the top of the plant.

18. The same with the Coconut. Before, I used to get big Coconut fruits. But nowadays, it's getting smaller and smaller. We don't have big Coconuts anymore. The leaves are also dying. I've observed this change over the past four or five years. It never happened before.

19. The Taro has been affected too. These days, it is very common to see sick Taro leaves. Healthy Taro leaves are a vibrant green and are so big you can use them as an umbrella when it rains and not get wet, Now, they are small, have turned a yellow-brown, and have holes in them.

20. The plant we use for Laplap is also dying. Like the Taro, the leaves used to be vibrant and so big we could use them for an umbrella. We still grow them now, but the leaves don't look healthy, they are smaller, they die off easily.

21. We also have a tree called *Nigulk*, it bears a tasty fruit that everyone loves. Right now, in January, it is supposed to be in season. The branches should be so heavy with fruit, but there are none. This is because while the tree was flowering, heavy rain came and washed away all the flowers. The rain is not supposed to be heavy like that.

22. My *Nikkaowah* started to fail just before Cyclone Judy and Kevin hit us in February/March 2023. Now it is all dead. *Nikkaowah* is essential to our Kastom. It is how we commune with the spirits. I was planting my *Nikkaowah* for ceremonies at the *Imalul*. Now that the *Nikkaowah* is dying off, I can't perform those ceremonies anymore. I'm trying very hard, because we must have *Nikkaowah* to do the ceremonies, but no matter what I do, the *Nikkaowah* keeps dying.

23. These changes started around the time of Cyclone Uma, which was in 1987. After this cyclone, my crops have been slowly getting smaller. But it was after Cyclone Pam in 2015, that I have noticed that things are getting worse, including the Yam, which got smaller and smaller and now can't grow anymore.

24. I still practice resting areas and use the *Lilahng* to make the soil rich, but it is not giving any good results.

Signed: Johnny Loh JOHNNY

Prepared on January 12, 2024

Witness: 2
Senior State Counsel
Office of the Attorney General

25. Tanna has always been an island with plenty. Our land is naturally fertile. Our people were never hungry. We always had food in the garden. Our people were very self-sufficient in terms of subsistence farming. We had lots. But it is very different now. The harvests are getting smaller and smaller, and every time you have a small harvest, you have less and less to plant.

Observations about the weather

26. There are three changes to the weather which I have observed. First, the cyclones come and moves the trees. Second, is the sun, and then the third is the rain.

27. Since Cyclone Uma, we've been experiencing cyclones that are much more severe. Pam was the worst. It removed all of the trees from some of the sloped areas where we garden. The trees are important because they hold all of the soil together. Without them, we get landslides. We started having landslides after Cyclone Uma. We used to have landslides only when we got the strongest cyclones, like Pam and Uma. But now, because all of the trees are destroyed, we get landslides when we have smaller storms, or even too much rain.

28. We used to plant some of our gardens in a sloped area. The soil was rich. But the landslides took all of the topsoil and all that is left is the bedrock. We can't plant there anymore.

29. A good number of people used to do their gardening on that slope. But now these people have no place to do their subsistence garden. They have to borrow land to do their garden, but the size of the land is much reduced because they are using part of someone else's land. It is no longer their land and their garden. To lose custom land like this, is to lose everything. Your customary ground is your mother, it provides everything that you need. It is to lose the past until now and the future. It is like death. This loss of land is also causing hunger in our community.

30. The sun is also affecting the crops. We used to have a good sun that would help the crops grow, but now when we have sun, it is too strong and too hot. It causes the leaves to burn and the plants to die.

31. The same with the rain. Before, we had good rain that the crops would drink and use to grow strong. But now we are getting too much rain. It is too heavy and lasts for too long. It washes away the leaves and the fruits and causes the crops to rot.

32. Everything is out of balance. Before, the sun and the rain gave us just what we needed, and our gardens flourished. But now both the sun and the rain are too strong. It is all wrong.

The Imalul

33. I perform the ceremonies of the *Imalul*. There are many different ceremonies.

34. Each of the ceremonies require different crops. The Yam is the King of the crops and plays a central role in all ceremonies. Yam is the King of all the crops because when all

the root crops are put in *Niel* and if only a Yam or more than one Yam is put into in the *Nail* it adds value to the *Niel* because Yam is considered as the King of all crops.

35. However, *Nikkaowah* is also important. *Nikkaowah* is how we access the spirits. It is like a gateway to the spirits. We need the *Nikkaowah* because that is how we talk to the spirits.

36. I go to the *Imalul* every day, in the afternoon/early evening, and it is my Kastom for the men of the village to do so. It is also Kastom for me to take *Nikkaowah* with me, as all men who attend should. All the *Nikkaowah* will be prepared together and shared among us. We drink it in coconut bowls. We each have our own bowl.

37. Each evening when the men go to the *Imalul*, we will drink the *Nikkaowah* which is social, but it is an important bond between elders and children. This is where the young boys and men meet to learn about the Kastom and ways of life.

38. Sometimes we will perform a ceremony called the *Tamafah*. We drink the *Nikkaowah* and commune with the spirits to ask them to look after our crops. Drinking *Nikkaowah* is like a prayer. We pray for the garden crops.

39. I am worried about the *Nikkaowah* because the crop has been failing. I used to be able to take *Nikkaowah* to the *Imalul* daily, but now I can't now because my crop failed. I still go to the *Imalul* even if I don't have enough *Nikkaowah*, and those who do share. But sometimes there is not enough *Nikkaowah* among all the men in the village to perform the *Tamafah*.

40. We used to perform the *Tamafah* daily, as is our Kastom, as it has always been. But now, because there is not enough *Nikkaowah*, the *Tamafah* is an on and off thing.

41. Before, when I was doing the *Tamafah*, I felt like my prayer was something meaningful. But now, because I am not doing it as much as I did, I do not feel like I am connecting with the spirits. Something feels broken.

42. I do not know when the *Imalul* started, but it has been there a long time up until now. It is our way of life. When the sun moves to a certain place in the sky, it's time for the men of the village to come to the *Imalul* and drink *Nikkaowah*.

Worries About the Future

43. Because the Yam has already vanished, I am worried about all of the other crops. I am worried they will disappear too. I want them to be there for my children, my grandchildren, and future generations so that they have something to survive on and so they can practice our Kastom.

44. I am worried too because we are losing all of our arable land, which we use for gardening. When all of the arable land is gone, where will our people garden in the future? How will they survive? I am worried for my children and my grandchildren.

Senior State Counsel
Office of the Attorney General

45. I've been living here my whole life, but I've been hearing stories about factories far away putting up big smoke. I don't want the big smoke to come here and harm my *Imalul* and my people.

46. To the Judges of the International Court of Justice, I want to say: The changes are causing us to really suffer. If it is the big factories that are causing all of these changes, I want the Judges to put a stop to the factories putting up the big smoke.

Signed:
Johnny Loh
JOHNNY

Witness:
Christine Lava
Senior State Counsel, Office of the Attorney General

Date:
12 January 2024

Annex L

I, Jimmy Namile, from Iautapunga Village, Tanna, Vanuatu solemly affirm and declare:

BACKGROUND

1. My name is Jimmy Namile. I am 71 years old. I was born on November 12, 1952 in Louwangou Health Center, on the island of Tanna, Vanuatu. I live in Iautapunga Village within Naurarimine Tribe.

2. I am a Vanuatu National and I provide a statement to the International Court of Justice on changes in the weather I have observed, my experience living through cyclones, including category 5 Cyclone Pam, and my concerns for my grandchildren and future generations.

3. I speak Nafe, as my local language, as well as Bislam which is one of Vanuatu's national languages. I have given my testimony in Bislama and Nafe through a translator. This written statement has been read back to me in its entirety in a language I understand and I have certified its accuracy.

4. My testimony is based on my direct knowledge or my knowledge based on kastom, which has been passed down to me from my parents, grandparents, great grandparents, and ancestors.

5. Iautapunga is an inland village located near the volcano, which in my language is called Yasur, meaning God.

6. I have six children, four grandchildren, three great grandchildren, and one great-great grandchild. I also have one great-great grandchild on the way.

7. I am the Chief of the Naurarimine Tribe. My duty as Chief is to look after my tribe and to make sure the people have unity.

8. I have lived on Tanna in Iautapunga Village for my whole life. I have seen big changes to the weather in my lifetime. I have also lived through several cyclones. I have experienced the cyclones getting more intense over time and causing more damage to my community.

CHANGES TO THE WEATHER

9. The weather has changed a lot during my lifetime. During my days, for the first 50 years of my life, the climate was normal – we got just enough rain and just enough sunshine. We were able to grow enough food.

10. Things changed after about 2000 or 2001. Since then, we've been experiencing more intense rain and thunder, hotter and more intense sun, and more earthquakes. Because of these changes we are no longer able to grow enough food. When the sun is strong, the crops are not able to produce. And then when the rain comes, the crops go rotten. The rain especially affects the root crops.

Signed: Prepared on 09/01/2024 at Ianakulu, Tanna, Vanuatu CounterSigned: 1

JIMMY

Senior State Counsel
Office of the Attorney General, Republic of Vanuatu.

11. The rain no longer cools the temperature down like it used to. Before, the rain would cool everything down. Now, even after the rain we still feel hot. Because of this I often feel too hot and have a hard time cooling down.

CYCLONES

12. I've lived through several cyclones. In the past, before 1972, we didn't experience too many impacts from the cyclones. But since then and especially after Pam, the cyclones have intensified, and the impact has been very huge on the people.

13. In 2015, Cyclone Pam came and destroyed everything. All of the houses were flattened, even the cyclone shelters.

14. When Pam hit, I was in my house with my wife, six children, and four grandchildren. The grandchildren were aged from about seven to 13. The house fell down around us. We had to run outside and hide under a big banyan tree for shelter.

15. After the cyclone passed, everything was destroyed. We had nowhere else to go so we continued living under that banyan tree for about two weeks while we built back our house. We built a traditional house using local materials. We build the roof out of coconut leaves that had fallen. We had to use them quickly before they rotted. We made the wall out of bamboo that had been knocked over by the storm, and held the house together using nalaus, which is a rope made out of a local plant.

16. All of the rain from Cyclone Pam caused graves to be washed away. Graves belonging to my grandfather, my father, and my brothers all washed away. My heart was broken when the graves were washed away. I cried.

17. The grave site is a tabu because that's where the spirits live. By washing away the graves, the cyclone disturbed the spirits. In our kastom we believe disturbed spirits bring sickness and disease.

18. In kastom, after the graves were washed away, I had to go get new soil and put it back where the graves were. I then had to go get a kava and a pig, and kill the pig at the Nakamal to stop the spirits from walking around, to put them back at peace. I wasn't able to do that until the water dried out and the soil was really dry. The nakamal is the centre of life for the village. It's a gathering place for performing ceremonies and rituals for everyone in the village.

19. Pam also destroyed all of our gardens. All of the crops for the whole village were gone. We had no food. The women would go look for anything they could find to feed the children in the debris. Any food they found in the debris went to the children. I ate the dried coconut flesh and the stem of the Taro Fiji plant. This part of the plant isn't really edible. It burns your throat if you try to eat it. It is very painful. But we were starving. We

Signed: JIMMY

Prepared on 09/01/2024 at Ianakulu, Tanna, Vanuatu

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didn't have any other option. I baked it on a hot stone to reduce how painful it was to eat, but it didn't help that much.

20. Our village is on a hill about 100 or 200 meters from the side of a valley. All of the rain from Pam caused the valley to fill with water. The waters raised right up to our village and even breached the Nakamal where some people were seeking shelter. Those people had to move.

21. We kept gardens on the other side of the valley, about 1 kilometer away. After Pam, I went there to check to see if there was any food. Normally we would walk through the valley to get to our gardens. But because the valley was flooded, I had to swim. I made a raft and paddle out of bamboo and paddled across the flooded valley. But when I got there, I saw that the gardens were destroyed. The water and the winds had rooted out all of the crops.

22. We lived like that, with no food, for about one month, until the government was able to get rations to us.

23. It was also hard to get fresh water. All of the flood water was stinking because of the rotten leaves. To get drinking water we used plastic water bottles to collect water from our water catchments. But we had to wait for the rain to come. While we were waiting for clean water to come, we had to drink from the flood water. I didn't get sick from the water, but the children did. They got sick and experienced flu-like symptoms.

24. After Pam, we slowly tried to recover. It was hard because the gardens were not giving good produce like they used to. Then, in 2019, we got hit by another cyclone and had to start recovering all over again. The same again in 2023, we got hit by the twin cyclones, Judy and Kevin, within one day of each other, and had to start all over.

25. The children really suffered. After Pam they couldn't go to school for three to four months. The same thing happened after the twin cyclone in 2023. My grandchildren were frightened by living through Pam and they still have that feeling whenever there is heavy rain or storm.

26. The changes we are experiencing is making life difficult. The hotter and rainier conditions plus the repeated cyclones is making it hard to grow food. When I was young, we used to have lots of fruits, taro, cassava, kumala (sweet potato). But now there is nothing.

27. In the future I will be dead already, but I worry for my grandchildren and great-grandchildren. I wish these changes to the weather and cyclones would stop.

28. Climate change is really affecting our way of life, but we didn't cause it. It is caused by all of those big countries emitting gases. I wish they would stop so we can continue to enjoy our way of life.

Signed: JIMMY

Prepared on 09/01/2024 at Ianakulu, Tanna, Vanuatu

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Office of the Attorney General, Republic of Vanuatu.

Annex M

I, Naus Iaho, from Yakel Village, Tanna, Vanuatu, solemnly affirm and declare:

Background

1. My name is Naus Iaho. I am a national of Vanuatu. I live in the village of Yakel on the island of Tanna in Vanuatu. I am 62 years old.

2. I have been asked to give a testimony to the International Court of Justice about how the weather is changing and how this affects the practice of traditional medicine in my village.

3. I speak my language Nahvwaal, I have given my statement through an interpreter John Kalwas, who can speak Nahvwaal. He read this statement to me in Nahvwaal and I agree with the content of it.

4. My testimony is based on my direct knowledge or my knowledge based on Kastom, which has been passed down to me from my parents, grandparents and my ancestors.

Traditional medicine

5. In Yakel, we have traditional herbs that we use for medicine. A very important medicine is an herb that we use to help young women to get pregnant.

6. I am responsible for preparing that medicine. Only myself and one other woman in my village, Linet Iawain, know how to prepare the medicine.

7. I am asked to prepare the medicine every time a woman wants to have a baby. They ask me every time because the medicine is so important.

8. The knowledge of the medicine and how to prepare it was passed from my ancestors, to my mother, and then passed on to me. The knowledge of the plants and how to prepare them is secret and sacred. It is too sacred for me to talk about in more detail.

Changes to the rain is damaging medicinal plants

9. Before, it was easy to find the herbs that I use for the medicine, but now, it is hard to find those herbs.

10. I think this is due to the bad rain that is coming and making the plants die off. The bad rain is too heavy. In the past, when we had good rain and the medicinal herbs grow very well. When the bad rain is coming it makes the plants die off. The bad rain affects the leaves, the leaves die and are falling off due to the bad rain. This is because when we get too much rain, the soil is absorbing too much water. That's why it is affecting the plant.

11. These changes started with Cyclone Uma. Before Cyclone Uma, it easy for me to make the medicine. When Cyclone Uma came it destroyed some of the medicine, but it was still there for me to do the medicine, up until Cyclone Pam. But after Cyclone Pam so many of the plants have died that it is hard for me to do the medicine.

Senior State Counsel
Office of the Attorney General

12. When someone asks me to do the medicine, I used to always be able to make it. But now, when I can't find the herbs, sometimes when they come and ask me, I cannot make the medicine.

13. Making the medicine is my sacred duty. It's something that I must do. If a woman is asking me to make that medicine so that she can get pregnant, it is a must for me. I have to look everywhere for the plant, so that I can make the woman pregnant. When I can't do it, to me it is a failure.

14. I worry about the future when there won't be any plants and it will be impossible to make the medicine. The knowledge that I have about the medicine, I have passed on to my daughters. I am worried that when I am gone, my daughter won't be able to keep practicing medicine because the plant is dying.

15. The last thing that I want to say is that we humans came to this planet, this world, to reproduce. When they are not able to reproduce, people come to me for the medicine so they can get babies. Now I am so worried about the future when there is no more medicine to produce the babies, I am worried.

Signed: Naus Iaho

Witness:
Senior State Counsel
Office of the Attorney
Date: 12 January 2024.

Senior State Counsel
Office of the Attorney General

Annex N

I, Sera Nawahta, from Yakel Village, Tanna, Vanuatu solely affirm and declare that:

1. I am a Vanuatu national, living in Yakel village in Tanna. We live a very traditional life, from the time of the ancestors.

2. I do the medicine for fever and headache and joint pains. This medicine is disappearing due to heavy rains, which are different to what the rains used to be like when I learnt this medicine.

3. I use customary knowledge and plants for this medicine.

4. Before, when the people came to me to do the medicine, it was not difficult for me to find the medicine. I had plenty of that particular plant to do that medicine. After Cyclone Uma in 1987, I still have the plants but after Cyclone Pam in 2015 the plants are disappearing. It is hard for me to do the medicine. Also due to the rains that are falling, there are bad rains that are making the plants die and not grow. It is hard for me nowadays to do medicine.

5. The bad rain comes and it will wash the plants. I was thinking that the plants will be Okay but the sun comes and the leaves become yellowish and fail.

6. It is a bad rain because when it falls it is so heavy and it is destroying the plant. It did not rain like this before.

7. My great grandfather taught my grandfather who taught my father-in-law and then my father-in-law taught me. Men or women can do this medicine. But only few people, including myself know this medicine.

8. Now, because of the changes in the weather, I was going to teach my daughter about the medicine but due to the weather this is happening. I do not know whether I am going to teach my daughter about the medicine or not. I would like my daughter to learn this medicine so she can serve the community by saving their lives when they are sick. If the plant is not growing anymore, she may not be able to find the plants to practice the medicine.

9. Because the medicine is for fever, headache and joint pains, I am asked a lot for this medicine. For the elders, if they have joint problems, can do that also to help them. For the fever, I work with people who are very sick in the community and I do this medicine for them.

10. This is essential medicine for the community and I am worried about the community because if the community is getting sick I am there to make the medicine for them. I am there to serve my community. Without the plants to make the medicine, I cannot look after the community's medical needs.

Signed: Sera Nawahta

X

Witness:
Senior State Counsel
Office of the Attorney General
Date: 12 January 2024

Signed: Sera Nawahta Prepared at Lenakel, Tanna, Vanuatu on 12 January, 2024 Signed: Witness 1

X

Senior State Counsel
Office of the Attorney General

Annex O

I, Robsin Tigona, Lecturer in Environmental Sciences at the Vanuatu National University, the Republic of Vanuatu, solemnly affirm and declare:

BACKGROUND

1. My name is Robsin Tigona, and I am a national of the Republic of Vanuatu ("Vanuatu"). I was born on 13 July 1975 in Silimauri Health Centre, Tongoa Island, Vanuatu

2. I am currently a Lecturer in Environmental Sciences at the Vanuatu National University. I have been in this position since 2022. Prior to that I was undertaking PhD studies at the University of the South Pacific in Fiji for 3 years whilst also acting as a teacher's assistant in the postgraduate diploma in climate change course.

3. My PhD dissertation, which is currently being finalised, is entitled "Improved seasonal rainfall predictions in the Tropical Pacific Islands". My PhD attempts to assist the meteorology departments of Vanuatu, Fiji, Tonga, Solomon Islands and Tuvalu to improve their predictions of seasonal rainfall in the southwest Pacific. Particularly, how accurately they can predict rainfall in the southwest Pacific after the announcement of an El Nino or La Nina weather event.

4. From 2002 to 2019, prior to undertaking my PhD studies, I worked for 17 years with the Vanuatu Meteorology and Geo-hazard Department ("Vanuatu Meteorology"). Whilst at Vanuatu Meteorology I held several different positions including; weather observer, climate forecaster, weather forecaster, climate officer as well as Principal Scientific Officer for the climate division within the Vanuatu Meteorology.

5. During my time at Vanuatu Meteorology I undertook masters studies at the University of Auckland in New Zealand. My masters research paper was on the relationship between the El Nino-Southern oscillation and rainfall in Vanuatu.

6. The matters that I speak about in this Statement are based on my research as well as my work with Vanuatu Meteorology. The opinions I express in this statement are based on my expertise.

CLIMATE CHANGE HAS INCREASED INTENSITY OF CYCLONES IN VANUATU

7. In Vanuatu, we have two main climate seasons, which are the dry season and the wet season. Normally, the dry season is from May to October, and the wet season is from November to April. The normal tropical cyclone season in Vanuatu is from November to April.

8. There are 5 tropical cyclone categories. Categories 1 and 2 are considered less severe cyclones and categories 3 to 5 are severe cyclones.

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9. People in Vanuatu plan around the seasonal calendar. Both the planting calendar for crops and the customary ceremony calendar are based around the seasonal calendar. For example, the dry season is the planting time, people may plant yam between May and October and harvest it the following April.The customary ceremony calendar is linked to when certain crops are ready to be harvested.

10. In the past, the planting calendar most ni-Vanuatu lived their lives around was assisted by the cyclone season. Less severe cyclones would occur after the dry season, usually bringing with them much needed rain. This was especially so if there had been a drought that year. The category 1 and 2 cyclones were generally welcomed because they would bring a lot of rainfall for the planting without too much wind causing destruction.

11. Since 1970, tropical cyclone data has improved and become more accurate with the introduction of satellite technology. From data collected since 1970, we know that in the past, Vanuatu's cyclone season consisted of mostly category 1 and 2 cyclones followed by the possibility of a category 3 cyclone in January, February or March.

12. I have observed that this historical weather pattern has changed from about the year 2000 onwards. In 2002, Vanuatu was hit by severe tropical cyclone (TC) Zoe, a category 5 cyclone, that formed in the Solomon Islands and destroyed the island of Tikopia before heading towards Vanuatu. Frequent and intense tropical cyclones have been on the rise since then.

13. In Vanuatu, the number of cyclones as a whole that we expect during tropical cyclone season has not really changed. But now, instead of getting less severe cyclones with the possibility of maybe 1 severe cyclone, almost all the cyclones that hit us during cyclone season are severe cyclones.

14. When the IPCC reports state that climate change will cause less frequent cyclones but more intense cyclones, for us in Vanuatu, it means less category 1 and 2 cyclones and more category 3 to 5 cyclones. So overall we may get the same number of cyclones as we did in typical tropical cyclone season but now, instead of mostly category 1 and 2 cyclones, almost all our cyclones during cyclone season are severe cyclones.

15. I have also observed in the last few years that severe tropical cyclones are falling outside the peak severe cyclone months of January, February and March. For example, TC Lola in 2023, occurred in October, even before the tropical cyclone season started. So now we are starting to experience severe tropical cyclones outside the normal tropical cyclone season as well as outside those peak severe cyclone months.

EXTREME WEATHER EVENTS IN VANUATU ARE CAUSED AND AMPLIFIED BY CLIMATE CHANGE

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Climate Change results in increased intensity and frequency of El Nino and La Nina Events

16. The increase in frequency of El Nino and La Nina events can also be attributed to global warming. The rising sea surface temperatures are causing more frequent and more intense El Nino and La Nina weather events.

17. Looking at the trend of El Nino and La Nina events since Vanuatu's Independence in 1980 it is evident that there has been an increase in frequency of El Nino and La Nina events. The first El Nino since Independence was from 1982-1983. The second El Nino was from 1987-1988. Followed by a La Nina from 1989-1990. Then there were El Nino like conditions from 1991-1993. El Nino again from 1997-1998. La Nina from 1999-2000. Between 2000-2009 there were possibly 2 El Ninos. Then a La Nina in 2013 and an El Nino in 2015.

18. From 2020-2022, we had three years in a row of La Nina. According to the World Meteorological Organisation, that's the first time we have experienced three La Nina's in a row.

Climate change-induced exacerbation of ENSO events results in more severe cyclones

19. The increased frequency and intensity of the ENSO as a result of climate change is likely the cause of the changes to cyclone patterns in Vanuatu.

20. To try and understand why TC Lola occurred when it did, I went back and looked at the data on tropical cyclones since 1970. I observed that there have been 6 tropical cyclones that formed in October in the Southwest Pacific since 1970: TC Ann in 1970, TC Bebe in 1972, TCs Martin and Lucy in 1997 and TC Xavier in 2006. Of these 6 tropical cyclones, only TC Lola reached category 5 status. So although a tropical cyclone forming outside of the tropical cyclone season may not have been totally surprising, what was surprising was its intensity.

21. When I went back and checked the climate situation, I found that each of these early cyclones was caused by the onset of an El Nino weather event. In October 1970, I found that an El Nino weather event started in September of that year and then TC Ann formed in October. In 1972, the El Nino started in September, then TC Bebe formed in October. In 1997, the El Nino started in September and TCs Lucy and Martin formed in October. In 2006, the El Nino started in September and TC Xavier formed in October. In 2023, the El Nino started in September, and TC Lola formed in October.

22. The El Nino means higher sea surface temperatures, which is a condition that is more conducive to severe cyclone formation. Specifically, there is potential for a cyclone to form when the sea surface temperature is 28 degrees celsius and above. Prior to TC Pam forming in 2015, the sea surface temperature was about 34 degrees celsius for 3 to 4 days. Cyclone

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Lola in 2023, formed just east of the Solomon Islands where the sea surface temperature was around 29 to 30 degrees celsius. These high sea surface temperatures were caused by global warming and exacerbated by the El Nino event. In isolation, El Nino makes it more likely that those temperatures will be reached.

23. Climate change exacerbates this by causing ocean temperatures to rise. Generally, an El Nino event means higher temperatures but an El Nino event coupled with global warming means even higher temperatures.

24. The increased ocean temperatures are also causing more frequent and more intense marine heat waves. Marine heat waves were not considered a climate disaster in Vanuatu and were not listed as an extreme event by the Vanuatu Meteorology up until the later 2000s. They are now considered an extreme weather event of concern for Vanuatu and are monitored by the Vanuatu Meteorology.

25. If we continue to experience increased frequency of El Nino events, combined with rising sea surface temperatures and more frequent marine heatwaves, then we should expect a lot more tropical cyclones. Whereas in the past, the development of an El Nino event might form a tropical cyclone at the beginning of the El Nino event, from the experience with TC Pam, I have observed that a more intense El Nino event may cause a tropical cyclone to form both at the beginning and at the end of the El Nino event.

26. TC Pam started developing at the beginning of the 2015-2016 El Nino event. Then towards the end of the same El Nino event, TC Winston formed. So we can say that the El Nino event of 2015-2016 created two tropical cyclones, one at the beginning and one at the end of the event. Both TC Pam and TC Winston were classified as category 5 cyclones.

27. There is also the increased possibility of severe twin cyclones. Whilst twin cyclones are not unusual for Vanuatu, in the past they have been less severe. Now, as we can see from TCs Judy and Kevin in 2023, both category 4 cyclones, twin cyclones are also becoming more severe.

Climate change-induced exacerbation of ENSO events results in more extreme weather

28. The El Nino and La Nina weather events are the biggest influence on rainfall and drought in Vanuatu.

29. My PhD dissertation looked at how climate change has caused the increase in frequency and intensity of the El Nino and La Nina weather events and what this means for rainfall in the Western Pacific and how we can better predict rainfall.

30. In 2022, I also contributed to a paper called the "Historical and Future Drought in the Tropical Pacific Islands and Atolls". This paper considers the increased frequency and

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intensity of El Nino and La Nina events and how we can predict and prepare for drought events in the Pacific Islands.

31. An El Nino event means extreme below normal rainfall and may lead to drought in Vanuatu and other Pacific Islands. This was what happened in 2015. TC Pam happened at the start of the El Nino and while people were trying to recover from its destruction, there was a drought, so that means Vanuatu was dealing with two natural disasters simultaneously. This drought was broken by TC Winston, but because TC Winston was severe, it came with a lot of rain and extreme wind. So instead of a welcome relief from the drought, TC Winston brought destruction and disruption to parts of Vanuatu.

32. As previously stated, ni-Vanuatu plan their lives around the seasonal calendar. When you have the intrusion of extreme weather events, it not only disrupts their lives but also their livelihoods. For example, normally you have a dry season from May to October, which is the time to plant food, but with 3 La Nina events in a row from 2020-2022, there was extreme rainfall and people could not plant food.

33. The World Meteorological Organisation said it was the first time there were 3 La Nina events in a row. During the same period there were also tropical cyclones occurring, including TC Harold, a category 4 cyclone, in 2020.

34. The impacts of climate change have placed Vanuatu in a very difficult position. Climate change has increased the frequency and intensity of El Nino events; meaning extremely low rainfall. At the same time, climate change has led to the increase in frequency and intensity of La Nina events meaning extremely high rainfall. So you either have a lot of rainfall that causes flooding and landslides or you have drought. In between this, you have severe tropical cyclones. All of this affects people's lives and livelihoods. That's the reality in Vanuatu right now because of climate change.

HOW CLIMATE CHANGE AFFECTS WEATHER FORECASTING

35. The role of the Vanuatu Meteorology is not just to observe and forecast weather and climate events but also to give out the information, advice and warning. If there's a tropical cyclone roaming around Vanuatu which is not a direct danger to the people then the Vanuatu Meteorology will just give information and advice. If the tropical cyclone or any other weather event is of danger to the people then it will give out a warning and advice.

36. The Vanuatu Meteorology also plays a role in disaster recovery in forecasting rainfall because rainfall can assist crop recovery in a country dependent on agriculture.

37. Normally, it is very easy to do seasonal forecasting in tropical climates such as Vanuatu because we only have 2 seasons. However, now with climate change and the increased

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frequency and intensity of extreme weather and climate events, it has affected the confidence we have in forecasting.

38. With El Nino and La Nina events, our general forecast may be accurate but it doesn't show the full picture of how this will impact people's lives. For example, during El Nino, the forecast will be of extreme below normal rainfall. That forecast is correct but that forecast does not accurately reflect how much below normal rainfall there will be and so people cannot adequately prepare for the El Nino event. Similarly, with a La Nina event, we can correctly forecast extreme above normal rainfall but what the exact rainfall will be and what this means for the livelihood of people is more difficult to predict. This is especially so when El Nino and La Nina events are happening more frequently and with more intensity.

39. This is why I focused on this issue in my PhD. I analysed sea surface temperature, the south oscillation index, as well as cloud cover, and then tried to determine how those parameters could be used to improve seasonal rainfall predictions in Solomon Islands Islands, Vanuatu, Fiji, Tonga, Tuvalu. From there, once there's a declaration of El Nino in the southwest Pacific, we can predict how long we have before rainfall drops to below normal levels or if there is a La Nina declared, we can predict how long before increased rainfall occurs in the southwest Pacific.

40. Changes to the climate also make it more difficult to predict cyclones, both in terms of when they might occur and how severe they might be. For a trend to be recognised as a new weather pattern by the World Meteorological Organisation there has to be 30 years of baseline data. So for example, because of events like TC Lola, if we wanted to revise the cyclone season in Vanuatu to start in October instead of November, we would need to observe this trend over 30 years. Without supporting baseline data over a 30 year period, events like TC Lola and the 3 consecutive La Ninas remain outside the normal weather patterns and are difficult to predict.

41. In terms of predicting the severity of tropical cyclones, the current cyclone scale does not accurately reflect the intensity of some of the cyclones we are getting in Vanuatu. The World Meteorology Organisation has a scale for tropical cyclones that only goes up to category 5. These categories are determined by the wind speed of the cyclone. In terms of severe cyclones; category 3 cyclones have a wind speed of between 64 to 85 knots, category 4 cyclones have a wind speed of between 86 to 107 knots and category 5 cyclones are any cyclone with a wind speed of 108 knots and above.

42. From the current tropical cyclone scale, we see that there is a range of about 21 knots within each cyclone category. So a hypothetical category 6 would have wind speeds of 130 to 151 knots and a hypothetical category 7 would have wind speeds of 152 to 173 knots.

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43. TC Pam, in 2015, had a wind speed of 134 knots and Cyclone Winston, in 2016, had a wind speed of 151 knots. If there were cyclone categories beyond category 5, then both Cyclone Pam and Cyclone Winston would be considered category 6 cyclones.

44. Vanuatu is now working on deploying measuring devices in the ocean as well as radar, which will assist us in forecasting extreme weather events, especially extreme rainfall and flooding.

WHAT DO FREQUENT, INTENSE AND SIMULTANEOUS CLIMATE CHANGE INDUCED EXTREME WEATHER EVENTS MEAN FOR VANUATU'S FUTURE?

45. In the paper I co-authored in 2022, we find that Vanuatu has been in a constant mode of disaster recovery for several years. That means one disaster strikes after another, or disasters strike simultaneously. People are trying to recover from one disaster and just as they are about to finish recovering or whilst they are still in recovery, another disaster strikes. For example, TC Harold, a category 4 cyclone struck Vanuatu in April, 2020. The recovery was on-going between 2021, 2022 and 2023, whilst La Nina events were taking place, and then in 2020 we had TC Harold, category 5, and in 2023 TCs Kevin and Judy, category 4, and TC Lola, category 5, strike, so the country was stuck in recovery for multiple disasters.

Signed: Robson Tigona

Signed: Witness

Senior State Counsel
Office of the Attorney General

Date: 14 March 2024

Annex Q

I, Peter Korisa Kamil, Head of Disaster Recovery Coordination Unit –DSPPAC for the National Disaster Recovery Coordination Unit within the Department of Strategic Policy, Planning and Aid Coordination (DSPPAC), the Republic of Vanuatu , solemnly and sincerely affirm and declare :

BACKGROUND

1. My name is Peter Korisa Kamil and I am a national of the Republic of Vanuatu ("Vanuatu"). I was born on 26 June 1980 at Green Hill Dispensary, Tanna.

2. I have worked at DSPPAC for 3 years. I have been in the [Head of Disaster Recovery Coordination Unit] of the National Disaster Recovery Coordination Unit (the "Recovery Unit") in DSPPAC since 2021.

3. The DSPPAC sits within the Prime Minister's Office. DSPPAC exists to support the Prime Minister (and by extension the Council of Ministers) to make policy and ensure that it is made operational. Its functions are to assist and enable the Prime Minister to develop, implement and monitor the vision of the government and to provide strategic leadership for cross-sectoral policies or programs, both government and donor. DSPPAC has 5 units, the Recovery Unit, the Aid Coordination and Negotiation Unit, the Monitoring and Evaluation Unit, the Policy Unit and the Right to Information Unit.

4. Prior to working with DSPPAC, I worked in the National Disaster Management Office for almost 13 years [2009 to 2021]. The National Disaster Management Office is a government department under the Ministry of Climate Change and Adaptation. It is the government's agency responsible for coordination of responses to emergencies and disasters across Vanuatu.

5. When the Recovery Unit was created in DSPPAC in 2021, I moved to work there.

6. There are two phases in Vanuatu's natural disaster response. The first is the humanitarian response, which looks at basic needs and lifesaving activities, and the second, is the "recovery response" which happens a few weeks or months later, where the focus shifts to reconstruction, mitigation and adaptation. Vanuatu's National Disaster Management Office is concerned with the first phase, the humanitarian response, and the Recovery Unit within DSPPAC is concerned with the second phase, the medium to long term interventions in the aftermath of national disasters.

7. The Recovery Unit is tasked with coordinating the gathering of information and producing the Post Disaster Needs Assessment and associated Recovery Strategy and Recovery Plan. The Recovery Unit is also responsible for coordinating the recovery activities and requirements in the Post Disaster Needs Assessment and the Recovery Strategy and Recovery Plan.

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Senior State Counsel
Office of the Attorney General P.I.C

8. More broadly, DSPPAC as a whole also focuses on implementation of the Vanuatu 2030 National Development Goals and its work is guided by the National Sustainable Development Policy. Within the National Sustainable Development Policy there are 3 pillars; society, environmental and economical pillars. The Recovery Unit has been mandated to carry out objective 3.3 of the environment pillar that is to strengthen post-disaster systems in planning, preparedness, response and recovery.

9. The matters that I speak about in this Statement are based on my direct knowledge of the facts stated and that have been reported to me by DSPPAC staff and our Government and non-government partners, as part of my role and function as [position] of the Recovery Unit within DSPPAC. The opinions I express in this statement are based on my expertise and on data, studies and surveys undertaken by DSPPAC as well as our partners.

HOW CLIMATE CHANGE INDUCED NATURAL DISASTERS IMPACT GOVERNMENT SYSTEMS

10. Vanuatu has several policies regarding disaster risk management; the Climate Change and Disaster Risk Reduction Policy and the Internal Displacement Policy, and the National Recovery Framework. These policies are all fairly recent and developed to respond to climate change. There is still no legal framework for most of these policies.

11. Within the Recovery Unit we are guided by the Recovery Framework and start our strategic process by conducting a Post-Disaster Risk Assessment. The purpose of this assessment is to calculate the loss and damage caused by a disaster. We worked with our partners, the World Bank, the Asian Development Bank, and UN agencies, to create the methodology used to conduct the risk assessment and calculate loss and damage.

12. Once we have calculated the monetary value of loss and damage, we measure it against Vanuatu's GDP for the year, to determine what the macroeconomic impacts of the disaster have been. From that measurement, we are able to draw conclusions on the human impact. We then work with consultants and economists, usually from donor agencies, to determine the "recovery needs."

13. Once we identify our recovery needs, the Recovery Unit creates a recovery strategy and a recovery plan in consultation with the other DSPPAC units. In terms of implementation, the recovery plan is usually identified as a Government project and it then follows the normal government process required to obtain approval and financing. Then it is up to the individual Government ministries identified in the plan to implement it.

14. In 2015, TC Pam was the first of a series of intense tropical cyclones over the last 8 years. We conducted a Post Disaster Risk Assessment and created policies and strategies from it that we started implementing a few years later but then TC Harold, another category 5 cyclone, hit us in 2020. Then only 3 years later, we had the twin cyclones, Judy and Kevin,

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both category 4 cyclones. So the loss and damage continues to accumulate and it is very difficult for us to address or mitigate the post-disaster risks.

15. The frequency of intense cyclones is a significant challenge to the capacity of relevant ministries engaged under any recovery strategy and plan. Currently, most ministries do not have a permanent project management unit to coordinate post-disaster risk activities stipulated in a recovery plan. You have the same people within these ministries dealing with multiple disasters, including frequent intense cyclones, over a prolonged period of time. It places these people under great stress and they cannot be expected to perform their duties within the required timeframes.

16. With each new disaster, Government ministries are constantly being forced to reprioritize their work. Let's take for instance TC Harold, a category 5 cyclone in 2020, its recovery plan was for a period of 1-5 years. The relevant ministries started implementing the plan and then the twin cyclones hit in 2022, so they have more activities and more responsibilities and they have to decide how to priorities them. In that time, COVID was also happening.

17. For the most part, in these circumstances, the ministries conduct the recovery plans for all the cyclones together. They implement all the recovery plans simultaneously because they don't want to lose their focus on one recovery which would mean those impacted communities remain even more vulnerable to the next disaster. So the ministries try to address everything at the same time.

18. We have so many recoveries running right now. The Recovery Unit only coordinates those projects that are within the common system. Ministries may also be coordinating projects on their own that are specific to their ministry. Then of course the UN agencies and civil society may also have their own recovery plans. So it is difficult to give an accurate picture of all the recovery plans running right now.

RESOURCE CONSTRAINTS IN RESPONDING TO NATURAL DISASTERS

19. The coordination of recovery plans largely depends on donor funding; whether the donor comes to DSPPAC, goes directly to a Ministry or runs its own recovery. Within DSPPAC, donor funding is handled by our Aid Coordination Unit. The Aid Coordination Unit allocates donor funding intended for disaster recovery to the Recovery Unit. However, donors are not required to work through DSPPAC and may approach Government ministries directly and this is why ministries may be running recovery plans outside of the Recovery Unit's purview. The Recovery Unit does not monitor recovery plans run by the UN and civil society independently.

20. DSPPAC is currently undergoing a comparative analysis, with the technical assistance of the World Bank, to determine how effective assistance from donors has been from 2015,

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with TC Pam, up to today. What we have observed so far is that the assistance coming from donors is declining. The preliminary findings is that donor funding is decreasing instead of increasing as Vanuatu faces more frequent high intensity cyclones. For TC Pam we received around 40-50% of the entire recovery cost from donors. For TC Harold in 2020, we only managed to receive 11% of the total recovery cost from donors. For TC Judy and Kevin in 2023, we received only about 1-2% of the total recovery costs from donors.

21. The accumulation of loss and damage from frequent intense climate induced disasters has placed Government resources under severe stress. We are currently experiencing problems with acquiring adequate resources to respond to the impact of disasters. It's overwhelming thinking about whether Vanuatu has the capacity to respond to all these climate-induced natural disasters.

22. Of the disaster risk management framework or risk management cycle, the recovery phase requires the largest portion of resourcing. The humanitarian phase may require about 20% of the overall resource allocation and the remaining 80% would be required by the recovery phase. However, the reality on the ground is that the recovery phase is only receiving about 10- 20% of the resourcing it requires.

23. The post-disaster humanitarian phase has a 1.5% budget allocation but the recovery phase is not currently budget appropriated. This means the Recovery Unit and the work we do relies on donor funding and on Government ministries allocating some of their funding to us or towards recovery plans. For both donors and Government ministries, their ability to allocate funding to recovery plans depends on whether they have sufficient funding in the first place and what their internal priorities are.

24. The current funding arrangement makes it challenging for the Recovery Unit to accelerate the recovery work. Donors, when they do assist in recovery, are focused on society building sectors, like social services, education and health. The areas that get the least resources in the recovery phase are essential sectors like infrastructure, telecommunications and the energy sector.

25. In addition, my understanding from my colleagues from the Aid Coordination Unit within DSPPAC is that the development banks like World Bank and ADB give us grants that are usually tied to both grant and loan component. So you can't receive grants without a loan. These loans make it very difficult for the Vanuatu Government to act freely to use the money to find solutions for our people. Not only is Vanuatu obligated to make loan repayments, the loans also impose reporting requirements, one of which is to deliver projects within a certain timeframe. When Vanuatu is being constantly hit by high intensity cyclones and there is no capacity within Government Ministries, it is very difficult to meet these reporting requirements.

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26. There is currently a bill before Parliament that has provisions that will require a budget allocation of 1.55% to be shared between both the humanitarian and recovery phases that may assist a little. That's only a 0.5% increase to the funding the humanitarian phase receives and it will have to be shared by both the humanitarian and recovery phases.

27. From our experiences with TC Harold, TC Pam and TCs Kevin and Judy, we have found that infrastructure, private housing and the production sectors are the most affected by intense tropical cyclones. The production sector includes agriculture. Some agriculture can recover quickly but not long-term cash crops.

28. At the moment, private housing recovery is the sole responsibility of the owners. The Government does not assist with repairing private housing. However, because this issue has become common and widespread with the onslaught of frequent intense cyclones, Government is in the process of developing a national housing policy to address it.

29. For public infrastructure, it's a real challenge. There's not much resource support, so the Recovery Unit and the relevant Ministries can't do much, this means the infrastructure remains damaged. For example, the Finance Building here in Port Vila was damaged during TC Pam in 2015, it's now 8 years later and it's still not repaired.

HOW NATURAL DISASTER'S IMPACT GOVERNMENT POLICY AND STRATEGIC PLANNING

30. As I've stated, the increasing frequency of climate change induced high intensity tropical cyclones (TC) has impacted DSPPAC's ability to respond to disasters, and we are constantly in recovery mode. This also impacts on DSPPAC's ability to focus on our policy and strategic direction. In 2023 alone, we had the category 4 twin cyclones, Judy and Kevin, and then the category 5, TC Lola. This means we don't have enough space or time to look at mitigation and adaptation to climate change. We are barely advancing the Post-Disaster Risk Assessment before the next cyclone hits.

31. The work of DSPPAC is ultimately guided by Vanuatu's National Sustainable Development Plan 2030. However, when we have unforeseen disasters happening so frequently, they disturb the Government's normal planning process and we have to constantly re-focus and re-priorities. We try to communicate and advocate the direction and priorities of Government to donors as best we can. We must rely on donors assistance, especially with the constant need to respond to disasters, we do not have the adequate resources to carry out our activities without donor assistance.

32. In terms of Government planning and development, a lot of focus has shifted towards disaster response and recovery. Vanuatu has the National Sustainable Development Policy 2030 but it's very difficult to stick to our policy objectives as we are required to

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continuously adjust them in line with the continuous disruption caused by intense tropical cyclones.

33. Not only do these climate change induced disasters throw us off our policy objectives, they also destroy work completed during peace times in pursuit of our sustainable development policy objectives. For example, as part of policy implementation, a sealed road may be built around one of the islands, and then a cyclone hits and damages that road and it has to be built again. This disrupts our economic progress, stresses our finances, and for many of these infrastructure projects, places us further in debt.

34. Our Government has taken loans from various banks and agencies to fund projects as part of the National Sustainable Development Policy as well as to fund response and recovery plans and activities. However, we have almost hit the debt threshold with multilateral funding agencies and they feel reluctant to continue lending to us. The World Bank and other multilateral funding institution losing interest to offer loan component for Recovery program, Vanuatu can only accept the grant.

35. From my understanding, tourism and the service industry and agriculture are the biggest contributors to Vanuatu's GDP and our economy. The COVID pandemic from 2019 until 2021 really affected our tourism and service industry and, as stated earlier, the tourism and service industry and the agriculture industry are two of the three most impacted sectors by climate induced intense cyclones. This makes it very difficult for Vanuatu to obtain and maintain loans for post-disaster recovery as well as for our development objectives.

36. With all the disruption and destruction from intense cyclones, especially since 2015, it is my opinion that the challenge is too great and that Vanuatu's National Sustainable Development Goals are too ambitious to be met by 2030. Vanuatu needs to do more risk informed development now that we are experiencing significant climate change impacts frequently. We need to do better planning but that is also difficult because a lot of our legislation is not suited to the changing environment. We also have serious legal and cultural discussions that need to be had, including around land tenure. We need to make these changes, but the government also does not have the time or resources to devote to this type of planning because, as I explained, we are always in disaster response and recovery mode.

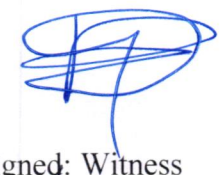
37. Some of the legislation that is not suited to addressing the climate change impacts Vanuatu is facing is our land tenure laws. In Vanuatu large areas of land belong to the ni-Vanuatu, the customary custodians. The Vanuatu Government knows that we need to plan for extreme heat and El Nino which would include conserving catchment areas and things like that but it is difficult for the Government to make those plans because the land is not owned by the Government but by Ni-Vanuatu.

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38. One of the ways we can address this is to educate our people about the impacts of climate change and to advocate for solutions. Some of the solutions may mean letting go of some of our traditional systems. Climate change is changing the world and is changing Vanuatu and our people may need to change to adapt to the different situation. The impact, intensity and frequency of climate change are overwhelming our traditional knowledge. Our traditional coping systems are not working on their own anymore. So to survive this, we will be forced to bring in modern systems as well. As a nation, we have chosen to maintain our traditional ways. Now we are being forced to abandon them because of climate change.

Signed: Peter Korisa Kamil



Signed: Witness

Senior State Counsel
Office of the Attorney General

Date: 14 March 2024

Annex R

I, Antoine Ravo, Director of the Department of Agriculture, the Republic of Vanuatu solemnly affirm and declare:

BACKGROUND

1. My name is Antoine Ravo and I am a national of the Republic of Vanuatu. I was born on Efate and my address is Agriculture Department Port – Vila, Vanuatu

2. I am the Director of the Republic of Vanuatu Department of Agriculture, a position which I have held for the past 7 years. I have been working for the Department of Agriculture since 2009. In 2016, I was appointed as the Director of the Department of Agriculture. I am also the Chairman of the Vanuatu Agricultural Research and Technical Center, which focuses on promoting sustainable and productive development of both subsistence and commercial agriculture in the country.

3. The Department of Agriculture has a broad mission. The overall goals of the Department are to improve livelihoods through improved agricultural innovation in all smallholder farming communities, to ensure food security for all citizens, to improve overall production of subsistence and cash crops, and to mitigate climate change-associated risks to food security. The Department aims to ensure that the country's agriculture resources are managed in an integrated and sustainable manner to provide food and income as well as protect the environment. These objectives seek to fulfill the commitments enshrined in the Constitution of Vanuatu, which states that it is the core duty of the Country to ensure that we manage our natural resources profitably and sustainably.

4. My responsibility as the director of the Department of Agriculture is to oversee and coordinate the overall management and implementation of 23 programs and priorities of the department. In recent years, many of our projects and priorities have been focused on climate change impact mitigation, adaptation, and disaster recovery. Since 2020, the primary focus of the Department has shifted to focus on assisting farmers, the private sector, and other stakeholders to cope with climate variability and cyclones, which are the two major challenges affecting the agricultural sector.

5. Currently, the Department has just 96 staff members to fulfill this mandate. However, due to increasing challenges as a result of changing weather, more frequent and intense extreme weather events, and more frequent and intense cyclones, the Department has been funded to expand to 204 staff by 2026.

6. The matters that I speak about in this Statement are based on my direct knowledge of the facts stated, have been reported to me by Departmental staff, as part of my role and function as Director of the Department of Agriculture. The opinions I express in this statement are based on my expertise and on data, studies and surveys undertaken by the Department of Agriculture or the Vanuatu Government.

AGRICULTURE IN VANUATU

7. Agriculture is the mainstay of livelihoods for the vast majority of Vanuatu's population. According to the 2022 National Agriculture Census, 77% of the nation's population depends upon agriculture. 98% of agriculture activity in Vanuatu is for subsistence purposes, while the remaining 2% of crops are grown for commercial sale. Commercial agriculture accounts for 3% of Vanuatu's GDP

8. Most agriculture in Vanuatu is focused on 19 crops. Of these, the major commercial crops include kava, coffee, cacao, and coconut. The staple food crops are root crops like taro,

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yam, sweet potato, cassava, and fruit trees, including breadfruit and banana. Other important crops include mango, watermelon, pumpkin, and Tahitian limes.

9. To qualify as commercial agriculture, growing plots must occupy at least one hectare of land.

10. Subsistence agriculture means crops that are grown to meet food security needs and for small-scale exchange within and across communities. Staple subsistence crops include root crops such as taro, sweet potato, yam, and cassava, as well as fruit trees, such as breadfruit,banana and coconuts. Other important subsistence crops include pumpkin, watermelon, mango, and pineapple.

IMPACTS OF CLIMATE CHANGE

11. Food security is increasingly important with natural disasters, Climate Change and increasing cost of living. The impact of the twin cyclones Kevin and Judy on the productive sector was valued at 113.2 billion Vatu *(TC Kevin and TC Judy PDNA report 2023)*

12. Climate change is having major impacts on the ability of both subsistence and commercial farmers to grow crops. We have extreme weather events, such as cyclones, drought, flooding and storms, which have increased in frequency and intensity over the time I have been working at the Department of Agriculture. Sea-level rise is also causing saltwater contamination of soil and groundwater, which is damaging crops and forcing people to reduce their drinking water intake.

13. Rising temperatures have negatively affected crop development. Some staple crops including coconut, cocoa, coffee, banana, kava, island cabbage, yam, cassava, taro, sweet potato (kumala), breadfruit, citrus and leafy vegetables have specific temperature requirements for germination, flowering, and reaching maturity. This has caused a decrease in yields for all crops, including root crops, vegetables, and fruit trees.

14. For example, as a result of rising soil temperatures, our tomato plants, which are supposed to produce big tomatoes, cannot do so. The tomatoes cannot withstand the impacts and they grow very small. This means we have to import new variants from outside of the country, from places like Australia or from Fiji. This is very expensive for us.

15. Drought is also hitting the crops. Drought conditions cause crops to wilt, reduce the yield of most crops, and increase the risk of wildfire. As a result of drought conditions, the Department of Agriculture is encouraging subsistence farmers to relocate their farms to be closer to water sources, like river banks. But relocation is a major effort and most farmers cannot do it on their own. They need assistance from the Government.

16. From my observations, droughts are now prolonged compared to the past. The period of drought is getting longer and we have more droughts. In the past, we would have a drought every 10 years, but now drought is more frequent. When there is a cyclone, there will be a drought.

17. We also have been experiencing increased frequency and intensity of extreme rainfall events over time. Periods of heavy rain have been lasting longer and occurring closer together. These days we have periods of heavy rain that last for one and half days–longer than ever before. So much rain causes the water table to overflow. This results in increased flooding events, which is a big problem for agriculture. Floods now go through the land, into the houses, the farm, the livestock farm. Extreme rain also causes rivers to overflow, which damages villages and causes soil erosion as well.

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18. Another impact of climate change is an increase in pests and disease affecting crops. With increased temperature and humidity the number and distribution of pests increases. We see new weeds and new pests coming in that were never here before.

19. A serious concern is the coconut rhinoceros beetle (CRB), which is destroying our coconut trees. The CRB thrives under hotter conditions. They eat more food under hotter conditions, and we've even seen them beginning to infect other crops like sugar cane and taro. We've been working with the department of biosecurity to control the CRB, with cultural control, biological control, and chemical control, but with the increased temperatures and increased rainfall it has been difficult. We still haven't been able to come up with a proper solution.

20. In every coastal area in Vanuatu the groundwater and soil has been contaminated by saltwater due to sea-level rise. This is especially bad in the low-lying islands. But even in the volcanic islands, soil has been washed away by rough seas and cyclones.

21. These low-lying, coastal areas are traditional agricultural grounds where people have always planted. For example, if you go to Ambrym Island, you will see coconut, mango, and breadfruit trees standing in saltwater. Places that used to be farmland are now covered in saltwater.

22. Contamination of groundwater by incoming saltwater has affected household consumption of water as well. Because groundwater is contaminated with saltwater, people have reduced their intake of drinking water, as well as water used for cleaning, watering the plants, and washing food.

23. In the bigger islands, like Efate, when people see that the groundwater has been contaminated in coastal areas they move inland. But in smaller islands, like the Torres Islands, there is no place to move. Wherever you move you would still have saltwater contaminating the groundwater.

CYCLONES

24. Cyclones are one of the biggest threats to the agricultural sector. These events cause physical damage to the crops at every step in the supply chain, including post-harvest. When we get a category 4 or 5 cyclone, then it's 100 percent damage. Everything is destroyed. The Department has found that both the cash crops like kava, cacao, coffee and coconut, as well as food security crops like root crops and fruit trees are destroyed by category 4 or 5 cyclones.

25. After a cyclone, crops need time to recover. We've been promoting climate resilient crops like green vegetables and sweet potatoes, which only take 2-3 months to regrow. These crops are considered climate resilient because they are early maturity–they have a chance to grow before another cyclone hits. But most staple crops take longer. Cassava takes six months, while taro, yam, and banana take nine months to recover. Crops that are low to the ground are also more climate resilient, but crops like fruit trees, breadfruits, avocado all get blown away by the wind. After a Category 4 or 5 cyclone, there's no more trees. No more fruits.

26. The Department is teaching farmers about climate resilient crops and also encouraging them to make specific plantings of crops for disaster. We are also teaching the farmers how to prepare before a cyclone and store their crops in a safe place after a cyclone, so that they will have something to eat while waiting for government assistance.

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27. With the repeated cyclones we've been experiencing, it has been very difficult for us to cope. We are supposed to get one Category 5 cyclone every five years. This year we have already had three Category 5 cyclones. Farmers and crops do not have a chance to recover from one cyclone before they are hit with another. Cyclones have also been staying in Vanuatu longer than in the past, lasting for longer periods of time.

28. Some communities, like those in North Pentecost, that keep getting battered by cyclones are really suffering. Their food security is compromised. Our advice is to manage food intake. Young people who still have energy have to eat less. They have to eat only once a day, at lunchtime, so there is enough food for more vulnerable groups, like the children, the old people, and the breastfeeding mothers. This usually continues for three months after a cyclone, until the quick crops (green vegetables and sweet potatoes) start growing again. For example, I was in Pentecost during Cyclone Harold (2020 Category 5 cyclone) and this is what occurred.

29. One of our major export crops, Tahitian Lime, is particularly vulnerable to cyclones. These trees are planted on sloped areas. With repeated cyclones these trees are lost due to soil erosion. After the twin cyclones in March only 4 of 11 Tahitian lime farms survived. And the eroded soil washes into the ocean and causes serious problems to the reef and marine resources as well.

30. Soil erosion has a number of cascading impacts. In addition to damaging the reef, soil erosion disturbs the habitats of many important pollinators for our staple crops. Soil erosion is also restricting access to farmlands by causing damage to roads. This is exacerbated by landslides, which occur during earthquakes and cyclones.

CYCLONE RESPONSE

31. When a cyclone hits, the Department of Agriculture is also responsible for disaster recovery and response through the Food Security and Agriculture Cluster (FSAC). FSAC works with the National Disaster Management Office (NDMO) to develop a plan for immediate response as well as short-term and long-term recovery in terms of community food security as well as the well-being of the agriculture sector.

32. When a cyclone hits, we stop our normal work and re-allocate our budget and our staff to deal with disaster recovery. The Department of Agriculture's annual budget is appropriated every year by parliament, and that is the budget to fulfill our normal business plan based on our policy and strategy. But when a cyclone hits and a state of emergency is declared, then all budget and resources are diverted to disaster response. This year there have already been three cyclones. We've been in a state of emergency for 7 months of the year, so our ability to carry out our normal work has been severely limited.

33. Right now, 100% of our staff is dealing with Cyclone Lola. When Cyclone Judy and Cyclone Kevin hit within a week of each other this March it was 100% of the staff working on disaster response for the duration of the 12-month state of emergency. When Cyclone Pam hit it was 100% of the staff for the duration of 24 months.

34. In terms of immediate response, normally if one island is hit, we work with other islands to take local food to feed the affected island. We also give out planting materials for climate resilient crops like cassava cuttings and sweet potato cuttings, as well as redirecting funding and resources to support this island. We try to coordinate sending food from nearby communities if possible, because it is very expensive to get food to the affected islands.

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35. These days, we are also worried about transferring food from one island to another–because what if another cyclone comes through and hits the island making the donation? Then where are we going to get the food? For example, there were twin cyclones that hit this March, one right after the other. Luckily, those cyclones passed through the same provinces, but if they had hit different locations we would have been in serious trouble.

36. We have to start planning for if a cyclone affects everyone. So we are beginning to pre-process our crops–for example making cassava flour, which we can store and send out as emergency food.

COMMERCIAL AGRICULTURE

37. A top priority of our department is ensuring the livelihoods of the people. Most of our population depends on agriculture, so despite the impacts of climate change, we need to ensure they can continue to make a living.

38. Vanuatu's most important export crop is kava. Kava accounts for 66% of Vanuatu's commercial export value. It also is the crop that most farmers earn income from. Kava grows best when the temperature is cooler, rainfall is consistent, and soil moisture is high. Climate change impacts, especially rising temperatures and increased drought conditions are affecting the ability of farmers to grow kava affecting 29,802 households planting 53,593,413 kava plants with a total volume of production (in metric tonnes) 153446.7 and total gross value of crop production (in billion Vatu) 240.175 *(Source: National Agriculture Census 2022).*

39. Cyclone damage also impacts kava farmers. For example, Cyclone Lola completely destroyed the kava.

40. The increasing intensity and frequency of cyclones in recent years have had a major effect on our commercial agricultural outputs. Before Cyclone Pam our exporting activity was so high. But after the cyclone, our export crops were destroyed. We had no more kava.

PREPARING FOR THE FUTURE

41. Looking ahead, the priority of the Department of Agriculture is to ensure that all of the people of Vanuatu have the fundamental right to eat. That they have to have food. We have to support people to ensure that they have enough food and that there is no food insecurity. Climate change is already impacting this. Especially after cyclones, there is not enough food available. People are already required to reduce their food intake. I worry for the future, where food security is already an issue in Vanuatu now because of these extreme weather events and other weather issues, such as drought.

42. As the impacts of climate change will continue, there will come a time when our resources will be scarce. So we need to prepare. We need to adapt and mitigate impacts on the resources that we have. We need science, good research to plan for the future. But a challenge is that the research capacity in our sector is too low and we do not have the resources required, especially when the Departmental capacity is redirected to response and recovery.

43. As my last statement: We need support! We need financial support to maintain our roles and responsibilities, to ensure that people have sufficient food and also increase the standard of living. The impact of climate change is here and will be ongoing. We need support in terms of infrastructure so that we can be more resilient in our response and adaptation to climate change.

JLS
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Office of the Attorney General

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Signed: Antoine Ravo 

Signed: Witness

Senior State Counsel, Office of the Attorney General

Date: 15th March 2024

Annex S

I, John Kaltau, Acting Director General of the Department of Education, Republic of Vanuatu, solemnly affirm and declare:

BACKGROUND

1. My name is John Kaltau and I am a national of the Republic of Vanuatu. I was born on 23rd June 1972 and my address is Department of Tertiary Education, Ministry of Education and Training, Port Vila, Vanuatu.

2. I am the Acting Director General of the Republic of Vanuatu Department of Education. I have been Acting Director General since 5th October 2023. The mandate of the Department of Education is to deliver high quality education to students in Vanuatu. We are responsible for normal schooling from the K1 to first year of primary education through to year 13, as well as higher education.

3. I have been working for the Department of Education since 1998. In addition to serving as Acting Director General, my regular post is Director of Tertiary Education. This means I am responsible for looking after scholarships, teacher development, TVET and higher education.

4. The matters that I speak about in this Statement are based on my direct knowledge of the facts stated or as have been reported to me by Departmental Staff, as part of my role and function as Acting Director General of the Department of Education.

5. I am giving a statement about the impact that climate change is having on the functioning of the Department and on student learning. One of the Department's biggest challenges are getting numeracy and literacy up to standard and preventing school drop-outs. Both of these challenges are exacerbated by climate change.

6. Climate change has also made it difficult for the Department to implement programming to address these challenges, because with more frequent and severe cyclones, we are almost always in a state of disaster response and recovery. This means our budget, resources, and personnel are focused on disaster response rather than improving education for our students.

CLIMATE CHANGE IMPACTS ON NUMERACY AND LITERACY

7. Climate change has really impacted the lives of our students and affected learning outcomes. Our basic issue is that numeracy and literacy are not up to standard. This is derived from the (1) The 2018 Education and Training Sector Analysis (ETSA); 2023 Joint

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Sector Review Report; 2021 data from the Pacific Islands Literacy and Numeracy Assessment (PILNA) and 2021 Vanuatu Standardised Tests of Achievement (VANSTA) identity multiple bottlenecks to improving primary literacy and numeracy rates.-Climate change affects numeracy and literacy in Vanuatu. We have other factors—the size of the classroom, the shortage of teachers in rural schools, multi-class, and all that. But climate change has really impacted on the lives of students and impacted learning outcomes.

8. The change of weather patterns affects students coming to school. When the weather is bad and there is flooding or storms, students can't come to school. For example, in North Ambae, they have had to change the timetable. Normally school is from 7:30 am to 3:00 pm. But so often it's raining and there is flooding, so the schools have to reduce their hours from 10:00 am to 1:00 pm to make sure there is enough time for students to make their way safely to school and to get back home before it gets dark. The Head of School will decide on an intervention that is suitable for the students and also for teachers at a particular moment in time of the event. This especially impacts disabled students and learners. Disabled kids can't go to school at all because it is not safe for them to travel in this bad weather.

9. Changes in weather also affect student learning at school. For example, when it is very hot, especially in rural areas where we have a multi-class where all of the students sit together, the classroom is very hot and it affects their learning. None of the classrooms in Vanuatu have any air conditioning. This wasn't a problem before. But now with more and more hot days, it affects students' learning.

10. The third major challenge is disasters. This year we have had three cyclones already. Schools have to close during cyclones and afterwards during recovery. So the minimum number of hours that teachers need to have with students is not met.

11. For these reasons, we cannot bring students and teachers together for enough hours to meet pedagogical requirements. This affects students' learning and their overall performance. So, based on my observation, this is a major factor as to why we see numeracy and literacy dropping below standards. We would like to do studies to substantiate this connection, but we have not been able to because we have been in constant disaster response for the last few years. However, the trend is clear based on observation.

12. Because their numeracy and literacy are not good, it is very hard for students to progress. So, because of that, a lot of year 10 students drop out. Recently, when students reach year 10, nearly half of the students drop out. We are doing interventions. We are doing bridging programs to get students into certificate courses, but if we didn't do that, they would have dropped out.

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EFFECTS OF CLIMATE-INDUCED DISASTERS ON STUDENT LEARNING

13. There are many instances in which schools have been destroyed or damaged by cyclones. When the cyclone hits, all the school materials are gone, the classrooms are destroyed, and there is nothing students can do except wait for help.

14. After a cyclone, students cannot go to class. Teachers prepare a homeschool packet with all of the materials and give it to the students to complete independently at home. But accountability is difficult in these circumstances where there is no classroom learning. We have an online school environment, but it is outdated and not accessible in many communities which do not have internet access.

15. When there isn't a disaster, students and teachers can go to school and spend time together and there is accountability there. But after a disaster, when the schools are damaged, the students and teachers cannot go to school and that accountability goes away.

16. It is up to the teachers to make sure that the homeschool packets are delivered, but teachers and principals are also part of the affected population when there is a cyclone. My staff has briefed me that teachers start to rebuild their own homes and take care of their own families before they can think about the students.

17. Another issue after cyclones is food security. Most of Vanuatu's population depends on subsistence agriculture for their daily food needs. The exact numbers can be provided to you by the Department of Agriculture. We know from experience, that after a cyclone, many of the subsistence crops are destroyed. There is not enough food. Students can't come to school when we have no food to give them to eat, and when they are hungry they cannot study well.

18. Thus, the focus of our disaster response is to get students learning materials as well as food rations. It's important. Even if you send the learning materials, students cannot learn when they are hungry. Once the cyclone is gone, we need to fix the classroom, so we fix the classroom. But once the students come, they need to have food.

19. Cyclone impacts have gotten much worse than they were in the past. Before we had one category 4 or 5 cyclone every five years. This year we've had three already. Many of our communities are still in recovery from the twin cyclones in March and Cyclone Lola in October. So right now, the Department is working hard just to figure out how to get food and learning materials to the students. But we are always short. We don't have enough resources to cope with the need.

CL Senai State Counsel
Office of the Attorney General

20. We have to figure out how to divide up the resources between the affected communities, and then other factors come into play, like shipping. If the weather is bad there are delays getting resources to the affected communities. There could be other ways of managing this problem, but we do not have time to reevaluate our approach when we are always responding to another cyclone.

21. On top of that, the secondary effects of the cyclones have gotten much worse. We call the communities that have been directly affected "Priority One" and focus all of the recovery efforts on them. But these days, our Department has noticed that more areas receive secondary effects of cyclones, for example heavy rains that lead to landslides. Even in communities and islands that are not hit by the cyclone, the rain causes all sorts of problems. Students cannot access schools when they are hit by heavy rain and landslides, and that affects the quality of education. Plus, we don't have enough resources to cope with the needs of the Priority One communities anyway, let alone all of these other communities that are affected.

22. Recovery after a cyclone can take a long time. Sometimes it takes forever. Some of the schools are in really remote locations, and it's hard to get materials there. Plus, we have to look for funding and the funding processes are long. Some schools still haven't been repaired from Cyclone Harold which struck in 2020. Right now, approximately 65% of schools in Vanuatu have cyclone damage.

23. The Department recently went touring the islands, and I saw some of the schools, their roofs are not there. Here in Vila, we talk about "oh we can do this, we can do that," but then when you get to the islands, it is a different story. It's complex. First you have to get the materials there, and then take the materials from the shore to the school. And if you don't put the materials in a safe place, people come and take them. Plus, we could be in the middle of fixing a school and then another cyclone comes through and we have to start all over again. We want to build schools, we want to repair schools, but we can't because every time we fix one school, the next cyclone comes.

24. We are trying to build cyclone resilient schools. For example, in Tanna, after schools were destroyed by Cyclone Pam, the World Bank helped us to build good schools that are resilient. So when Cyclones Judy and Kevin hit Tanna, we didn't get much damage. If we could build all of our schools to be resilient, that would reduce our burden of fixing them time after time. But we don't have the resources to do that. Right now, only about 10% of schools in Vanuatu are cyclone resilient.

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25. Cyclones have a direct impact on student drop-outs. There learning is so frequently interrupted by disasters, emergencies, and climate change. I think it's the perception that students have, that the hammer keeps dropping, because disasters are coming all the time. And then the question comes, why school? Because their school materials are damaged, their houses are damaged, and their gardens damaged. So students are sitting and thinking, what's next? What's the point?

CLIMATE CHANGE IN CURRICULUM

26. Climate change affects everything now in Vanuatu, so we have changed the curriculum to address this. We now teach classes on climate change so that students will be able to understand what is climate change, what is resilience, and actually apply that to their lives.

27. We implemented climate change into the curriculum starting in 2012. We started integrating it into the curriculum where we could. But now we are actually developing courses that are more climate change focused that students can enroll in.

Signed: John Kaltau

Signed: Witness
Senior State Counsel
Office of the Attorney General.

Date: 14 March 2024

Annex T

I, Abraham Nasak, Director of the Vanuatu National Disaster Management Office, Republic of Vanuatu, solemnly affirm and declare:

BACKGROUND

1. My name is Abraham Nasak and I am a national of the Republic of Vanuatu. I was born on 1st of April 1979 and my address is Beverly Hills, Port Vila, Vanuatu.

2. I am the Director of the Vanuatu National Disaster Management Office (NDMO). I have been Director of NDMO since 2017.

3. The matters that I speak about in this Statement are based on my direct knowledge of the facts stated, have been reported to me by NDMO staff, as part of my role and function as Director of the NDMO. The opinions I express in this statement are based on my expertise and on data, studies and surveys undertaken by NDMO or the Vanuatu Government.

4. NDMO is responsible for disaster risk reduction and disaster risk management in Vanuatu, as well as harmonizing climate change adaptation into disaster management. NDMO has a staff of 17 people. Our mandate is to develop a more resilient nation and more resilient communities.

5. At the government level, NDMO's objectives are to mainstream climate adaptation and disaster risk reduction and disaster risk management and to effectively coordinate disaster response. We also coordinate climate adaptation projects that also improve disaster resiliency to improve access to water, access to health, access to food security, and the other livelihoods, things like livestock, forestry and all of that.

6. One of our other focus areas is building durable solutions at the community level. We try to not just work on disaster response, but also on the small improvements that could be done before the disaster strikes to improve resiliency, whether that be strengthening a seawall or growing back mangroves.

7. But in recent years, it has been hard for us to implement any of our goals because we are always in disaster response. While we can plan big, we can only implement projects that can be achieved in say a one-month, two-month, three-month window, because that's the most time we have before we are hit with another disaster.

Changing disaster conditions

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8. Since 2017, Vanuatu has experienced increasing incidences of extreme weather. These include severe marine weather disturbances with waves and wind, extreme rainfall that is much higher than normal, and periods of drought that are much longer than they were previously and for a longer period than usual.

9. Based on the historical trend for Tropical Cyclones ('TC'), normally we would expect one Category 4 or 5 TC every 7 years. We built our resiliency plan based on this prediction. However, since TC Pam in 2015, we've also seen a shift in the intensity of TC that has stayed with us until now. TC Harold came in 2020, before that 7-year prediction, and then the two in March of 2023, TC Judy and TC Kevin, were a curveball based on our experience. And then TC Lola came October 2023. So now we have asked the Vanuatu Department of Meteorology to provide annual forecasts for TC, because we can no longer rely on the longer-term predictions that were part of our official forecasting.

10. Since TC Pam, the extent of the country affected by TC has increased. TC Pam affected pretty much the entire country, which no TC has ever done before. And then TC Harold came and did the same for Santo, Malekula, Ambrym, and South Pentecost. In my experience, this is new. These areas, which are in the north of the country, historically have not been affected by TC damage.

11. More areas and people are impacted than normal, and the disaster response needs are much higher. The communities in these areas were not prepared to cope with a TC since they had never been hit before, so that magnified the impacts a lot.

12. We've seen corresponding changes in the level of damage sustained, and the level of effort required to recover. In the past, TC would damage houses, damage gardens, affect access to water, things like that and our response would be focused on these things. But now on top of these things, we are seeing the general infrastructure and the transportation infrastructure being damaged. We thought the roads were quite solid, but somehow the water has dug across the roads and the bridges. So that was a shock to all of us because it hadn't happened before.

13. The quantity of water coming down and the impact of the severe weather on these infrastructures takes a toll. From my observations, the severe weather and heavy rain exposure has broken the roads, disturbed the bridges, and then even some of the buildings that considered strong, now we have to look at again. That's why as of 2023, "climate-informed infrastructure" is now a mandated requirement for our infrastructure development. And that's from road infrastructure right through to airports and buildings. Because what we think is strong–the TC will always test it.

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We, at the NDMO, deal with disaster response. We do not deal with the science of these disasters. But we do notice these unusual things are happening. So that's why we keep coming back to the scientists and asking them what's happening. They gave us an analysis predicting one Category 5 TC in 7years, and that's what we planned for and then we get hit with TC Harold in less than 5 years followed by the twin TC within 24 hours of one another, which is unheard of. And then TC Lola, which hit before TC season is supposed to start and sped up to a Category 5 before dropping to a tropical low, which has never happen before.

14. The NDMO deal with the aftermath. So that's why for us it makes sense to have things to plan for. But there have just been so many unprecedented events in the past few years, it has been impossible to plan.

15. The procedures that we've previously relied on to prepare for TC are no longer reliable. The Department of Meteorology would typically do TC mapping based on the strength of a system, its position, and how long it would take for a system to arrive in Vanuatu. But this no longer applies. Now, a system can come in as a tropical low, and become a TC within the next hour. I mean TC Lola, it came in hidden as a cloud system. We called the Department of Meteorology and asked about it and they said it's a cloud system, and the next hour they called back and said, now its a Category 5. Now that predictions are inaccurate, how can we prepare? That leaves people totally unprepared.

16. The agreed standards of issuing alerts and mobilizing resources are based on previous, predictable experiences. That's not how it is anymore. So we've asked the Department of Meteorology to expand their mapping area so we have a much earlier warning of a weather system coming–even if it is just a tropical low or a cloud system–we want to know about it. And we told them to issue a severe weather alert so at least we are tracking it. Because now we don't know. It could turn into a TC.

17. Another challenge is that our disaster response system only caters to severe TC, not to other extreme weather like extreme rain, extreme drought. Because in the past those didn't cause such big problem. But now things are changing and we have to start thinking about these events. For example, I think it was 2022 we had a Category 1, 2 TC that came around New Caledonia and South Tanna. It stayed at the category that didn't even trigger a response but the wind and water damage was quite big because it hung around for 48 hours. But we couldn't respond to it because it didn't trigger the agreed requirements for national response, which is only for category 3 and above. This is unprecedented too. We expect TC to just pass straight through, not to hang around for 48 hours. With all of these unexpected surprises, it is almost impossible to prepare for disaster.

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18. The impacts compound with the amount of TC that we are getting. Some of the comments that we get from locals in the aftermath of TC is that their place looks like somebody came across with a weed cutter, cut down everything, and then came along with the rake and then raked everything away. So there's no more trees and no more natural barriers to stop the wind and stop the erosion and everything. That's happening a lot recently. More so than in the past.

19. I'm not sure. Maybe only in Santo will we still find the big ancient trees. Everywhere else the ancient trees are down now. The forests are clear. Those trees were landmarks actually. They could link up the trees to stories and say this is where this event happened and this event. You could orient yourself based on the trees and gauge where you were. They were also used to indicate ownership of land. So that's a reality that we have to live with.

20. And then you have the coconuts. I mean when you see a straight coconut tree, you know the TC can't get through there. It was my wall that protected me. But now that the TC have repeatedly blown through, the coconut trees are twisted up in all sorts of shapes, and that leaves everyone more vulnerable.

21. I observed a change in the frequency and intensity of the TC we are getting with TC Pam in 2015. I think Pam signaled the change in the weather. Previously we had TC, but there was a longer period between them.

Cyclone Response

22. The TC season is supposed to run from November 1 to April 30. Each year, the Department of Meteorology gives us a TC forecast for the year. But that's the forecast, it doesn't mean that's what happens.

23. To prepare for the TC season NDMO has a pre-season meeting with all of the government agencies who are also the cluster leads. In addition, we also conduct meeting with the Humanitarian Partners. There are 11 clusters namely Logistics, Transport and Infrastructure, Emergency Shelter, Evacuation Centre, Emergency Telecommunication, Energy Services, Water Sanitation and Hygiene, Health, Food Security and Agriculture, Gender and Protection and Education. We let them know the forecast from the Department of Meteorology and the TC we are expecting. We also inform them and they inform us of the improvements they've been making since the last TC season, whether it be strengthening a community setup or a particular response planning, or improvements made with another department's information. Finally, we discuss all of the in-country capability that is available for disaster relief, and if there are short-comings relative to expected needs

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we discuss where we would need to bring in additional support. That's the only pre-season meeting we have.

24. As soon as we have a warning for a TC or tropical storm, I issue an activation for the National Emergency Operation Center (EOC). The EOC sits within NDMO and monitors the event before it becomes a TC. If the event does turn into a TC that's hitting the country, the EOC stays activated to provide information to the public on preparedness activities, as well as collect any information coming back about what the impact is. All the information collected during this time is to inform emergency response immediately after impact.

25. There is an EOC office in each of the six provinces. The offices in whichever provinces the TC is hitting are also activated. And the other offices are monitoring, and if the TC shifts to them, then they are activated.

26. As soon as we have an event, all of the other agencies that have a responsibility for disaster response also mobilize their teams. So after impact they immediately begin moving and report back here. They can move even if communications are down, because in the pre-season meeting we would have already informed them of the different responsibilities, and different actions to be taken before, during, and after impact.

27. For each TC we also develop a TC response plan. This is actually a new improvement we had to do in response to recent TC. We used to have a TC support plan that detailed the support component and the response component in one. But because of the frequency of recent TC we decided to break it up.

28. The support information is the same for any TC–any partner can look at this in the context of any TC and get involved in support–but each TC needs its own response plan. So by breaking it up, response partners can get the support information they need without having to wait for us to pull it together, which is important given how many TC we've had.

29. A response plans is developed for each TC based on our surveillance of the damage in a 24 hour post-impact assessment and a 72-hour post-impact assessment. We use this information to develop an emergency response plan for the first 6-months after the impact.

30. Then after response, we enter into recovery. Recovery is the process of getting people back to normal life. This is another challenge for us–even getting to the recovery stage, because we keep getting hit. For example, we closed the response period for TC Judy and TC Kevin, which hit in March 2023, on October 14, 2023. But then we had TC Lola hit the same areas and we activated the Lola response plan seven days later.

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31. Recovery used to be under NDMO but in 2018 it got moved to the Prime Minister's Office in a newly created National Recovery Committee. That's a change we had to make in response to the frequency of disasters. Recovery consists of three parts which are preparedness, disaster response and recovery cycle. But we took out recovery and put it in the Prime Minister's office because we are frequently in the response mode

32. We no longer have a six-month to one-year break between disasters. Every year we go through many disasters. I think in 2020 we had the most, we had 8 disasters. With that many disasters we never get out of response and we aren't able to work on recovery, so we had to move recovery to the Prime Minister's office.

33. Constant response doesn't just drain NDMO's resources, it affects the entire government.

34. We're a small country with limited resources. So in each agency, it's the same staff of professionals that have to be involved in all of the regular operations of government, regulatory function, providing public services, servicing the productive sector, as well as in disaster response. But of course providing those regular government services is also part of recovery because the quicker people get back to their normal lives, it means we are recovering. But when our officers are constantly responding to disasters then that capacity to provide normal services doesn't exist until the response is over.

35. Because government is constantly in response these days, it also means they can't focus on programming to build resilience to the next disaster. For example, when one community is hit, we focus on them until we have to respond to the next one. So if that community have the capability to be able to continue with the improvement, then it stalls progress until the government team can come back and assist.

36. For example, in March 2023 TC Judy and TC Kevin affected part of Torba province and affected all the provinces of Vanuatu which are Sanma, Penama, Malampa, Shefa and Tafea but now we have TC Lola that hit Vanuatu in October 2023. So we have to reallocate the government resources from TC Judy and TC Kevin recovery to focus on TC Lola response to part of Torba, part of Shefa, Malampa and Penama provinces that were most affected. The rest of the southern part of Shefa province and Tafea province are saying, "Hey don't forget about us. We have not fully recovered from the impact of TC Judy and TC Kevin." But we have to shift our focus to the immediate emergency response, because we have limited resources. It does stretch our resources and manpower across to do constant response–there are only so many hours you can work before you need a break. And that's just thinking about response and recovery, without considering the other responsibilities government officials have.

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37. It's also a challenge because you have to understand and accept that the NDMO officers responding are also part of the affected population. So through TC Judy and TC Kevin, the team was busy responding and handling pressure from everywhere, but they were also part of the affected community. Their houses had been blown off. They're probably in the evacuation center. The gardens have been damaged, all that. But they do their best not to concentrate on that for the time being, but focus on service response going on before they eventually come back and look at the immediate needs.

38. NDMO also knows we have a part to play in climate change adaptation. We push actively for climate adaptation initiatives because the more initiatives and interventions we do at the community level to build resilience that helps. But doing this while also looking at what comes after response is difficult. We're only 17 staff for all this work.

39. The other government departments have also been very helpful in making sure disaster risk management is part of their normal operations. It's integrated into the business plan across all sectors. And that's very good because then that tells us that we are working towards improving adaptation and resilience. Then when we come to response, we are able to gauge a community's improvement level against the hazards that they are exposed to

40. It's challenging for us. But we know we don't control the weather. If we did, we'd probably put a pause on the weather and say come back to reactivating after one year. But we cannot. We're not scientists for the climate but we do notice the intensity increasing, the frequency increasing.

State of Emergency

41. On top of developing the disaster response, we declare a state of emergency when the needs of the impacted population are beyond the capacity of the normal service mandate to fulfill. The state of emergency reallocates government resources and manpower from their budgeted purpose to be used for disaster response. Normally government resource expenditures are guided by the business planning of the ministries that's budgeted for and then appropriated by parliament. When a state of emergency is declared, it allows us to reprioritize and divert resources to respond. When we have a major event, the level of impact will require multiple agencies to stop their normal programming and focus on emergency response.

42. The state of emergency is defined in the Constitution. It can be declared to respond to natural hazards and when we are in a state of war. The state of emergency for natural disasters became much more clearly defined in the Disaster Risk Management Act, which was legislated in 2019. The act was passed in response to the frequency of disasters. I mean,

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previously, we had states of emergencies declared, but not that often because there weren't that many intense disasters. Since 2015, there's been 4 State of Emergencies, one in 2017, three in 2018, two in 2019, five in 2020, two in 2021 and three in 2023. I think the Office of the Attorney General has now become expert at issuing instruments authorizing states of emergency.

43. The state of emergency is declared based on an assessment of the damages. But when a category 4 or category 5 TC tracks through the country, we can anticipate the damage. So for Category 4 TC and above we have to declare a state of emergency.

44. The length of the state of emergency is determined based on our assessment of all of the challenges that must be met in order to meet needs, like supply shortages and logistical challenges of working inter-island. We have to take that into account when we make our plan because we only have a handful of planes and a handful of ships. So in the first two weeks after a disaster, NDMO might occupy all of the planes and ships, so normal travel stops. And then after that we say okay, we'll only use three ships and three charters so the rest can go back to normal operations. So those capacity constraints we have to take into account when determining the length of the state of emergency.

45. Prior to 2015, the entire agency would focus on response when a state of emergency was declared. Now, we have made improvements so that each agency can create teams and move them out of normal service to focus on disaster response, while still providing a little bit of normal service to the public. But when you move a particular officer to response, that particular capability that they have is no longer available until they move back into normal service again. So while departments do their best, because we are always in response, normal service is always limited, and that's something we're still working through.

46. It's also a challenge because the government has limited budgets, limited personnel, and we have multiple islands to assist. For example, TC Lola affected 16 islands. So anything you want to do you replicate it to sixteen islands. And NDMO has only 17 staff.

Bad weather impacts disaster preparedness

47. One of our challenge in response is that we are made up of islands, so everything we do has to be mobile, and we can only operate if the weather provides us good conditions to move by sea or by air, or even by land.

Extreme weather events

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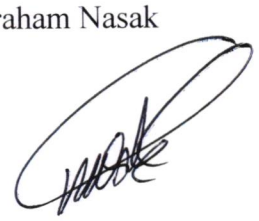
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48. We've also been facing challenges because our El Nino/La Nina cycle is destabilized. From my understanding and experience in the past, it is supposed to be every other cycle, El Nino, La Nina, El Nino, like that. But recently we've had three to four cycles of El Nino followed by three to four cycles of La Nina.

49. So we went from extreme dry to extreme rain and this presented problems for agriculture. Because during the extreme dry period they tried to introduce trial dry environment crops and things, and people started farming into areas where water used to be flowing, because when the usual farming areas were dry, those areas were green. They felt like they had to try to farm there because their normal areas were so dry. But then when the cycle switches, and we get La Nina and have lots of rain, those areas start to get flooded. Another challenge with that was that those crops were hybrids for dry weather environments. So then agriculture has to introduce the other varieties that are more used to lots of rain, a lot of water, and then we'll move out from that cycle to the dry one. So it is a lot of work. A lot of disruption.

50. For smaller countries like Vanuatu, you cannot plan everything in advance. We only have capability to react. We cannot build an entire preparedness system for a one in one hundred year event. But, for us now, those one in a hundred year events are no longer one in a hundred year. They are happening all the time. For example, Teouma Bridge. That bridge was built to withstand a one in a hundred year flooding event where the water would overflow the bridge. That bridge got flooded two times in one week in 2022 because of rain. It was supposed to happen once in a hundred years and it happened twice in a week. And as a result we had to evacuate people from the area, we had to move them out.

Signed: Abraham Nasak



Signed: Witness

Senior State Counsel
Office of the Attorney General.

Date: 15 March 2024

Annex U

I, Dr. Vincent Lebot, root and tuber crop breeder and researcher with the French Agricultural Research Centre for International Development (CIRAD), the Republic of Vanuatu, solemnly affirm and declare:

BACKGROUND

1. My name is Vincent Lebot and I am a national of the Republic of France and of Vanuatu. I am 65 years old. I have lived in Vanuatu since November 1980.

2. I am currently a tuber crop breeder and researcher with CIRAD. I have been in this position since 1991. I obtained my PhD in 1989 and I have been working on root and tuber crops for the last 40 years. My area of expertise is root and tuber crops, breeding and genetics. I was the scientific coordinator of the SPYN (the South Pacific Yam Network), TANSAO (the Taro Network for South East Asia and Oceania) and INEA (International Network for Edible Aroids).

3. The matters that I speak about in this Statement are based on my direct knowledge of the facts stated, and that have been reported to me, during my research career over the past 40 years. The opinions I express in this statement are based on my expertise and on data, studies and surveys I have conducted, researched and written personally.

YAMS IN VANUATU

4. According to archeologists, who succeeded in dating starch yam found on stone tools recovered from caves in Papua New Guinea, yams were domesticated about 40,000 years ago. Very soon after the arrival of humans on the Sunda plate, when Papua New Guinea was attached to Australia; before the last ice age. Humans started domesticating the yam when they started to migrate from Southeast Asia to Northern Sahul. So, they are a very, very old plant.

5. Vanuatu is about 10 to 20 million years old. When humans arrived in Vanuatu, only 3000 years ago, there were no crops here. So, the first humans to Vanuatu, of the Lapita culture, introduced crops, including yams.

6. The Lapita introduced the yam as a piece of tuber in a box on a canoe. It came like this. Yams were in Papua New Guinea, they were in the Solomons Islands, and they were introduced by the Lapita to Vanuatu and other Pacific Islands by voyaging from one island to the other.

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7. Yams were introduced clonally. There were no true botanical seeds. Yam is a tuber. A tuber is a stem which stores starch and it's a swollen underground stem. This means that you can take a piece of it and replant it and a growing butt will appear. We plant the tuber to get another tuber but from a botanical perspective it's not a seed. If you plant a tuber, you get a plant which is genetically identical to this. We call that a clone.

8. If you are a farmer in the western world, in Australia or in Europe, when you plant a seed, you understand that seeds are the product of sexual recombination. So, seeds can adapt to any sort of changes because you have genetic recombination. Genetic variation is the key to adaptation.

9. When you have clones, you don't have the genetic diversity which would enable the plant to adapt. What this means is that you have genetic vulnerability. So, if a change is introduced, the clone will not be able to adapt and will be impacted.

10. You have two people in Vanuatu, taro people and yam people. Scientifically, it comes from their adaptation to the local climate and environment. Culturally it means you plant "your" crop as the first one.

11. Traditionally, when a garden is started, a taro person plants taro first. A yam person, plants yam first. Then around Easter in April, after the taro or yam is harvested, cuttings of sweet potato are placed in the hole left by the harvest because sweet potato is a short cycle crop that gives better produce during the cool season.

12. Once the sweet potatoes are harvested, cuttings of cassava are planted in the same hole. Basically you have the very noble species in the first head of the growth cycle, sweet potato in the second head, and cassava is planted last. Cassava is grown last because it doesn't need rich soil. It can grow just as well on poor depleted soil. The other crops cannot. So, labor investment is optimized within the same hole.

THE SIGNIFICANCE OF YAM IN VANUATU

13. Yams are very, very complex. We have about seven different species, and within these species we have different varieties. So, the most important yam is what we call the "greater yam", which is the one being used for all the ceremonies. Throughout Vanuatu, they use the greater yam for ceremonies, except in Malekula where they use wild yams. The greater yam is used for ceremonies throughout the world and in the Pacific; in PNG, Solomons and Vanuatu. It has a cultural value and has beautiful varieties.

14. One of the reasons the greater yam is used for cultural ceremonies is because it is a very, very long tuber that the owner can show off at ceremonies. It takes a lot of effort to dig up a greater yam, you may have to be on your knees for 2 hours to dig one up, so it's not used for everyday consumption. Other varieties are used for everyday consumption.

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15. The greater yam is also clonally material so it is also genetically vulnerable.

16. Nutritionally, yams are a fantastic food. Yams are very dense in fiber, very rich in proteins in, of all the root and tuber crops, it's probably the most complex and the most interesting in nutritional compositions. You have all sorts of antioxidants, secondary metabolites with physiological properties. It's a fantastic food. I have published several papers on its nutritional value.

17. In science, we call foods like yam a bio-functional food. It means that when you eat it, it's not just plain food, it also acts almost as a medicinal plant. Asia is completely fanatical about yams because of this. There are a lot of publications about the yam from Taiwan, China and Japan.

18. Yam is a superfood and you don't need to eat much to have a feeling of satisfaction. In *bislama* we say, "*em i holim bel*" or "it holds your stomach". So you eat a small yam in the morning and you are okay for the whole day because it's rich in active ingredients.

THE VULNERABILITY OF YAMS IN VANUATU

19. In Vanuatu, we have a terrible disease for yams, which is called Anthracnose. It's so violent that sometimes farmers think it's the result of their yams being hit by thunder. When they tell me they have lost their crop and I ask them what happened, they respond, "Oh, thunder destroyed everything. They were all burned overnight."

20. Anthracnose is a fungus. It occurs when you have a very wet season. It's a well-documented fungus existing around the world. But in Vanuatu, the impact is really bad because the genetic base of the crop is narrow. So there is no room for adaptation. All the yams are genetically vulnerable.

21. When we discovered the genetic vulnerability of the yam about 40 years ago, we attempted to sexually reproduce and recombine them. My work as a plant breeder involves cross-breeding plants to get hybrids, but with yam it's very complex because you have the male flowers on one plant and female flowers on the other plant. They are both genetically vulnerable. So we were at a dead end and we couldn't achieve anything until about 15 years ago.

22. We found success when a good friend of mine in India agreed to give me true botanical seeds of yam. My team and I introduced them to Vanuatu, and by doing so, we introduced new blood, new genes, new genetic makeup. We raised these plants and we recombined them with our local yams. And now we have beautiful hybrids which are genetically resistant to Anthracnose.

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23. Yams are tubers, sweet potato and cassava are swollen roots and taro is a basal stem. In Vanuatu, we don't speak about agriculture, we speak about veggeculture. It's all vegetatively, propagated, not sexually propagated.

24. In the western world, farmers are plant breeders because they sow wheat or corn, they select the best individuals, they replant. So each harvest produces a selection of the most adapted individuals. In Vanuatu, you cannot do that. When you replant, you replant identical plants, clones.

25. It's the same across the South Pacific because the islands were colonized through the same human migration. The same plants went all the way up to Hawaii with the Polynesians. So in Tahiti, they have the same problems as we have, in Hawaii they have the same problems as we do and so forth. The only way to correct this situation is to start breeding or to introduce new blood, to allow for adaptation. Unfortunately, there are no breeding programs in the South Pacific, and therefore it's going to be very difficult for these countries to adapt.

26. In Vanuatu, when we cross-breed, all the propagation is done by hand; a mini set. So it takes a lot of time. In other countries, they do tissue culture which is faster. Here, when we successfully propagate hybrids, we host open field days and farmers come and collect their hybrid yams; we are building up resistance through this system. But it takes time.

27. We saw this with Western Samoa in 1993. The whole economy was based on taro and when the taro leaf blight was introduced, overnight they lost everything. It took them almost 20 years or 30 years to go back to square one. They had to breed taro, introduce new blood, introduce new varieties, do it again, and do it again. It takes time.

28. Anthracnose was in Vanuatu in 1980 when Vanuatu got Independence but it was not so bad. There is always competition between the fungi population and the yam population. Anthracnose gets bad when the fungi population is too high and knocks down the yams. If the yam population is high and well organized, many plants can survive.

29. Anthracnose is very active when it's wet. When it's dry, you can grow yams. That's why yams are grown more on the lowland leeward side of Vanuatu and on the windward wet side, people grow taro. Even on the lowland leeward side, when it's dry, you can have nice yams. However, when you have a wet La Nina event for example, you lose your yams.

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30. The hybrid yam we developed is resistant to anthracnose but they will not replace the place of the greater yam in ceremonies. The hybrid yams are delicious but maybe 2 out of 10 of them have an oxidizing flesh. Normally, when you cut a tuber, the flesh should remain a nice white color. But unfortunately, some of the hybrids oxidize, they turn brown, the taste is really good but the consumers in Vanuatu are very demanding. They know what a really good yam looks like.

31. Vanuatu's increasing human population is also a contributor to the increased anthracnose fungi population. As Vanuatu's population increases, there is increased pressure on the land. When human pressure builds up then humans reduce the land's fallow period; the land is not given enough rest. Before land in Vanuatu was given a fallow period of 8-15 years, now it is much shorter after independence. This means the land is building up the inoculum of pests and diseases and allows the fungi population to establish itself and start to expand.

32. On the other hand, what we know is that Vanuatu's human population was much more significant before the microbiological shock imposed by the introduction of the Europeans to Vanuatu. It's estimated that the population in Vanuatu was around 800-900,000 people before Europeans arrived in the 17th century. Then there was the microbiological shock. At Independence in 1980, the human population was estimated to have been reduced to 80-120,000. Now the population is around 320,000 and is doubling every 20 years in the country and every 10 years in town because of urban drift.

33. When you look at the map of Vanuatu you may observe that they have a lot of land. However, the reality is that they don't have much accessible land and good soil. As part of my work, I have mapped all the soils of Vanuatu. I know exactly where the good soils are. And unsurprisingly, the population is already living on the good soils. The island of Ambrym, is a good example. It's a big island but the populations are only in the tips of the triangles because that's where the good land is.

34. There are some places where there is still good land, but in order to access it, you need to walk for three or four hours. There are no roads, there is a lack of infrastructure and this is a major constraint to agricultural development because you cannot extract the harvest. This leads to people being concentrated in areas and putting a lot of pressure on the lands on those areas.

THE VULNERABILITY OF OTHER STAPLE CROPS IN VANUATU

35. None of the crops in Vanuatu originate from here because the islands of Vanuatu were burned by the steaming magma, it was a volcanic ash plane. Plants have been introduced through human migration, ocean drift and wind birds. Everything was introduced. This

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means the diversity is quite poor, especially if you compare Vanuatu to New Caledonia or even Fiji, which are parts of a continental plate.

36. Vanuatu is in a particularly difficult situation because all its important crops are not sexually propagated; yam, taro, sweet potato, cassava, kava, bananas. This means all the staple food crops are genetically vulnerable and the Pacific as a whole has not been moving fast enough into breeding staple crops. So now we are in a difficult position.

37. For now, taro is doing very well, we know our taros are vulnerable to pythium rot or taro leaf blight, another fungus, and we are touching wood that doesn't make its way to Vanuatu. It is already in the Solomons and Fiji. This is the same fungus that destroyed all of Western Samoa's taro in the 1990s.

38. The taro leaf blight thrives in hot rainy weather. The taro itself is a crop for very wet, high rainfall areas but the same conditions are also suited to the fungus. So taro needs to be bred. Unlike yams, we know how to breed taro. Yams were very difficult to breed, but taro is okay although it took us about 2 decades to breed a palatable hybrid taro.

39. Taro and *kumara,* sweet potato, are highly resilient to cyclones. The cyclone winds may damage the leaves but because they're a cover crop, they almost always survive the most severe cyclones. The taro leaves will be destroyed by the cyclone but it'll shoot again.

40. Cassava is now becoming very popular in Vanuatu. It's quite resilient to drought and it's tolerant to heavy rainfall. You can grow cassava on the banks where you have four meters of rainfall but not in flooded conditions. If it is flooded, the root system will rot away.

41. However, cassava is highly vulnerable to cyclones. If you don't prune it before the cyclone comes it will dislodge. Even without a cyclone, if winds are at speeds of 30-40 knots, cassava can dislodge and break and rot away.

42. We have been able to successfully breed cassava.

43. Right now in Vanuatu, kava is the dominant cash crop. Kava alone is about 90% of the total value of agriculture in Vanuatu and 68% of the total value of cash cropping. This is scary because kava is a highly vulnerable crop. Kava is the only plant species that we don't know how to breed. We attempted, we tried, we just don't know how to breed it.

44. Kava is a genetically complex plant species. Humans only have two sets of chromosomes. Kava has 10 sets of chromosomes. And because of this complex genetic makeup, we cannot generate new kava hybrids. There are 82 varieties of kava in Vanuatu. All 82 varieties are highly vulnerable.

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45. If there is a drought, the kava canopy is so huge compared to the root system that it dries overnight and it can die. Fortunately, it's a shade loathing plant. If farmers are smart, they will plant kava in what we call agroforestry systems under the trees. Ni-Vanuatu farmers should already know this because this is how they traditionally farmed. However, unfortunately, traditional knowledge is not well transferred from one generation to the next.

46. Pre-European arrival, the human population of Vanuatu was high, but the forests were maintained. This is because when the first humans arrived, they arrived with their crops, they had to plant them and wait for them to be harvested, they couldn't feed themselves until then. So they started to gather foods from the forest. Very soon they discovered that the forest itself was a source of food. There were no predators in the forest so plants were not biosynthesizing toxin, so many fruits were edible.

47. The first humans in Vanuatu realized the richness of the forest so they developed what we call the traditional garden, a resilient cropping system, an agroforestry cropping system. In other words, if you want to increase production, don't increase the size of the plot, but increase the number of small plots. So basically keep the plot small under the trees and it will be safe. If you start to open a big plot, then you are getting vulnerable to high strong winds, to droughts, to floods, to everything.

FOOD SECURITY IN VANUATU

48. Wild yams (not the Greater Yam) are a foodbank because they can stay in the ground for 5-8 years. Once harvested, yams can be stored for 4-5 months. In a yam barn at room temperatures, if you keep them at a cold temperature, yams can keep for up to a year. It's incredible. They have a great advantage compared to the other root crops.

49. Taro can last 3-4 weeks in the shade and same with sweet potato. Cassava does not last long, once you harvest it you need to eat it. However, in the ground, cassava can grow 3-4 years if there are no cyclones.

50. Like yam, taro has exceptional nutritional value. It's really rich in antioxidants, high in proteins, very low lipids and the advantage of taro compared to yam is that you can eat the leaves. The leaves are rich in proteins, vitamins, antioxidants, and minerals. It's the most digestible starch on earth because its starch grains are extremely small, really fine. Taro is an excellent food, frankly.

51. There are different varieties of taro for babies and for old people who cannot chew anymore. It's perfect for baby food because it's very easy to digest. On paper, scientifically, taro is an amazing food.

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52. However, taro is very difficult to grow on a large scale.

53. Cassava on the other hand is easy to grow. It's become highly popular because it's the lazy man's crop. You throw cuttings in your backyard and they grow. However, cassava has very poor nutritional value. It is mostly plain starch, very poor in sugars, very poor in minerals.

54. Some young people are replacing their noble species with cassava. On the southeast part of the island of Tanna, for example, the young people have shifted from yam to cassava. After anthracnose became a problem and they couldn't get enough food from their local yams, they started planting cassava. Now, if there is a cyclone, they lose all their food overnight.

55. Bananas are also very vulnerable to cyclones. In places like Northern Malekula their diets are based on the local *malele* banana. If there is a cyclone going through, they lose all their bananas and, therefore, their food security.

56. Apart from cyclones and fungus affecting traditional food crops, globalisation has also meant people have diverted their energy and time away from substance gardens and towards growing and harvesting cash crops. Compared to when Vanuatu gained Independence, there is very little food in the ground for sustenance. In 1980, each household was planting 5-8 gardens. Now they're down to 1-2 gardens.

57. Once the Ni-Vanuatuans have cash in their hands from their cash crops, they go to the store and they buy food; mostly rice and tinned meat and fish. We did some studies on the household budgets and found that most of the household revenues goes towards the purchase of food or transport.

58. However, cash crops like the coconut have a declining industry because of the introduction of the rhinoceros beetle. Young farmers will not replant coconuts because they know the beetle is here. They are switching to kava as a cash crop, again, a highly vulnerable crop.

59. We cannot predict what will happen in the future but we know that the situation that we have in place right now is vulnerable because all our major crops are genetically vulnerable and we don't have breeding programs. Ni-Vanuatuans are not planting as much food for sustenance, especially of the more noble species like yam. On top of this, ava, the cash crop they are increasingly relying on to access cash to buy their store foods, is a highly complex and vulnerable plant that we do not know how to breed.

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60. Ni-Vanuatu food security in terms of nutrition is also a concern. The major nutritional problem in the Pacific is the glycemic index. As stated earlier, Ni-Vanuatu are replacing foods like yam and taro with foods like rice and cassava. Cassava has very little nutritional value and rice is very rich in sugar because it's been polished in order to be easy to cook in 10 minutes. In other words, the proteins, the fibers, the cellulose, all these ingredients are removed from the rice grain. It's just plain starch that swallows very rapidly. So in order to have a feeling of satisfaction, you have to eat a big volume because it's not dense in fiber.

61. In the western world, we had the time to develop our agriculture before we were globalized. In the Pacific, they never had the time before they were globalized. They were bulldozed overnight without having the time to build up some resistance. So the impact has been huge.

62. Globalization, population growth and climate change, the three combined have created a lot of issues for the Pacific.

Signed: Vincent Lebot

Signed: Witness

Senior State Counsel, office of the Attorney General

Date: 14 .....March 2024

Annex V

CLIMATE CHANGE IMPACTS ON ROOT CROP PRODUCTION IN VANUATU

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This case study examines climate change impacts on root crop 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], and these changes are projected to continue [2]. Understanding how these changes may impact root crop production is an important aspect of planning for the future in order to improve resilience to future conditions. In Vanuatu, root crops are grown mainly for local consumption. They include several species of yams, island taro, Fiji taro, cassava or manioc, and kumala (sweet potato) [3]. Aligning agricultural crop production to the climate is a key factor for any producer to consider. **Here we explore the temperature suitability for root crop production in Vanuatu under current and future climate conditions.** For information on how this climate hazard-based impact assessment fits into a broader risk framework, see the Climate risk factsheet.



Figure 1 Growing root crops in a garden (top left). Root crops for sale in the local markets in Tanna (top right) and Port Vila (bottom).

STEP 2 Engage and meet with stakeholders

In February and July of 2023, Van-KIRAP agriculture sector personnel, Vanuatu Meteorology and Geo-hazards Department (VMGD) staff and CSIRO scientist visited some gardens and farms where root crops are grown to discuss various aspects of production. In preparation of this document key literature was also drawn upon e.g. [4], as well as industry planning reports [3].

From these discussions and readings important climate variables affecting root crop production were identified, as well as gaining a better understanding of how and where root crops are typically grown.

STEP 3 Explore background information and historic climate data

Increasing greenhouse gases are changing the climate. Vanuatu has warmed by 0.7 °C since the pre-industrial period (1850–1900) [2], sea level has risen 3.5-5.0 mm/year since 1993 there has been little change in the annual average rainfall [5], extreme rainfall has increased slightly [1]. The frequency of tropical cyclones (TCs) affecting Vanuatu has declined, while the severity (i.e. average TC wind speed intensities) of TCs passing over Vanuatu has increased [1, 6]. The trends in drought between 1981–2010 and 1951–1980 [7], and consecutive dry days (1951–2020) [8], are statistically non-significant and mixed spatially, with Bauerfield, Efate, showing positive trends while Sola and Aneityum have negative trends.

Root crops are a staple food for people in Vanuatu and are grown using traditional methods. Growers have developed a cultural understanding for growing root crops. This is in relation to species/cultivar/location matching, timing of plant phases e.g. maturity, and crop preservation techniques. As different varieties are vegetatively propagated, exact genotypes of cultivars are preserved in a district. There are more than 300 varieties of yam, and 400 varieties of taro distributed across the Vanuatu archipelago [3].

Annual average temperature of Vanuatu ranges from 20.4–30.9 °C for the 1970–2000 period, tending cooler in the south and more elevated areas (Figure 2) [1, 5]. Annual rainfall ranges from around 1700 mm up to nearly 5000 mm (1970–2000), tending wetter in the north [1, 5].

The preferred climate 'envelope' for root crop production varies slightly with the different species. The average temperature range for sweet potato, yam, taro, and cassava is as follows [4, 9]:

- Sweet potatoes: 24–34 °C
  (above which tuber formation is impaired)
- Yam: 25–30 °C
- Taro: 25–35 °C, 30 °C optimum
- Cassava: 25–29 °C optimal, but 12–40 °C is tolerated.

For taro, an evenly distributed annual rainfall of 1500–5000 mm is required, while cassava prefers drier conditions (1500–2000 mm) [4]. Across the archipelago, all but the more elevated areas have a climate supporting at least one species of root crop.



Figure 2 Annual average temperature (1970–2000) shown on the Vanuatu Climate Futures Portal (Data source: WorldClim).

Earlier maturity of some root crops is being reported by root crop farmers in the northern islands, like Torres and Banks, and they are harvesting earlier compared to the past [10]. This may be linked to the warmer temperatures being experienced in the northern province [1, 11]. Normally in northern Vanuatu the harvesting of yam will be around May to August. However, recently, farmers in the north are starting harvest around March [10]. This acceleration in the timing or seasonality of root crop production has also been reported in Fiji [12]. Earlier harvesting and change in seasonality are commonly reported around the world and most often linked to observed increases in temperature [13-15].

STEP 4 Collect information about future climate scenarios

In addition to the warming that has already occurred, the climate is projected to change further. Simulations of future climate indicate annual average temperatures will increase in Vanuatu from 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, 2] and while projected median changes in average rainfall by 2050 are small, the intensity of rainfall on the wettest days is projected to increase.

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 from CMIP5 models are given, with the 10th–90th percentile uncertainty range in brackets. 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 [2].

	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 is captured: What would we do under a 'least warming, drier' or 'more warming, wetter' future climate scenario? This is known as the 'storyline approach' [16]. The scenarios account for uncertainty in future greenhouse gas emissions, the regional climate responses to those emissions, and natural climate variability. Using this approach, by 2050 suitability for taro production may improve in the south as the climate warms, more so under a higher warming scenario (Figure 3). This is because the region currently has a below optimum temperature for this crop [9].

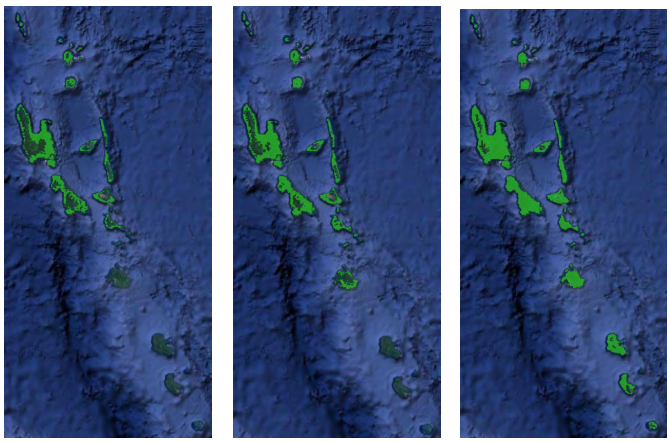


Figure 3 Suitability for production of taro (indicated by light green shading), where annual average temperature ranges from 25–35 °C, and annual rainfall ranges from 1500–5000 mm, is indicated in light green for 1970–2000 (left), 2050 least warming drier (RCP2.6; GISS-E2-R model) (middle) and 2050 most warming wetter (RCP8.5; IPSL-CM5A-MR model) (right). The Vanuatu Climate Futures Portal has a tool where the various climate criteria can be adjusted to generate climate suitability maps for other species of root crop. NB: *'Suitability' is used as a guide ONLY. Micro-climate, soil, and other management factors will all influence taro productivity.*

The Vanuatu Climate Futures Portal provides options to explore different future scenarios for root crop production (and other crops), and the ability to interact with the climate variables separately to better understand the drivers of some of the shifts seen in Figure 3. Furthermore, future climate suitability for coffee and cocoa has also been undertaken and reported in separate infobytes. Collectively there appears a potential for shifts in climate suitability of some crops in some locations in Vanuatu. For example, while suitability for coffee production may decline under some future warmer scenarios, opportunities for cocoa and taro production, for example, may improve.

Regarding the timing of the plant's development phases, or phenology, these may also change under warmer conditions. This can affect cultural gardening practices. A study on the timing of harvest of taro in Fiji indicated that for each 1 °C increase in average temperature, there was about a two week reduction in timing of days to maturity (Figure 4) [17].

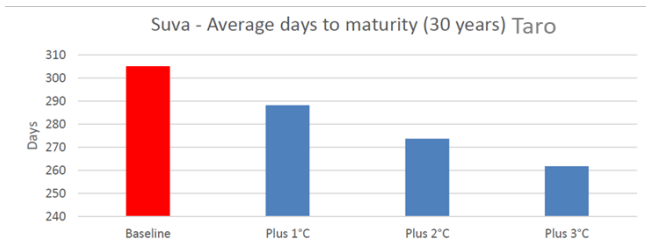


Figure 4 Using a crop production model APSIM (Agricultural Production Systems sIMulator) (Holzworth et al. 2014) the taro variety 'Tarapatan' in Fiji was assessed under baseline (1985–2015) temperature and rainfall conditions (red), and under +1 °C, +2 °C, and +3 °C temperature increments (blue) (reprinted with permission from Crimp et al. 2017 [17]).

Relating this relationship to taro in Vanuatu, by 2050 using plausible 'lower warming' and 'higher warming' models and a range of emission scenarios, earlier maturity of from one to four weeks may result (Table 2). Equivalent results have been reported for Fiji [18].

Table 2 Projected average annual temperature change (°C) for a 20-year period centred on 2050 (relative to 1986–2005) for selected CMIP5 models; a 'lower warming' model (GISS-E2-R) (left) and 'higher warming' model (IPSL-CM5A-MR) (right) for low (RCP2.6) and high (RCP8.5) emissions pathways. Estimated changes to maturity timing for taro are proposed.

2050	**Projected temperature change (°C) relative to 1986–2005 [4]**		**Approximate change in timing of maturity (after Crimp, [17])**	
	'Lower warming' model	**'Higher warming' model**	**'Lower warming' model**	**'Higher warming' model**
RCP2.6	0.4	0.8	1 week earlier	2 weeks earlier
RCP8.5	1.0	2.0	2 weeks earlier	4 weeks earlier

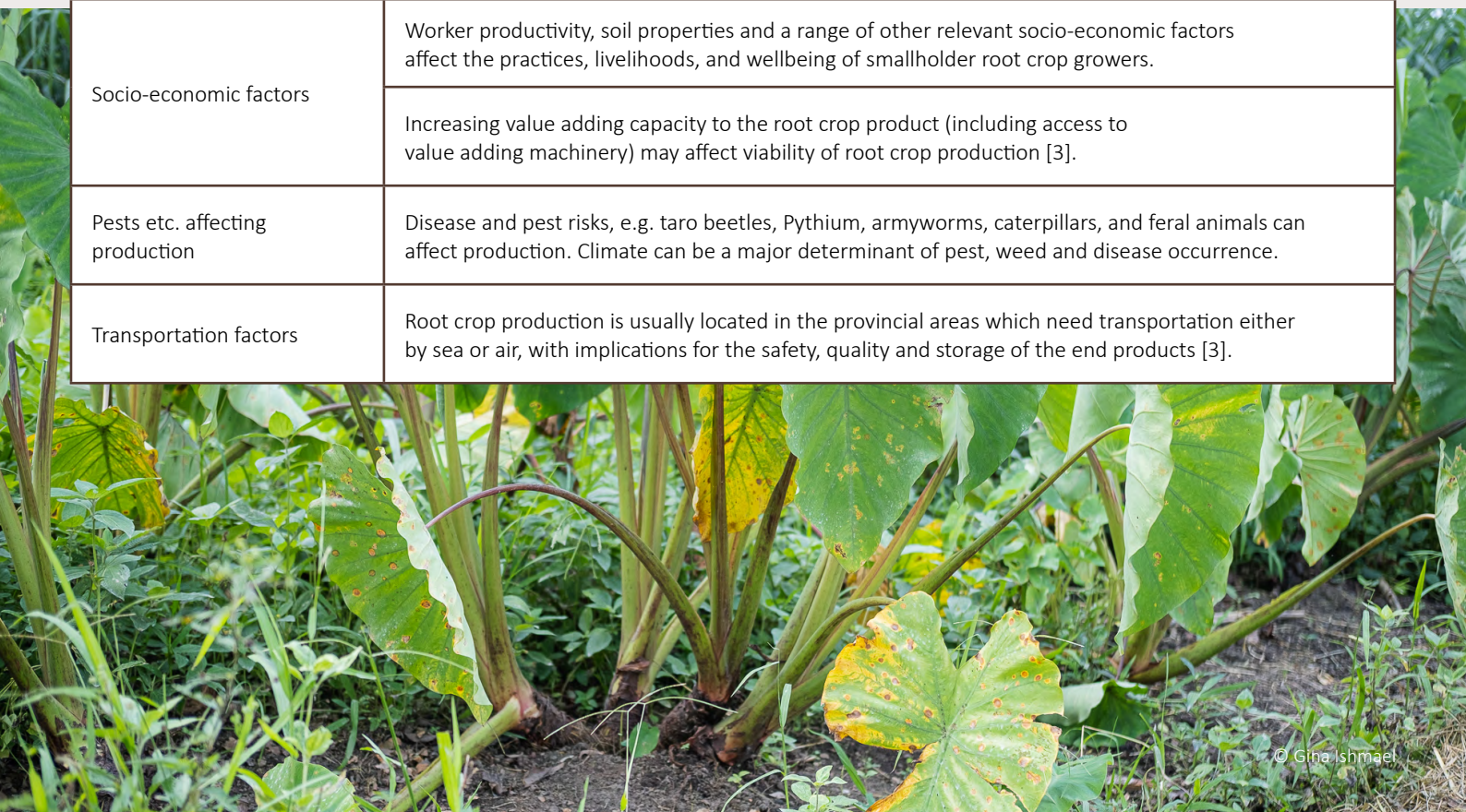


STEP 6

Evaluate other climate and non-climate factors

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

Climate factors affecting root crops	
Night-time temperature	Minimum temperature greater than 21 °C have been linked to Taro Leaf Blight (TLB) occurrence [9]. Reports indicate TLB has not yet been problematic in Vanuatu, while the disease has been devastating elsewhere in the Pacific [19]. Rising temperatures will increase the chance of incursions [9, 20].
Rainfall	While average rainfall is likely to remain adequate for root crop production across most of Vanuatu out to 2050, further analysis may be required to estimate impacts relating to the driest projections, 12 % reduction in rainfall (Table 1), particularly in the drier southern regions of Vanuatu. Increasing extreme rainfall may become an issue due to flooding risk [9].
Drought	Root crops are reported as being relatively drought tolerant according to the literature, though stakeholder groups [21] have reported reduced yields attributed to drought. Low soil moisture has also been linked to increases in cyanogen toxins in cassava [22] (see Drought factsheet for more information).
Tropical cyclones	Root crops can be negatively impacted by Tropical Cyclones (TCs) [9], as experienced in severe TC Harold (2020) [23] and Pam (2015) [24]. After TCs Judy and Kevin in 2023, sweet potato in Erromango appeared less affected with its lower growth habit, however taro leaves were reported damaged and cassava growing close to the sea was also impacted [10] (see Tropical cyclone factsheet for more information).
Sea level rise	Root crops can be vulnerable to salinity [25]. Direct inundation through sea level rise could occur in some lower lying areas (see Coastal inundation factsheet for more information).
El Niño Southern Oscillation (ENSO)	ENSO is a large-scale driver of climate variability in the Pacific, affecting rainfall, temperature, and drought [7]. 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 [26]. Extreme La Niña and El Niño events are projected to increase in future [27, 28] (see Climate variability explainer for more information).
Non-climate factors affecting root crops	
Socio-economic factors	Worker productivity, soil properties and a range of other relevant socio-economic factors affect the practices, livelihoods, and wellbeing of smallholder root crop growers.
	Increasing value adding capacity to the root crop product (including access to value adding machinery) may affect viability of root crop production [3].
Pests etc. affecting production	Disease and pest risks, e.g. taro beetles, Pythium, armyworms, caterpillars, and feral animals can affect production. Climate can be a major determinant of pest, weed and disease occurrence.
Transportation factors	Root crop production is usually located in the provincial areas which need transportation either by sea or air, with implications for the safety, quality and storage of the end products [3].



STEP 7 Plan future adaptation

There are several ways in which root crop growers 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. Adaptation options that could be considered, tested, and verified in the community to improve resilience includes:

In the past, locals have been encouraged to make flour from cassava after the crop is damaged in a cyclone. This flour is rich in nutrients and will last for months, covering periods when food availability can be limited.



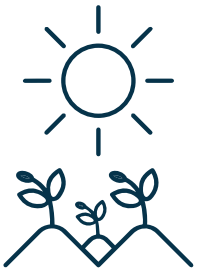
New farm management practices



Could either adopt new technologies and farming methods or, as preferred by the current farming community, adapt traditional farming methods



Farming on higher ground to avoid flood/ inundation prone areas



Change crops to more heat tolerant varieties



Diversify the farming system



Plan for cultivation of TLB-resistant taro varieties

Further analysis of adaptation options can be found in *Managing the Impacts of Climate Change on Root Crop Production and Value Chains in Fiji [12]* and *Vulnerability of Pacific Island agriculture and forestry to climate change [9]*.

STEP 8 Communicate findings

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

Vanuatu Climate Futures Portal

Case Studies

Fact Sheets

Guidance Material

Videos

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Authors: Leanne Webb (CSIRO) and Pakoa Leo (Vanuatu Department of Agriculture and Rural Development).

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Annex W

EXTREME HEAT IMPACTS ON ELECTRICITY DEMAND IN EFATE

INFRASTRUCTURE



This case study examines the impact of temperature on electricity demand in Efate. 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

Electricity for about half of Efate (including Port Vila) is supplied by UNELCO, a private company operating since 1939, with electricity generation of 60 GWh in 2021 [1]. In 2022, total generation was almost 63 GWh, of which 92 % was from diesel, 4 % from wind, 3 % from solar and 1 % from an independent power producer (UNELCO, personal communication). This mix varies month-by-month depending on local and prevailing weather factors e.g. wind or solar input [2]. This energy mix is currently provided by two diesel power stations, two solar farms and one wind farm (UNELCO, personal communication). UNELCO had around 16,000 electricity customers in 2021 [1].

The National Energy Roadmap 2016–2030 (NERM, 2016) for Vanuatu lists five priorities for action and investment: (1) access to secure, reliable, and affordable electricity for all citizens by 2030, (2) reliable, secure and affordable petroleum supply, (3) a more affordable and low-cost energy service, (4) an energy secure Vanuatu, and (5) mitigating climate change through renewable energy and energy efficiency. While around two-thirds of Vanuatu's population can access the electricity grid [3], energy security can be disrupted by extreme weather events such as tropical cyclones.

An analysis of UNELCO electricity demand data for Efate during 2019–2022 showed that highest demand is required in the warmest months of the year, mainly for both public and private use of air conditioning (Figure 1). Climate change will increase the frequency, intensity, and duration of extreme heat, leading to greater use of air-conditioning and greater electricity demand. This infobyte assesses **the impact of extreme heat on electricity demand** in Efate, using data provided by UNELCO and Vanuatu Meteorology and Geo-hazards Department (VMGD), along with future climate change scenarios from CSIRO. For information on how this climate hazard-based impact study fits into a broader risk framework, see the Climate risk factsheet.

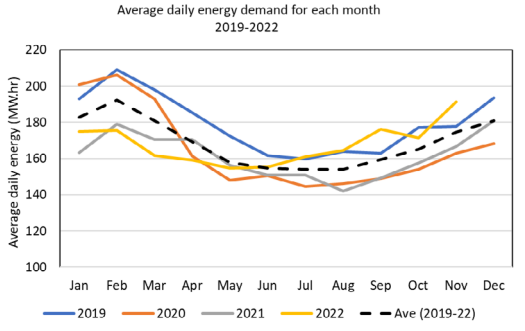


Figure 1: Average daily electricity demand for each month during 2019-2022 for Vanuatu.

STEP 2 Engage and meet with stakeholders

Van-KIRAP infrastructure sector experts, VMGD and CSIRO scientists liaised with UNELCO energy company in 2023 to discuss electricity production and demand and to review available data. Relevant literature was also drawn upon, including energy policy and planning reports.

STEP 3 Explore background information and historic climate data

For the 1986–2005 period, the hottest day of the year was, on average, 32–33 °C at all seven VMGD weather stations, with the hottest day being 33–34 °C. Over the past decades the number of cold nights in Port Vila has been decreasing, while the number of hot days has been increasing [4]. Over the period 1950–2020, there has been a clear warming of the hottest day of the year (Figure 2) [5, 6].

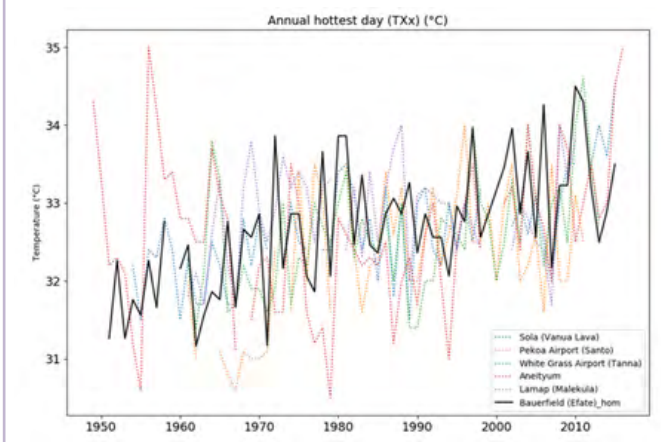


Figure 2 Temperature (°C) time series (1950–2020) of the annual hottest day for selected VMGD weather stations across Vanuatu. The station with homogenised data (Bauerfield, Efate) is shown with a solid line. Data source: [7]

Higher maximum temperatures correspond to higher electricity demand (around 30 % of the variation explained; Figure 3 top), mainly due to meeting an increasing demand for air conditioning. This correlation is strengthened through heatwave periods, with 40 % of the variability in electricity demand explained by variation in daily maximum temperature (Figure 3, bottom).

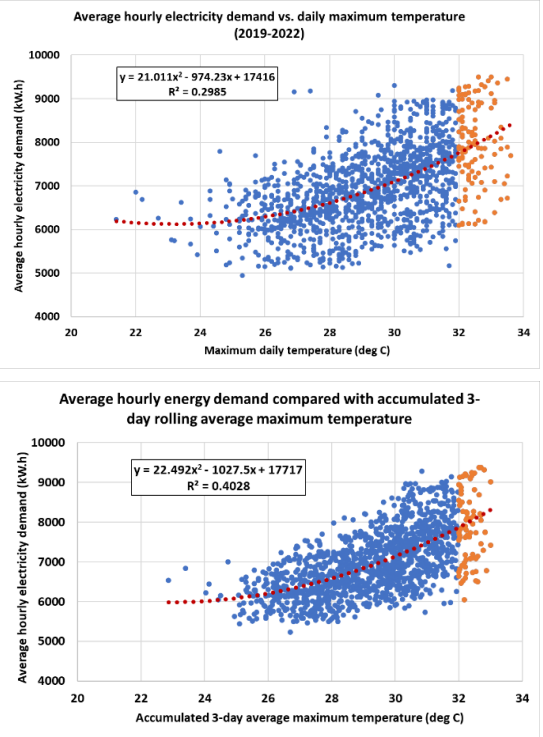


Figure 3 Average hourly energy demand (kW/hr) compared to daily maximum temperature (top) and average 3-day electricity demand compared to accumulated 3-day average maximum temperature (bottom). Non-linear regression lines (dashed) are statistically significant. Days with maximum temperature 32 °C and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

The influence of other climate variables on electricity demand were explored in this assessment (e.g. relative humidity and minimum temperature) however maximum temperature was found to have the most influence.

STEP 4 Collect information about future climate scenarios

Extreme temperatures are projected to rise, consistent with the observed trends and projected warming in average temperatures. The projections are influenced by 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). Under a high emissions scenario (RCP8.5), extreme temperatures are projected to be approximately 0.6–1.8 °C hotter by 2050 and 1.0–3.5 °C hotter by the end of the century (Figure 4).

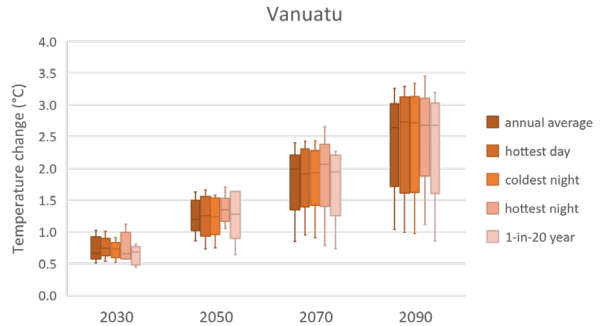


Figure 4 Projected changes in various temperature metrics: annual average, annual hottest day, annual coldest night, annual hottest night and 1-in-20 year hottest day, for the Vanuatu region over four future time periods (2030, 2050, 2070, 2090), relative to 20-years centred on 1995. The box plots show the multi-model minimum and maximum; 25th and 75th percentile; and median (50th percentile) based on the five CCAM climate model simulations under a high emissions scenario (RCP8.5).

STEP 5 Analyse climate-related impacts

When undertaking climate hazard-based impact assessments to inform climate change risk, it is important that a range of future climate change scenarios is considered. 'What would be the impact and what would we do (how would we adapt or otherwise manage or reduce risks) under a 'best-case' or 'worst-case' future climate scenario?' This is known as the 'storyline approach' [9].

Future daily maximum temperature timeseries for four years centred on 2050 and 2070 were created by adjusting four years of observed (2019–2022) maximum temperature data with the changes in temperature projected from climate models. The analysis considered low and high emissions scenarios, as well as a climate model projecting 'less warming' and a climate model projecting 'more warming' [10]. (See Climate projections for use in impact assessments factsheet for explanation of methods). Future electricity demand was estimated using these projected daily maximum temperature data in the electricity-temperature relationship derived in Step 3.

For low emissions (Figure 5 dashed lines), there was almost no change in electricity demand for the 'less warming' model, and around 4.0 % increase in electricity demand for the 'more warming' model by 2050. Under high emissions (Figure 5 solid lines), there was around 1.6 % increase in electricity demand for a 'less warming' model, and around 6.6 % increase for a 'more warming' model by 2050. Larger changes were estimated by 2070 e.g. high emissions and a 'high warming' model caused up to 11 % increase in electricity demand by 2070 (not shown).

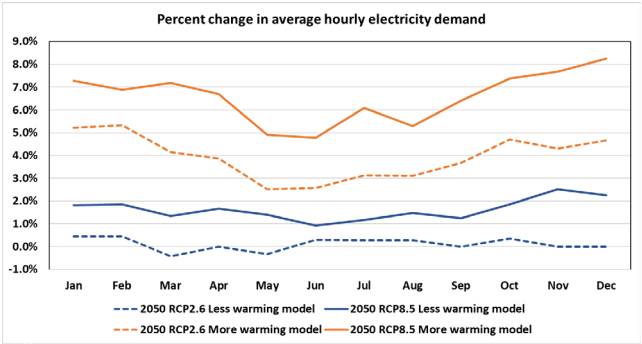


Figure 5 Per cent change in average hourly energy demand for Port Vila for 20-year periods centred on 2050 for a low emissions scenario (RCP2.6), a high emissions scenario (RCP8.5), a climate model with less warming (GISS-E2-R) and a climate model with more warming (IPSL-CM5A-MR).

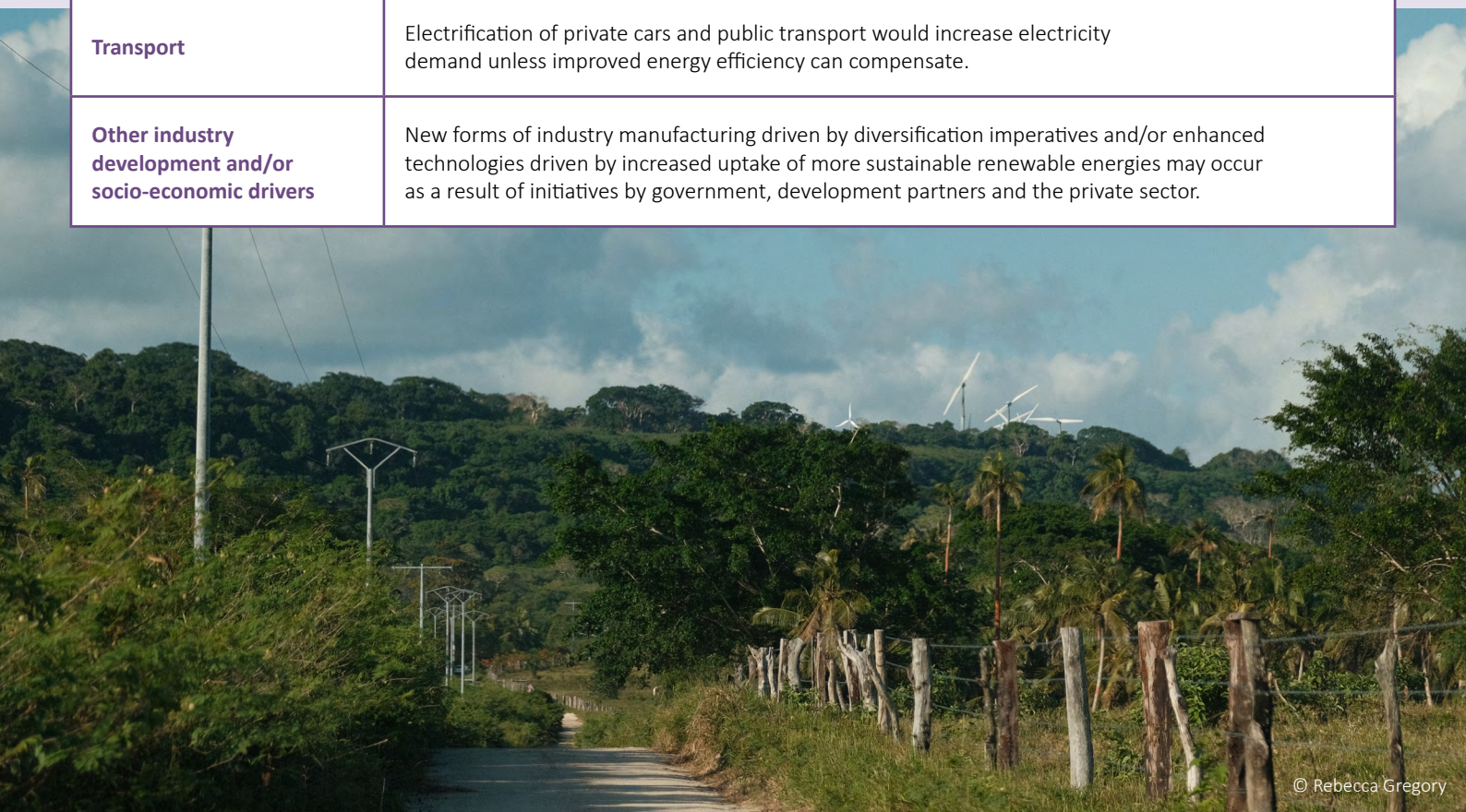
This analysis assumes no other change in demand based on possible new connections to the grid over the reporting period driven for instance by population growth, industry development and/or productivity gains, and/or improved socio-economic circumstances of the population more generally (see also Step 6). International studies indicate that an increase in energy demand is likely with future climate change, e.g. 25 % increase in the tropics by 2050 [11-13], a 4 % increase in Brisbane (Australia) for a 2–3 °C warming [14, 15], and while not as tropical, a 9.2 % increase for a 1.0 °C warming in the Yangtze River Delta, China [16].

STEP 6

Evaluate other climate and non-climate factors

It is important to note that only temperature conditions are assessed in Step 5. Other climate and non-climate factors are listed below that may also influence energy demand. Further analysis around these may be prudent.

Climate factors affecting electricity demand	
Extreme rainfall	Flooding associated with extreme rainfall may damage electricity sub-stations and other critical infrastructure, disrupting electricity distribution.
Tropical cyclones	Extreme wind associated with cyclones may damage critical infrastructure, disrupting electricity generation, transmission and distribution. Extreme wind can also require shutdown of wind turbines and cause damage to solar panels, limiting renewable energy generation.
Solar radiation	High solar radiation (low rainfall and cloud cover) can enhance solar electricity generation, while low solar radiation (high rainfall and cloud cover) can limit solar electricity generation.
El Niño Southern Oscillation (ENSO)	ENSO is a large-scale driver of climate variability in the Pacific, affecting rainfall, temperature and drought [17]. 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 [18]. Extreme La Niña and El Niño events are projected to increase in future [19, 20].
Non-climate factors	
Socio-economic	Population growth and/or industry productivity growth and socio-economic wellbeing may increase uptake of electrical and cooling appliances, thereby increasing electricity demand. On the other hand, improved climate resilience and energy efficiency within industry and local communities may compensate.
Tourism	Increased tourism may increase electricity demand for hotel air conditioning and other electrical appliances.
Transport	Electrification of private cars and public transport would increase electricity demand unless improved energy efficiency can compensate.
Other industry development and/or socio-economic drivers	New forms of industry manufacturing driven by diversification imperatives and/or enhanced technologies driven by increased uptake of more sustainable renewable energies may occur as a result of initiatives by government, development partners and the private sector.



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STEP 7 Plan future adaptation

Adaptation can be incremental or transformative, with enablers and barriers, synergies and trade-offs, pathways and limits, costs and benefits. The process usually starts with consideration of adaptation options. A list of adaptation options and planning considerations for Vanuatu to reduce electricity demand increasing in a warmer climate that could be reviewed, tested, and verified as appropriate with local sectoral and community stakeholders include:



Installing ceiling insulation and building more energy efficient houses is more effective for reducing energy demand for residential cooling than increasing the energy efficiency of cooling systems or decreasing the uptake of cooling systems [21].



Passive cooling includes solar shading, window orientation, increased insulation, reflective materials and greater natural ventilation [22].



Changes to the design and built form of cities can contribute to reduction of the urban heat island effect and the impacts of heatwaves. Urban 'greening' includes parks, open spaces, forests, wetlands, and green roofs [21].



Increased energy demand may be sustainably managed by way of increased generation of and access to lower cost renewable energy supplies (e.g. mix of wind, solar and battery supply).



The National Energy Road Map (NERM) emphasises affordability, accessibility, sustainability, reliability, and the importance of transitioning to renewable energy generation [23].

STEP 8 Communicate findings

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

Van-KIRAP Web Portal

Case Studies

Fact Sheets

Guidance Material

Videos



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EXTREME HEAT IMPACTS ON ELECTRICITY DEMAND IN EFATE

INFRASTRUCTURE



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Authors: Leanne Webb (CSIRO), Kim Nguyen (CSIRO), Kevin Hennessy (Climate Comms) and Moirah Matou (Van-KIRAP).

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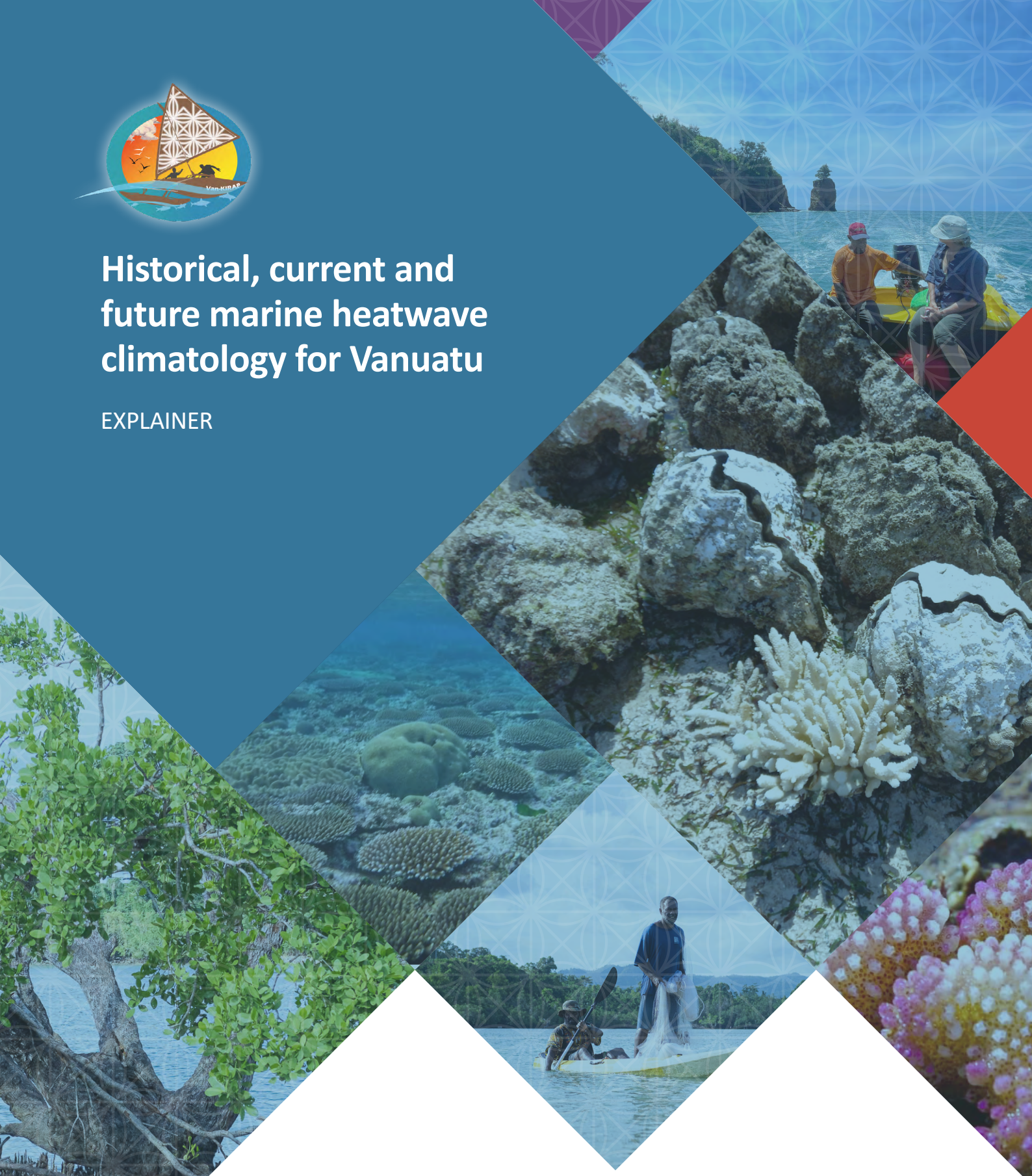
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Annex X

Historical, current and future marine heatwave climatology for Vanuatu

EXPLAINER



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Summary

- Marine heatwaves (MHWs) are defined as ‘discrete, prolonged anomalously warm water events which last for five or more days, with sea surface temperatures (SSTs) warmer than the 90th percentile relative to climatological values’.
- The most common drivers of MHWs include ocean currents which can build up areas of warm water and air-sea heat flux, or warming through the ocean surface from the atmosphere. Winds can enhance or suppress the warming in a marine heatwave.
- MHWs can have a very different temperature profile depending on the seasonal, regional-scale background ocean temperatures.
- Across Vanuatu historically there has been an increasing frequency of MHWs (1982–2021), mostly in the ‘Moderate’ to ‘Strong’ category.
- Broadly speaking, northern Vanuatu has experienced more frequent, longer duration and higher intensity MHWs than southern Vanuatu for the period 1982–2021.
- Across all sites, historically the typical number of MHWs is around 25 days per year (20-year average centred on 1995). Under the low greenhouse gas emissions scenario (SSP126), this is projected to increase to about 80–150 days per year by 2050. Under the high emissions scenario (SSP585) this increases to about 170–310 days per year by 2050, with many days in the ‘Strong’ and ‘Severe’ MHW categories.
- Degree heating weeks (DHW), a related MHW metric, provide a measure of coral stress.
- Using DHW estimates, more exposed reefs are found in northern Efate, west Epi, east Malekula and south-west Ambrym islands. Less exposed reefs, identified as historical refugia, are in Tanna, southern Efate, Ambrym, north Pentecost and west Maewo islands.
- Some of these refugia are projected to experience delayed impacts such as annual severe bleaching seven or more years later than the average for Vanuatu in 2040.



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Introduction

Marine heatwaves (MHWs) are episodes of prolonged and anomalously high ocean temperatures [1, 2]. They can have devastating impacts on aquaculture and marine ecosystems, including many that provide critical habitat and ecosystem services (e.g. coral reefs, seagrass, kelp beds). MHWs can be caused by a whole range of factors, and not all factors are important for each event. The most common drivers of MHWs include ocean currents which can build up areas of warm water, air-sea heat flux or warming through the ocean surface from the atmosphere. Winds can enhance or suppress the warming in a MHW, and climate variability drivers like ENSO can change the likelihood of events occurring in certain regions [3]. MHWs are often associated with periods of clear skies and more settled conditions, and consequently less wind-driven mixing of the surface ocean which enhances surface heating.

Globally, MHW frequency, intensity, and duration have increased over the last four decades [4], and climate projections indicate that this trend is set to continue for decades to come in many regions, including the Pacific [5]. This will have serious impacts on marine species and aquatic ecosystems over the coming decades [6], along with the coastal communities dependent on these natural resources for coastal protection, livelihood and environmental amenity (ecosystem services), with the rate of change depending on the global greenhouse gas emissions pathway followed in future [7]. This report describes what MHWs are, observed changes and how MHWs may increase in future (also see the Seagrass infobyte).

Observed sea surface temperature, seasonal cycle and trends for Vanuatu

Across the Vanuatu archipelago annual average sea surface temperatures (SSTs) range historically from about 25.5 °C to 28.5 °C from south to north (Figure 1). Through the 1993–2021 period, monthly-average SSTs at the Port Vila tide gauge ranged from around 29 °C in February–March to 25.5 °C in August (Figure 1, top right) [8], with individual monthly SSTs varying within 2 °C of the monthly average.

As part of the Van-KIRAP project case studies, SST observations taken from the NOAA daily Optimum Interpolation Sea Surface Temperature v2-1 data set[1] (hereafter called OISST v2-1; [9]), have been averaged over the Vanuatu Exclusive Economic Zone, revealing a historical warming trend of 0.23 °C per decade during 1981–2021 (Figure 1, bottom right) [8]. SSTs are now reaching record high levels globally [10] driven by global warming due to increases in greenhouse gases [11].

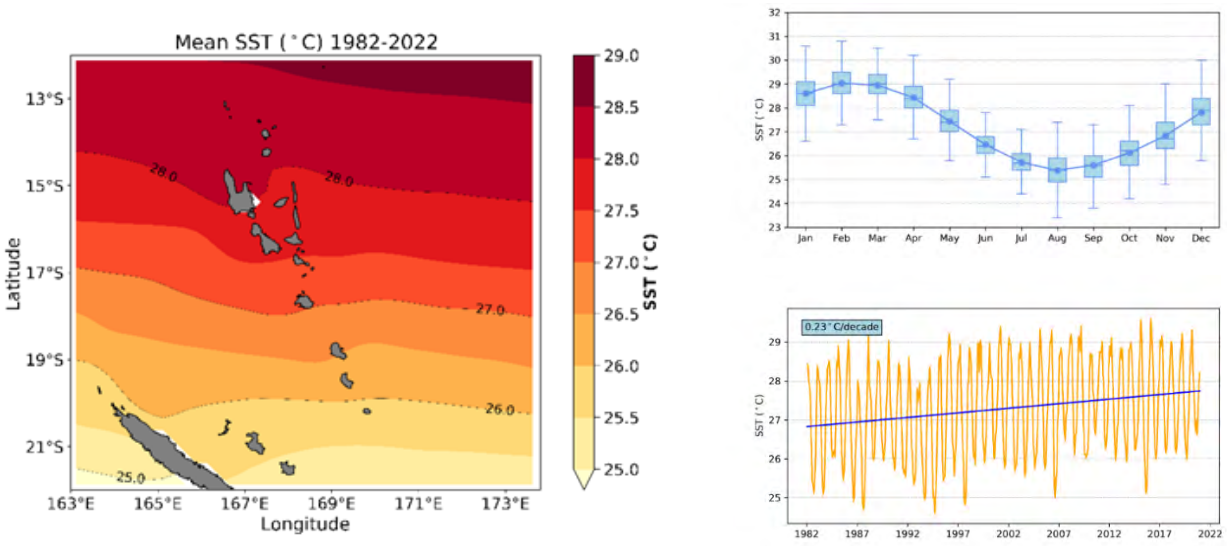


Figure 1 (left) Vanuatu annual average SST (°C) (1982–2022). (Top right) SST (°C) measured at the Port Vila tide gauge (1993–2021), with blue dots showing the monthly average, shaded boxes show the median (middle 50 % of observations) and lines showing the top and bottom 25 % of observations. (Bottom right) SST from satellite observations averaged across the Vanuatu region, with annual averages shown as the orange line. The blue line shows the linear regression trend [8]. Data source for left and bottom right plots: [9].

[1]Daily OISST data are constructed by combining observations from different platforms (satellites, ships, buoys, and Argo floats) on a regular 0.25 ° global grid (around 27 km between data points) with interpolation to fill any data gaps. Full year data are available from 1982–2022.

Definition of marine heatwaves

Marine heatwaves are defined as 'discrete, prolonged anomalously warm water events which last for five or more days, with SSTs warmer than the 90th percentile relative to climatological values' [1, 2] where:

- 'discrete' implies a well-defined start and end date, and separated from a previous MHW by more than two days
- 'anomalously warm' is warmer than the 90th percentile (top 10 % of events) in a 30-yr baseline period
- 90th percentile accounts for seasonal differences as it is uniquely computed for each calendar day.

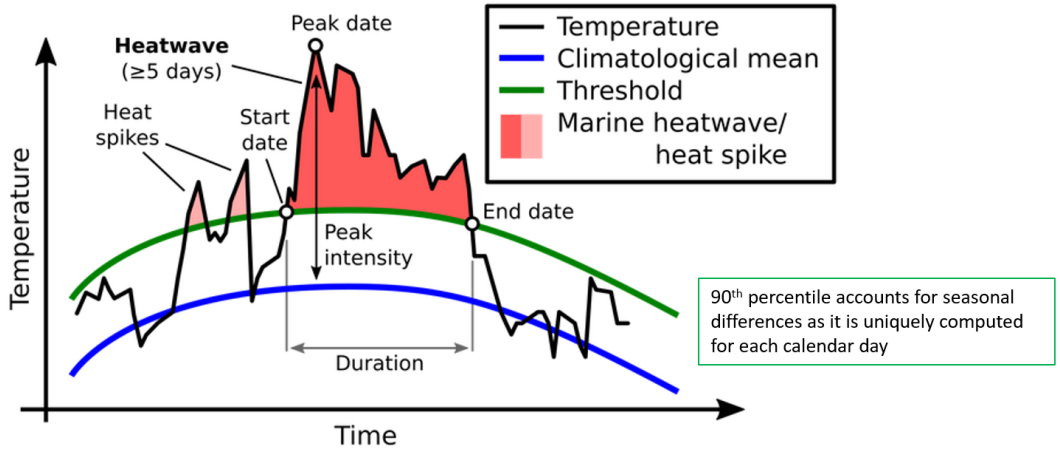


Figure 2 Diagram illustrating MHW definition: SST (°C) timeseries (black line) overlaid on the average SST (blue line) and the 90th percentile threshold (green line). When the SST exceeds the threshold for more than five days, it is defined as a MHW (red shading) [1, 2]. Heat spikes (pink shading) are not classified as a MHW because they are shorter than five days and are separated from the MHW by more than two days.

MHWs are categorised into four intensity categories, defined by multiples of the difference between the mean SST across a defined period and the 90th percentile threshold i.e. the difference (D) between the blue and green lines in Figure 3. For example, an event with moderate intensity is 1–2 x D. Intensity is defined as 'Moderate' (Category I, 1–2 x D), 'Strong' (Category II, 2–3 x D), 'Severe' (Category III, 3–4 × D), and 'Extreme' (Category IV, greater than 4 x D) [2].

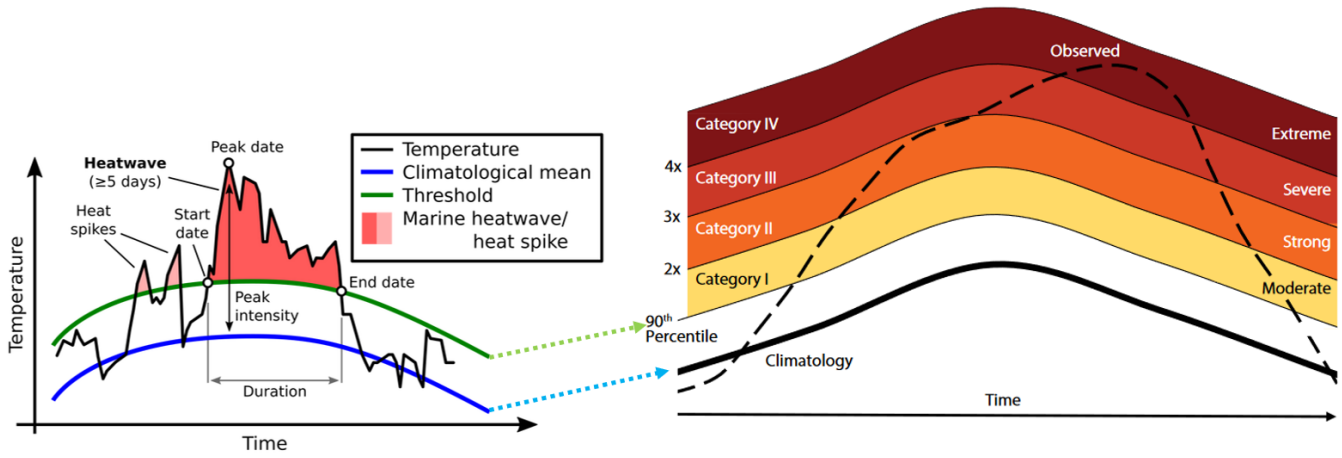


Figure 3 Multiples of the 90th percentile difference (2×D, 3×D, etc.) from the mean climatological value define each of the MHW categories I–IV, with corresponding descriptors from moderate to extreme. This example (dashed line) peaked as a Category IV (extreme) MHW [2].

Detecting and measuring marine heatwaves from global gridded data sets

To measure MHW occurrence, SST timeseries are extracted from the OISST v2-1 data for the closest grid cell best representing the location of interest. It is noted grid cells may not be centred on the exact location (Figure 4). Recent analysis undertaken for Fiji, Samoa, Palau, [5] and Cook Islands [12] indicates OISST v2-1 SST is usually very close to actual temperatures recorded in coastal areas and reef systems. Similarly, recent work in Vanuatu indicated that the OISST v2-1 data were very close to SST observations from marine Spotter wave buoys deployed around the coastline by the Van-KIRAP project (see Ocean monitoring factsheet).

In Figure 4, timeseries for the period 2002–2021 are shown for Pango (adjacent to Port Vila, Efate), in which a significant MHW event occurred, resulting in thousands of fish being killed [13]. The MHW in mid-February 2016 reached the 'Strong' category with SST between 1.75–2.0 °C above normal.

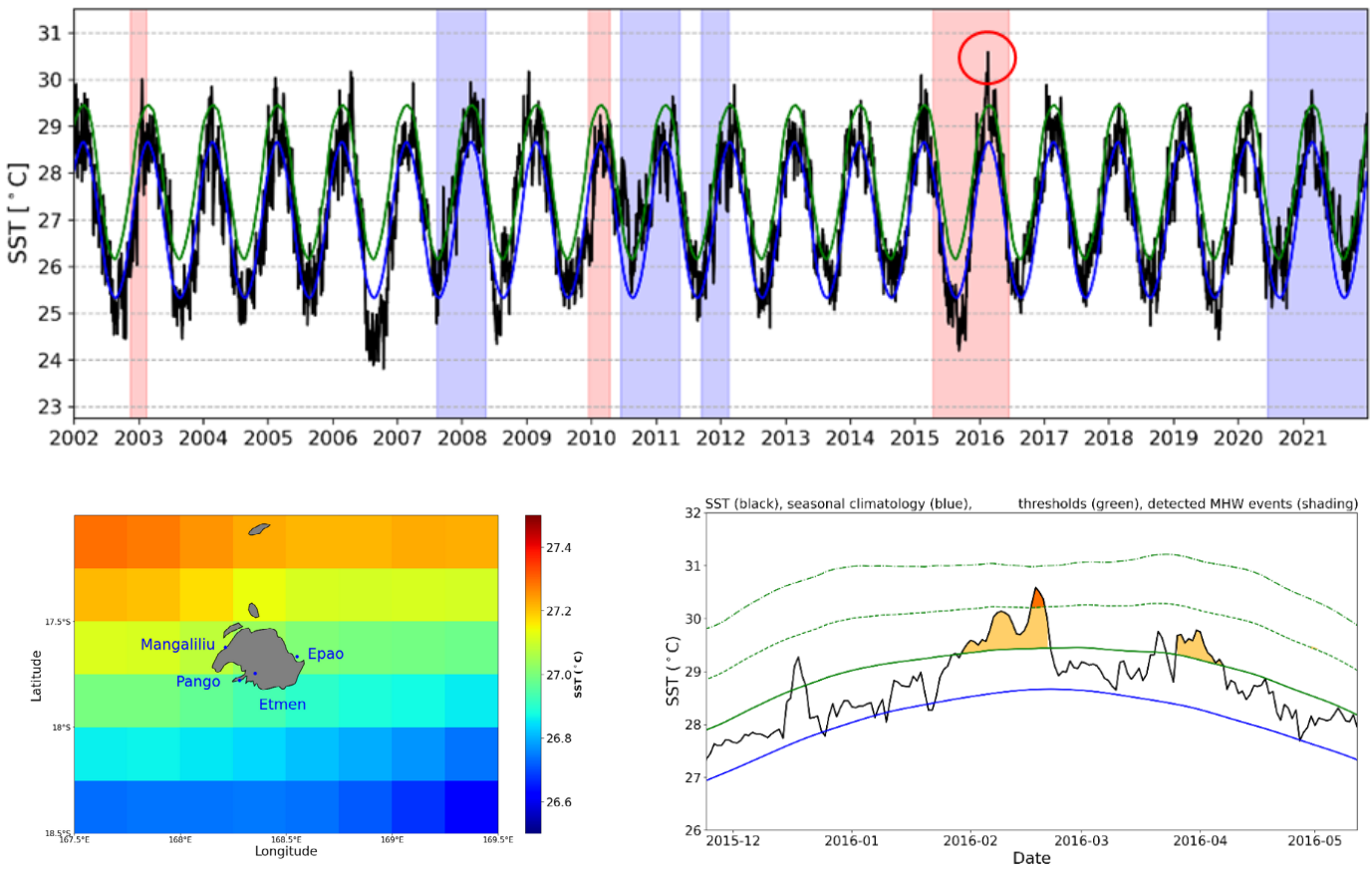


Figure 4 (top) SST (°C) timeseries from 2002–2021 for Pango region showing the observed daily values (black line), the seasonal mean climatology (blue line; based on 30-year baseline, 1986–2015), and the 90th percentile threshold (green line). Coloured bars denote strong El Niño (pink) and La Niña (blue) events. The February 2016 heatwave is highlighted with a red circle. (Bottom left) NOAA OISST v2-1 grid focused on Efate, noting the relative size of the grid cell from which each timeseries and MHW analysis is taken. (Bottom right) SST timeseries of the February 2016 event for Pango showing observed daily values (black line), seasonal mean climatology (blue line), 90th percentile threshold (green solid line), 2× threshold (dashed line), and 3× threshold (dash-dot line). Data source: [9].

Analysis of the longest MHW duration and cumulative intensity for Pango indicate the largest MHWs have occurred in the last 15–20 years (Figure 5), with cumulative intensity being the sum of the daily intensities through the duration of the MHW event.

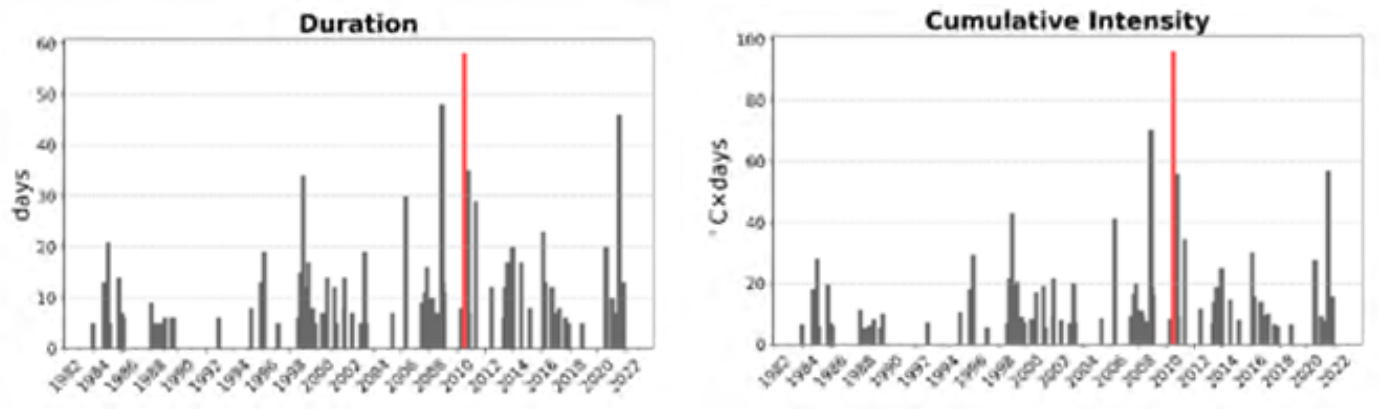


Figure 5 MHW duration (days) and cumulative intensity (°C x days). Data source: [9].

Observed marine heatwaves for sites of interest for Vanuatu's fisheries sector

Timeseries of MHW observations have been assessed for Vanuatu's fisheries sector. At eight sites of interest there has been an increasing frequency of MHW's during 1982–2021, mostly in the 'Moderate' to 'Strong' category (Figure 6).

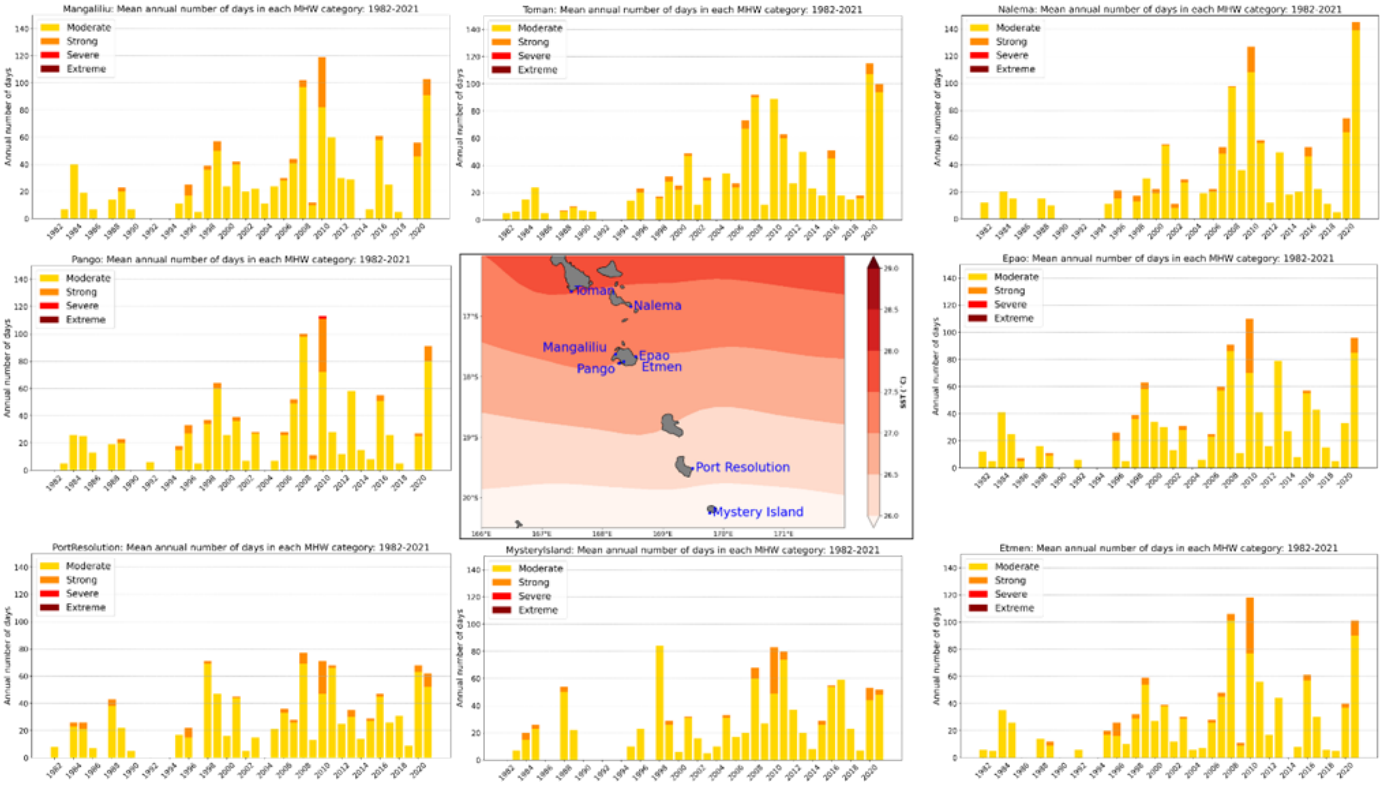


Figure 6 Mean SST (°C) (1982–2021) for Vanuatu fisheries sector sites of interest from north to south: Toman, Nalema, four sites on the coast of Efate, Port Resolution and Mystery Island (central map). For each site, the annual number of MHW days (1982–2021) is shown in each category [1, 2]. Data source: NOAA OISST v2-1 [9].

Spatial analyses of trends in observed marine heatwaves for Vanuatu

Spatial analyses of MHWs occurring in the Vanuatu region for 1982–2019 are presented in Figure 7. Note that MHWs are considered as separate events if a period of more than two days elapses since the occurrence of a previous MHW [1, 2]. Qualitative interpretation of trends in, and numbers of, observed MHWs are listed:

- Trends in annual MHW frequency are positive across the archipelago, with more occurring in the north than south (Figure 7, top left).
- The trend in annual MHW duration is mostly positive in the north, particularly around Sola and Avire, and negative in some sites in the south (Figure 7, top right).
- The trend in annual maximum MHW intensity is mostly positive in the north, and less in the south, with Aneityum (Mystery Island) having a trend to shorter duration MHWs through the specified time period (Figure 7, bottom left).
- The total number of MHW events over the period 1982–2019 varies across the region, mostly above 50, with more in the east (Figure 7, bottom right).

Regarding the fisheries sector sites of interest (Figure 6), Toman and Nalema were more exposed to MHWs, whereas the southern regions of Port Resolution and Mystery Island were less exposed.

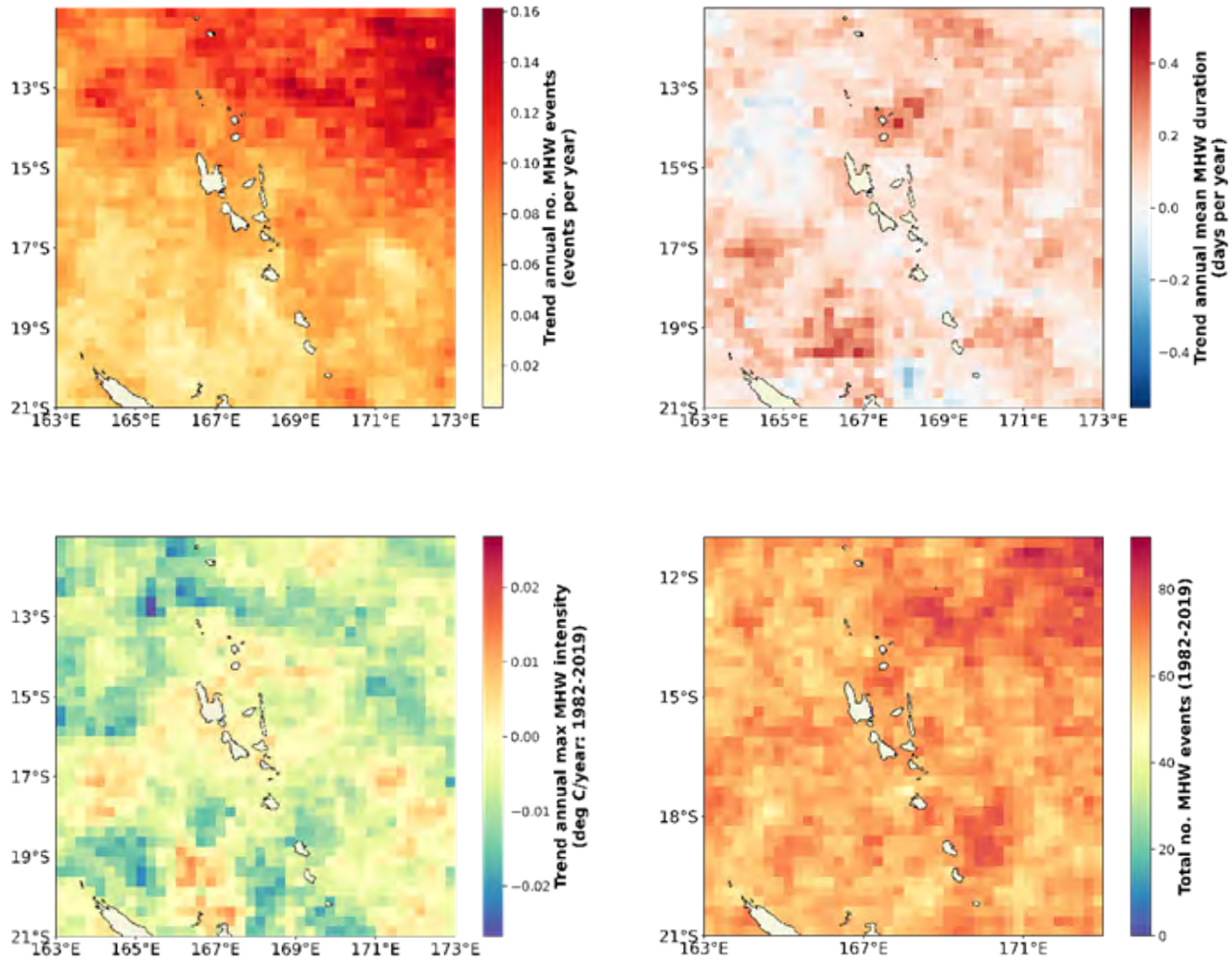


Figure 7 Trend in annual number of MHW events (top left), annual mean MHW duration (top right), annual maximum MHW intensity (bottom left), and total number of MHW events (bottom right). Source data: NOAA OISST v2-1 SST [9].

Marine heatwaves and ENSO

The incidence and intensity of MHWs is naturally influenced by the El Niño-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO), as well as local factors such as circulation patterns and processes that affect air-sea heat fluxes [14]. During El Niño events, higher SST, rainfall and sea level are clearly apparent in the central tropical Pacific. For Vanuatu, in the western tropical Pacific, El Niño events are normally associated with cooler and drier conditions [14] (also see Climate variability explainer). There is a higher likelihood of MHWs in La Niña periods, but they can occur during any ENSO phase (e.g. the 2016 MHW occurred during an El Niño event, Figure 4).

Timing of marine heatwaves

MHWs can have a very different temperature profile depending on the seasonal and regional-scale background temperatures in the ocean. MHWs can occur in summer or winter – they are defined based on differences with expected temperatures for the location and time of year. For example a heatwave occurring in August, a cooler month in Vanuatu, is unlikely to reach temperatures as high as those occurring in February. However there may be other biological, hydrological and physical and chemical processes (e.g. fish spawning and recruitment, food web and critical habitat relationships, diurnal feeding and distributional patterns, nutrient cycling etc.) that would still be sensitive to MHWs in winter [15]. Winter MHWs on top of long-term warming can also enable establishment of invasive species in some instances where previously cool winters would have killed them off [16].

Tracking marine heatwaves

The Marine Heatwave (MHW) Tracker shows the occurrence of MHWs around the world in near-real-time (roughly a one-two day delay). The tracker also shows daily the historic records for the whole planet going back to 1 January 1982. There are several other data layers offered in the tracker [3]. The February 2016 MHW event can be selected on the tracker interface as depicted in Figure 8.

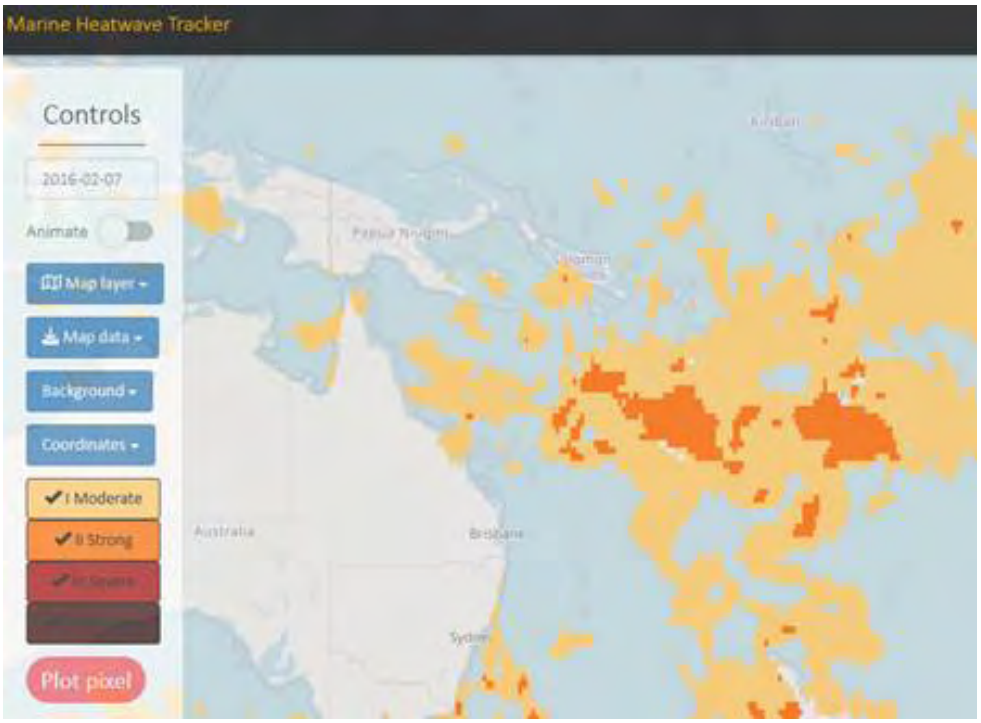


Figure 8 Marine Heatwave Tracker visualisation of the 7th of February 2016 'Strong' heatwave event (categories described here: [2]) that resulted in fish kills in Fiji and Vanuatu. http://www.marineheatwaves.org/tracker.html

Projected marine heatwaves

Projected MHWs out to the end of the century have been calculated for a lower-warming climate model (NorESM2-MM) and a higher-warming climate model (CanESM5), under low (SSP126) and high (SSP585) emissions scenarios, to capture the projected range of possible future change (Figure 9). To account for large interannual variability, data are averaged for 20-year periods centred on the years 2030, 2050, 2070 and 2090. The 20-year average (centred on the year 2005) from the OISST v2-1 observations are also plotted in Figure 9 by the left bar in each plot, denoted with an 'x'. Across all sites, the typical number of MHWs historically is around 25 days per year (20-year average centred on 2005; Figure 9). Under the low emissions scenario (SSP126) this increases to about 80–150 days per year by 2050 (20-year average centred on the year 2050; Figure 9). In Epao, under the high emissions scenario (SSP585) this increases to about 170–310 days per year by 2050, with many days in the 'Strong' and 'Severe' MHW categories (Figure 9).

By 2090, larger increases in MHWs are projected, more so in the north of Vanuatu. For a low emissions scenario the number of MHW days is 110–190, with a substantial increase in 'Strong' events. For a high emissions scenario the number of MHW days is 320–360, with a big increase in 'Severe' and 'Extreme' events (Figure 9).

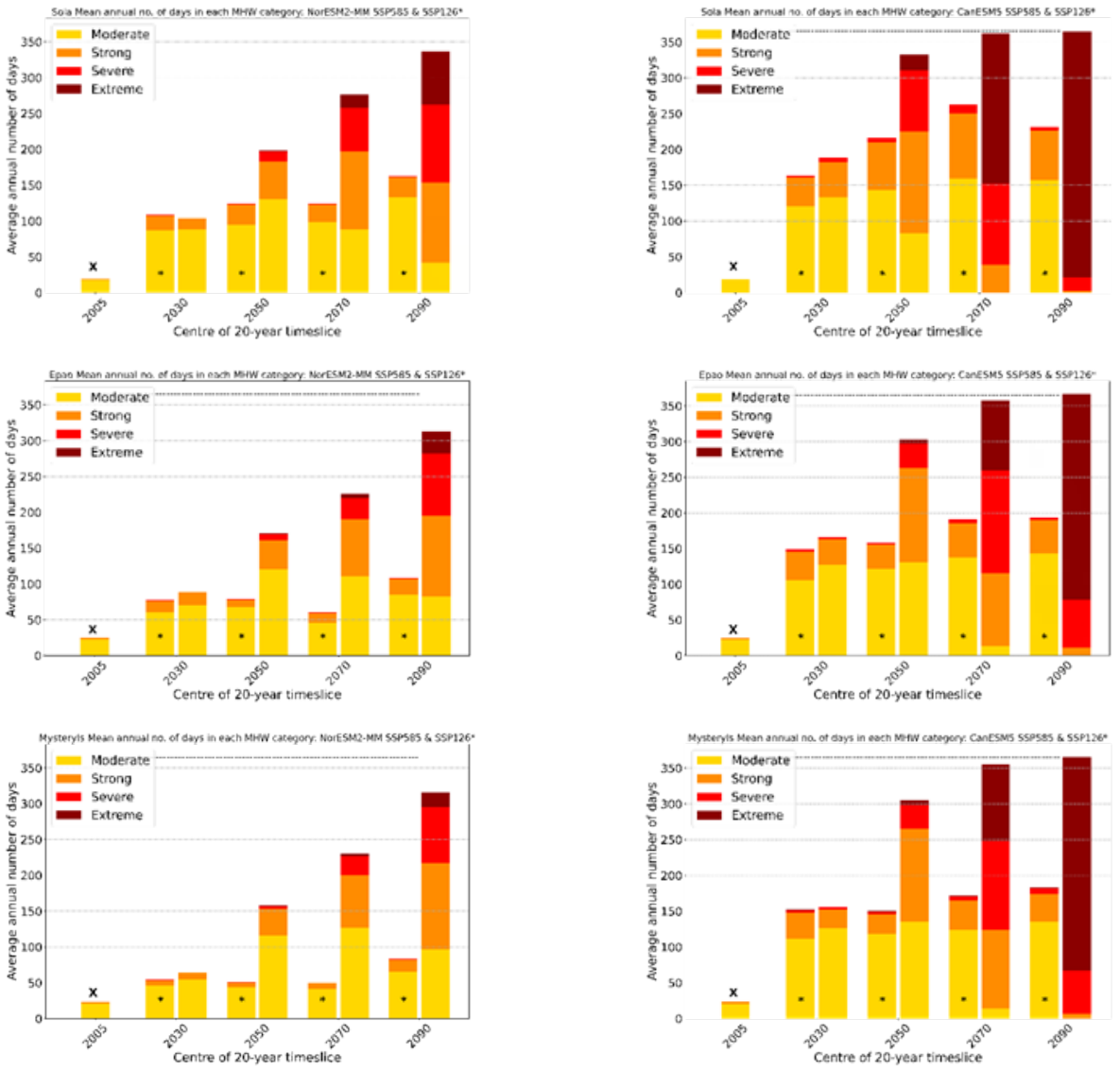


Figure 9 Projected average annual number of MHW days for an area-averaged domain encompassing northern through to southern regions of Vanuatu: (top) Sola, (middle) Epao, and (bottom) Mystery Island. The far left bar on each plot 'x', indicates historical MHWs for a 20-year period centred on 2005 (1995–2014) (x). Projections based on CMIP6 climate modelling indicate future MHW frequency for 20-year periods centred on 2030, 2050, 2070, and 2090. These are plotted for a lower warming model (NorESM2-MM; left panel) and higher warming model (CanESM5; right panel). For each future timeframe the low emissions scenario (SSP126) has an asterisk included in the bar (*), while the high emissions scenario (SSP585) has no asterisk. For all periods MHWs are categorised: moderate, strong, severe, and extreme [2]). (Data source: OISST v2-1 SST [9]: and CMIP6 climate models).

Impact of ocean temperatures on corals: degree heating weeks

Degree heating weeks (DHW) is another measure of ocean temperatures which also provides a useful measure of coral stress [17-19] (see Coral bleaching infobyte). Corals become stressed when SSTs are warmer than the bleaching threshold (solid blue line in Figure 10). This threshold is defined as 1.0 °C above the maximum of the monthly mean (MMM) SST climatology (indicated by the dashed blue line in Figure 10). Heat stress builds up the longer SST stays above the bleaching threshold. Both the magnitude of threshold exceedance and length of the exceedance are important factors in measuring stress, and thereby DHW. See Donner et al. [20] for a discussion of the metrics used.

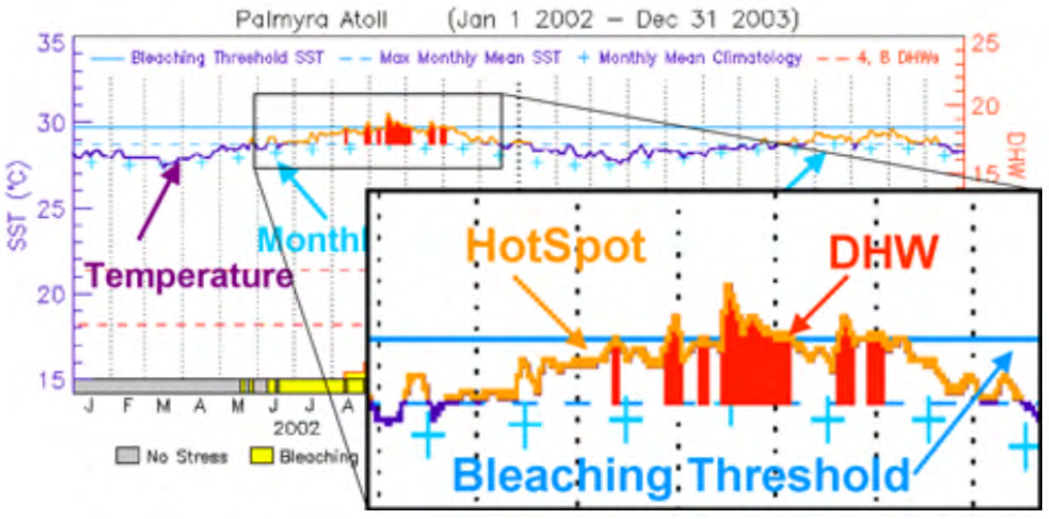


Figure 10 Simulated SST (°C) timeseries. A HotSpot is included in the DHW calculation when SST reaches or exceeds the bleaching threshold temperature. DHW (red region) is accumulated from HotSpot occurrence as the magnitude of exceedance above the MMM for a period of 12 weeks.

The term 'HotSpot' indicates the extent (in °C) that SST is above the MMM each day. DHW indicates how much heat stress has accumulated[2] and is calculated by summing the HotSpot values, over the previous 12 weeks, whenever the SST reached or exceeded the bleaching threshold. It is calculated as a running sum over a 12-week window (i.e. as you advance each day, you lose a day off the start of the 12-week window). The sum is divided by 7 to obtain the unit of '°C-weeks'. In that way a DHW of 2 is equivalent to one week of HotSpot values persistently at 2 °C (i.e. 2 °C x 7 days/7 =14/7 = 2), or two weeks of HotSpot values persistently at 1 °C (i.e., 1 °C x 14 days/7 =14/7 = 2) etc. (see : https://coralreefwatch.noaa.gov/product/5km/methodology.php#dhw). The United States National Oceanic and Atmospheric Administration (NOAA) monitors world SST and releases warnings for bleaching based on DHW (e.g. Figure 11).

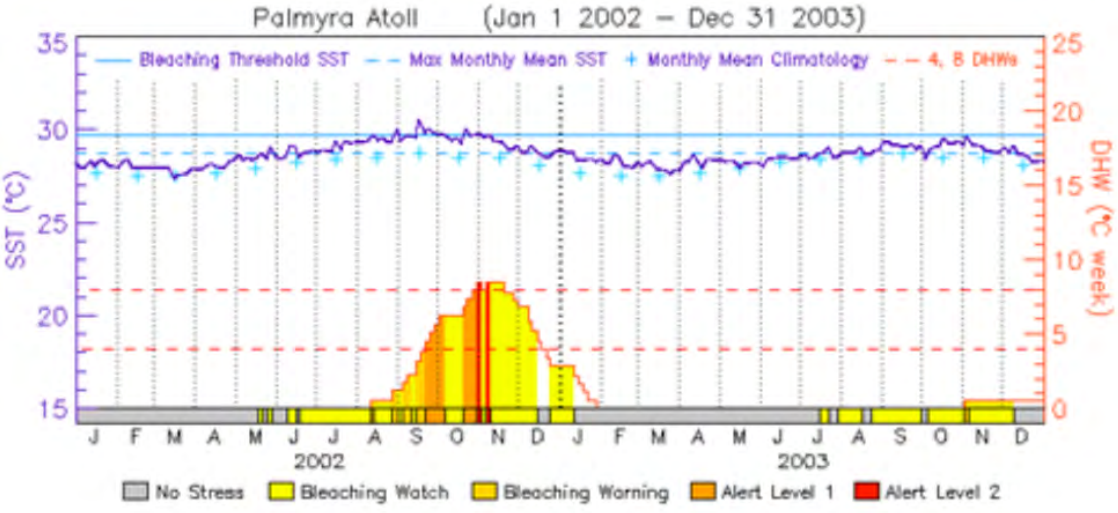


Figure 11 DHWs are plotted along the bottom of the graph, corresponding to the accumulated threshold exceedance of SST above bleaching threshold. The 4-DHW and 8-DHW thresholds are shown as dashed, horizontal red lines. The colours that fill below the DHW line correspond to established satellite bleaching alert levels (see Table 1).

A status level of 'Bleaching Watch' (Table 1) means that there is low-level thermal stress present at that location but not of sufficient magnitude to accumulate stress for corals, should they exist in that location. Alert Level 1 indicates that DHW is 4-8 and coral bleaching is likely to occur for some coral species. Alert Level 2 indicates DHW is greater than 8, so both widespread bleaching and significant coral mortality are likely. This scale has been successfully validated across historical observations at eight sites in the north-western Pacific Ocean [21].

[2]This anomaly is summed for the preceding 12-week period to produce 'Degree Heating Days' over 12 weeks. Dividing this by seven, can change the unit to 'Degree Heating Weeks' over 12 weeks.

Table 1 Coral bleaching thermal stress levels based on the NOAA Coral Reef Watch warnings.

STATUS	INTERPRETATION	DEFINITION
No Stress	No heat stress or bleaching is present.	HotSpot of less than or equal to 0.
Bleaching Watch	Low-level heat stress is present.	HotSpot greater than 0 but less than 1; Sea Surface Temperature (SST) below bleaching threshold.
Bleaching Warning	Heat stress is accumulating; possible coral bleaching.	HotSpot of 1 or greater; SST above bleaching threshold; Degree Heating Week (DHW) greater than 0 but less than 4.
Bleaching Alert Level 1	Significant coral bleaching likely.	HotSpot of 1 or greater; SST above bleaching threshold; DHW greater than or equal to 4 but less than 8.
Bleaching Alert Level 2	Severe bleaching and significant mortality likely.	HotSpot of 1 or greater; SST above bleaching threshold; DHW greater than or equal to 8.

Degree heating weeks exposure across Vanuatu

Many of the reef locations in Vanuatu have historically been refugia from thermal stress that causes coral bleaching. Using the DHW metric, these refugia were identified [22]. For the period 1985–2012 the frequency of events greater than 4-DHW (Alert Level 1) and 8-DHW (Alert Level 2) were mapped. More exposed reefs are in northern Efate, west Epi, east Malekula and south-west Ambrym islands. Less exposed reefs, identified as historical refugia, are in Tanna, southern Efate, Ambrym, north Pentecost and west Maewo islands [22].

In the Coral bleaching infobyte produced for Van-KIRAP, DHWs were compared for Port Resolution (Tanna) and Toman Island (Malekula), with projections for low warming by 2050 which indicates a higher frequency coral bleaching, i.e. where alert levels are exceeded, in the more northern site of Toman Island (Figure 12). This result aligns with the Maynard et al. study [22], where the onset of annual severe bleaching is shown to occur much later in Port Resolution than Toman Island [22]. Under a high warming scenario by 2050, and most concerningly, Alert level 2 is exceeded in 100 % of years at Toman Island, and 95 % of years at Port Resolution (see Coral bleaching infobyte).

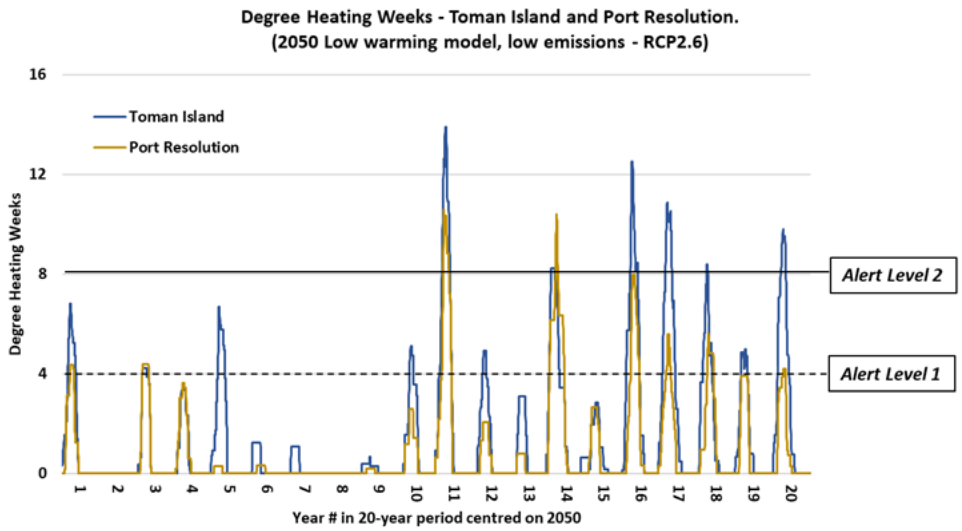


Figure 12 Regional variability of degree heating weeks (DHW) under warming. Timeseries of DHW (in °C-week) for a 20-year period centered on 2050 for 'low warming' (GISS-E2-R model, RCP2.6) for Toman Island, Malekula (blue), and Port Resolution, Tanna (brown). The horizontal lines show the risk limit: Alert Level 1, DHW >4 °C-week; significant coral bleaching is likely (dashed line) and Alert Level 2, DHW >8 °C-week; severe bleaching and significant coral mortality are likely (solid line). We assume no adaptation to thermal stress through the period. Method used here follows Langlais et al. 2017 [23]. Data source: OISST v2-1 SST [9].

This is important because, as an example, such assessments can inform adaptation planning, including opportunities for staged and prioritised management and protection of impacted reefs and other coastal resources around Vanuatu that are otherwise potentially facing severe impacts from projected changes in MHW climatology for Vanuatu over coming decades.

Climate Information Services developed by the Van-KIRAP project through the Vanuatu Climate Futures Portal are designed to facilitate such assessments and the application of the science-based evidence to inform decision making in order to build resilience to climate change in Vanuatu.

Also see Coral bleaching infobyte.

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Annex Y

LETTER

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Committed emissions from existing energy infrastructure jeopardize 1.5 °C climate target

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Net anthropogenic emissions of carbon dioxide (CO_2) must approach zero by mid-century (2050) in order to stabilize the global mean temperature at the level targeted by international efforts[1–5]. Yet continued expansion of fossil-fuel-burning energy infrastructure implies already 'committed' future CO_2 emissions[6–13]. Here we use detailed datasets of existing fossil-fuel energy infrastructure in 2018 to estimate regional and sectoral patterns of committed CO_2 emissions, the sensitivity of such emissions to assumed operating lifetimes and schedules, and the economic value of the associated infrastructure. We estimate that, if operated as historically, existing infrastructure will cumulatively emit about 658 gigatonnes of CO_2 (with a range of 226 to 1,479 gigatonnes CO_2, depending on the lifetimes and utilization rates assumed). More than half of these emissions are predicted to come from the electricity sector; infrastructure in China, the USA and the 28 member states of the European Union represents approximately 41 per cent, 9 per cent and 7 per cent of the total, respectively. If built, proposed power plants (planned, permitted or under construction) would emit roughly an extra 188 (range 37–427) gigatonnes CO_2. Committed emissions from existing and proposed energy infrastructure (about 846 gigatonnes CO_2) thus represent more than the entire carbon budget that remains if mean warming is to be limited to 1.5 degrees Celsius (°C) with a probability of 66 to 50 per cent (420–580 gigatonnes CO_2)[5], and perhaps two-thirds of the remaining carbon budget if mean warming is to be limited to less than 2 °C (1,170–1,500 gigatonnes CO_2)[5]. The remaining carbon budget estimates are varied and nuanced[14,15], and depend on the climate target and the availability of large-scale negative emissions[16]. Nevertheless, our estimates suggest that little or no new CO_2-emitting infrastructure can be commissioned, and that existing infrastructure may need to be retired early (or be retrofitted with carbon capture and storage technology) in order to meet the Paris Agreement climate goals[17]. Given the asset value per tonne of committed emissions, we suggest that the most cost-effective premature infrastructure retirements will be in the electricity and industry sectors, if non-emitting alternatives are available and affordable[4,18].

International efforts to limit the increase in global mean temperature to well below 2 °C, and to 'pursue efforts' to avoid a 1.5 °C increase, entail a transition to energy systems with net-zero emissions by mid-century[1–5]. Yet recent decades have witnessed an unprecedented expansion of historically long-lived, fossil-fuel-based energy infrastructure—particularly associated with the rapid economic development and industrialization of emerging markets such as China and India[9,10]—and a shift towards natural-gas-fired power plants in the USA. Although existing infrastructure are shown with darker shading, and emissions from proposed power plants (that is, electricity) are more lightly shaded. Numbers within graphs show total amounts of emissions over the period shown.

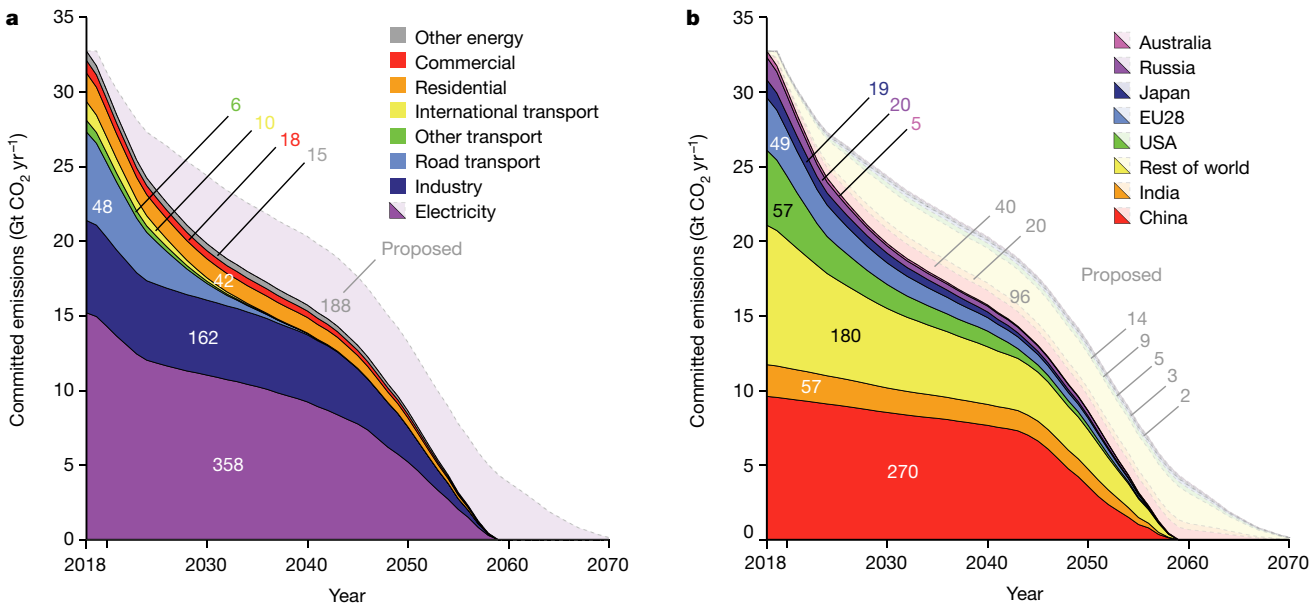


Fig. 1 | Committed annual CO_2 emissions from existing and proposed energy infrastructure. a, **b**, Estimates of future CO_2 emissions by industry sector (**a**; see also Supplementary Tables 1, 2) and country/region (**b**), assuming historical lifetimes and utilization rates. Emissions from

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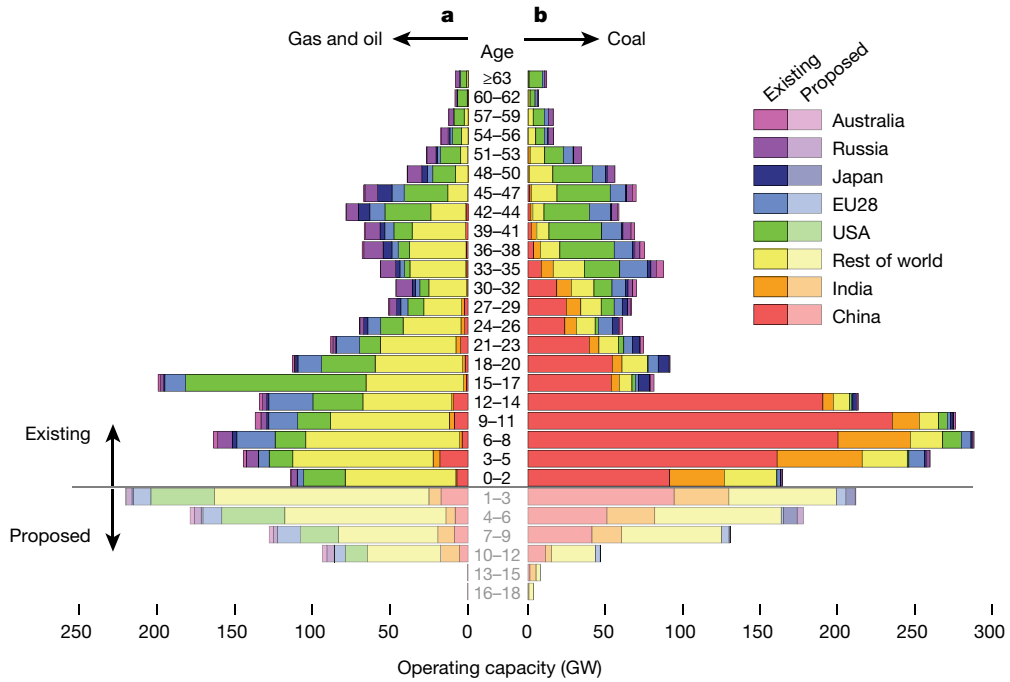


Fig. 2 | Age structure of global electricity-generating capacity. a, **b**, The operating capacity of gas- and oil-fired electricity-generating power units (**a**) and coal-fired units (**b**). The youngest existing units are shown at the bottom of the 'existing' section. The more lightly shaded bars underneath show proposed electricity-generating units according to the year (from now) that they are expected to be commissioned. The recent trends in Chinese and Indian coal-fired units (red and orange at the lower right) and US gas-fired units (green at the left) are easily apparent. '0 years old' means that the power units began operating in 2018.

such expansion may be slowing[19,20], substantial new electricity-generating capacity is proposed—and in many cases is already under construction[12]. Consequently, there is a tension between dwindling carbon-emissions budgets and future CO_2 emissions that are locked-in or 'committed' by existing and proposed energy infrastructure[6,21,22].

A 2010 study estimated that operating fossil-fuel energy infrastructure would emit roughly 500 Gt CO_2 over its lifetime[8]. Subsequent studies estimated that existing power plants alone committed around 300 Gt CO_2 as of 2012 (ref. [9]) and 2016 (ref. [12]), and that existing and proposed coal-fired power plants represented 340 Gt CO_2 as of 2016 (ref. [11]; Extended Data Table 1). Other studies have used integrated assessment models (IAMs) to assess the economic costs of 'unlocking' emissions under stringent climate goals[23,24], and to identify 'points of no return' past which no new infrastructure can be built without exceeding the 2 °C target[25]. Most recently, the potential climate responses to committed emissions were explored[13], using a reduced-complexity climate model and an idealized phase-out of fossil infrastructure to argue that aggressive mitigation of non-CO_2 forcing could yet limit global warming to 1.5 °C. However, it has been nearly a decade since a comprehensive bottom-up assessment of fossil infrastructure and committed emissions was made, during which years China's economy has grown tremendously, there has been a global financial crisis and a natural gas boom in the USA, and the Paris Agreement was ratified and entered into force. Substantial new fossil-fuel energy infrastructure has been commissioned over this period, proposals of new power plants have waxed and waned, and climate-mitigation efforts have grown more ambitious in many countries.

Here we present region- and sector-specific estimates of future CO_2 emissions related to fossil-fuel-burning infrastructure existing and power plants proposed as of the end of 2018, as well as the sensitivity of such estimates to assumed lifetime and utilization rates, and the economic value of associated energy assets. Our analyses are based upon a compilation of the most detailed and up-to-date datasets for energy infrastructure available (see Methods). Our central estimates assume historical lifetimes (for example, 40 years for power plants and industrial boilers and 15 years for light-duty vehicles) and utilization rates (for example, region- and fuel-specific power-plant capacity factors and region-specific averages of vehicle fuel economy and annual kilometres travelled).

Figure 1 shows future CO_2 emissions from existing and proposed energy and transportation infrastructure by sector (Fig. 1a) and country/region (Fig. 1b). We estimate that cumulative emissions by existing infrastructure, if operated as historically, will be 658 Gt CO_2. Of this total commitment, 54% or 358 Gt CO_2 is anticipated to come from existing electricity infrastructure (mainly power plants), reflecting the large share of annual emissions from electricity infrastructure (46% in 2018) and the long historical lifetimes of the infrastructure. Another 25% of the total, or 162 Gt CO_2, is related to industrial infrastructure, and 10% or 64 Gt CO_2 is related to the transportation sector (mainly on-road vehicles; Fig. 1a). This difference reveals the effect of infrastructure lifetimes: although industry and road-transportation sectors have similar annual CO_2 emissions (6.2 Gt and 5.9 Gt CO_2, respectively, in 2018), vehicle lifetimes are roughly a third as long as that of industrial capital. Finally, existing residential and commercial infrastructure represents respectively 42 Gt and 18 Gt CO_2 of committed emissions.

Global committed emissions are now at the apex of a 20-year trend. From 2002 to 2014, as China emerged as a global economic power, total committed emissions grew at an average annual rate of 9% per year (Extended Data Fig. 1a). Meanwhile, committed emissions related to infrastructure in the USA and the 28 member states of the European Union (EU28) have been shrinking since 2006 (Extended Data Fig. 1c). Since 2014, the rate of infrastructure expansion in China and India has also fallen, and committed emissions in China declined by 7% between 2014 and 2018, even as committed emissions in the rest of the world have continued to climb (Extended Data Fig. 1a, c). These most recent trends may reflect nascent shifts in China's economic structure[19] and global trade[20], and may be important harbingers of future changes in regional annual CO_2 emissions[9].

Figure 2 shows the age distribution of electricity-generating units worldwide. Overall, the youth of fossil-based generating units worldwide is striking: worldwide, 49% of the capacity now in operation was

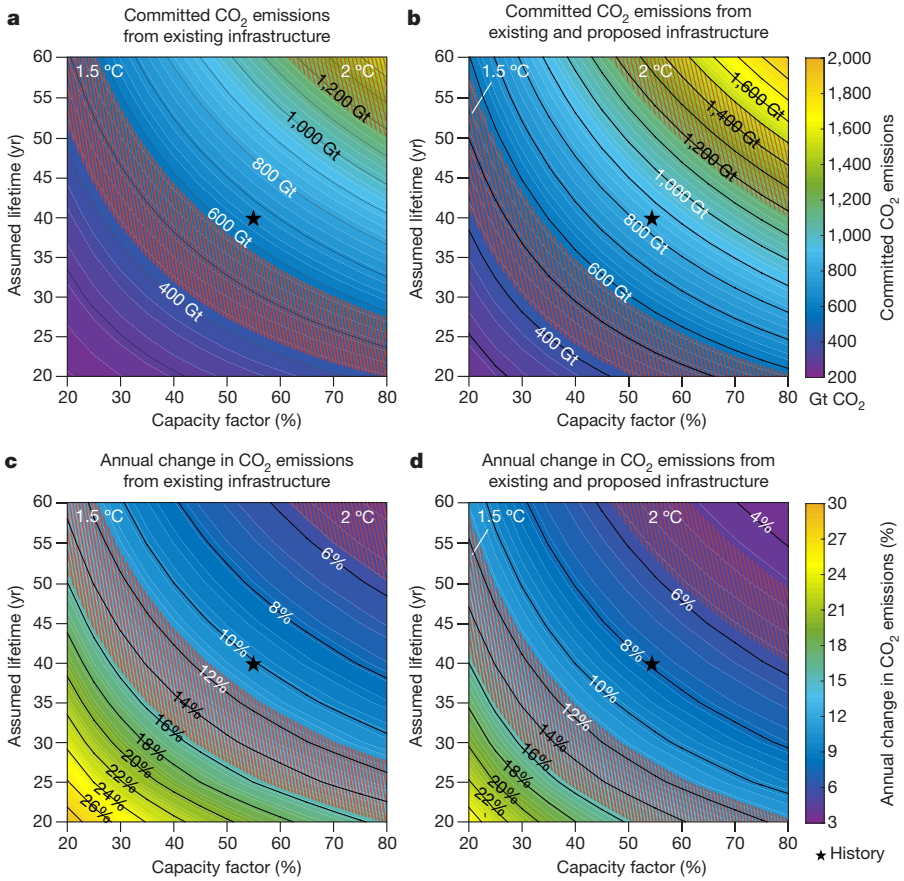


Fig. 3 | Sensitivity of committed emissions and mitigation rates to utilization rates and assumed lifetimes. a, **b**, Committed CO_2 emissions. Contours show estimates of committed CO_2 emissions related to existing infrastructure (**a**) and existing infrastructure plus proposed power plants (**b**) when the assumed lifetimes and utilization rates of electricity and industry infrastructure are varied from 20 years to 60 years (vertical axes) and from 20% to 80% (horizontal axes). **c**, **d**, Committed mitigation rates. For the same ranges of lifetime and utilization as in panels **a**, **b**, the annual rates of emission reduction span from 3% to 30% (**c**, **d**). Hatched orange and red zones indicate carbon budgets and mitigation rates that are likely to limit mean warming to 1.5 °C and 2 °C, respectively (see Methods), and stars denote committed emissions and mitigation rates if existing/and proposed infrastructure is operated as historically.

commissioned after 2004; in China and India, the post-2004 capacity is 79% and 69%, respectively. The average age of coal-fired power plants operating in China and India (11.1 and 12.2 years, respectively) is thus much lower than in the USA and EU28 (39.6 and 32.8 years, respectively; Fig. 2b), with correspondingly longer remaining lifetimes. The predominance of young Chinese infrastructure (which extends to the industrial and transportation sectors; Extended Data Figs. 2, 3) reflects the scale and speed of the country's industrialization and urbanization since the turn of the century. As a result, infrastructural inertia is greatest in China, accounting for 41% of all committed emissions (270 Gt CO_2; Fig. 1b). By comparison, infrastructure in India, the USA and the EU28 represents much smaller commitments: 57 Gt, 57 Gt and 49 Gt CO_2, respectively (Fig. 1b, Supplementary Table 1).

In addition to existing infrastructure, new power plants are being planned, permitted or constructed, and the committed emissions related to such proposed plants can be estimated[11,12]. As of the end of 2018, the best available data showed that 579 gigawatts (GW), 583 GW and 40 GW of coal-, gas- and oil-fired generating capacity respectively was proposed to be built over the next few years (some 20% of it in China; Fig. 2). If built and operated as historically, this proposed capacity would represent an additional 188 Gt CO_2 committed: 97 Gt CO_2 from coal-fired and 91 Gt CO_2 from gas-, oil- and other-fuel-fired generating units (Supplementary Table 2).

Together, committed emissions from existing infrastructure and proposed power plants total 846 Gt CO_2 if all proposed plants are built and all infrastructure is operated as historically (Fig. 1).

Existing electricity and industry infrastructure accounts for 79% of total committed emissions if operated as historically (that is, with a 40-year lifetime and 53% utilization rate; Fig. 1a). However, the lifetime and operation of such infrastructure will ultimately depend on the relative costs of competing technologies, which are in turn influenced by factors such as technological progress and the climate and energy policies in each region[22,26]. Figure 3 highlights the sensitivity of committed emissions (Fig. 3a, b) and the rate of annual emissions reductions (Fig. 3c, d; see Methods) with respect to assumed lifetimes and utilization rates (that is, the capacity factors) of industry and electricity infrastructure (note that the lifetimes and operation of infrastructure in other sectors do not vary from historical averages), with the star in each panel indicating historical average values. For example, total committed emissions related to existing infrastructure decrease to around 200 Gt CO_2 if lifetimes are 20 years and capacity factors are 20%, but increase to almost 1,500 Gt CO_2 if lifetimes and capacity factors are respectively 60 years and 80% (Fig. 3a). These ranges of lifetimes and utilization are quite wide, at the low end probably exceeding economic feasibility for recouping capital investments and covering fixed operating and maintenance costs. When proposed power plants are included, total committed emissions over the same range of lifetimes and capacity factors increase to 263–1,906 Gt CO_2 (Fig. 3b). Maintaining historical capacity factors, a 5-year difference in the lifetime of existing infrastructure represents roughly 70–100 Gt of future CO_2 emissions (Fig. 3a), or about 90–130 Gt if proposed power plants are included (Fig. 3b). Maintaining historical lifetimes and changing the assumed capacity factor by a comparable 9% (for example, from 46% to 55%) results in roughly the same changes in committed emissions, suggesting that these factors have a similar influence.

For comparison, the hatched red and orange zones in Fig. 3a, b show the Intergovernmental Panel on Climate Change (IPCC)'s most recent estimated ranges of remaining cumulative carbon budgets that span the 66%–50% probabilities of limiting global warming to 1.5 °C and 2 °C, relative to the preindustrial era[5]. Excluding proposed power plants, our central estimate of committed emissions (658 Gt CO_2; star in Fig. 3a) exceeds the range of the remaining 1.5 °C budget (420–580 Gt CO_2)[5]. When proposed plants are included, our estimate of committed emissions (846 Gt CO_2; star in Fig. 3b) is two-thirds of the lower estimates of the 2 °C budgets (1,170–1,500 Gt CO_2)[5]. This suggests that, unless compensated by negative-emissions technologies or by retrofitting with carbon capture and storage, 1.5 °C carbon budgets allow for no new emitting infrastructure and require substantial changes to the lifetime

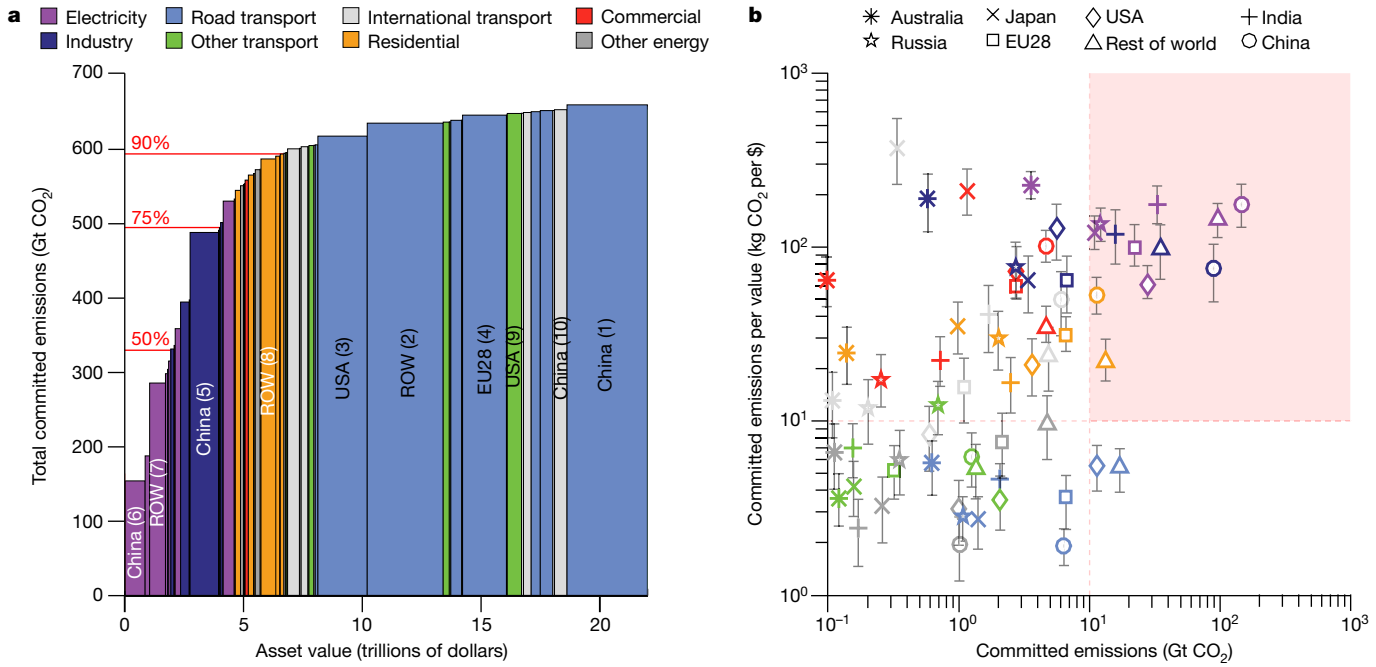


Fig. 4 | Asset value and committed emissions of existing infrastructure. **a**, Rank ordering of CO_2-emitting assets by committed emissions per dollar value reveals large disparities (coloured by sector). The horizontal red lines indicate 50%, 75% and 90% of total committed emissions (658 Gt CO_2) if operated as historically, and the top ten most valuable region sectors are labelled (see Extended Data Fig. 4 for region-specific versions). ROW, rest of world. **b**, Plotting emissions per value (in kilograms of CO_2 per US dollar) against committed emissions suggests targeted opportunities to 'unlock' future CO_2 emissions if alternative technologies become affordable (region sectors in the pink-shaded quadrant). Error bars denote 95% confidence intervals.

or operation of existing energy infrastructure (for example, decreasing lifetimes to less than 25 years or capacity factors to less than 30%; Fig. 3a). Moreover, CO_2 emissions related to the extraction and transport of fossil fuels[27], as well as non-energy CO_2 emissions (for example, resulting from land-use change)[28], are not included in our estimates and will further reduce the remaining carbon budgets.

Climate targets have sometimes been contextualized by the annual rate of emissions reduction they imply. For example, it has been shown[29] that, as of 2013, the cumulative carbon budgets likely to avoid 2 °C of mean warming imply necessary average annual reductions in global CO_2 emissions (that is, mitigation rates) of roughly 6% per year. The hatched areas in Fig. 3c, d show that such mitigation rates, recalculated from the latest carbon budgets, are about 5% per year for the 2 °C budgets (4.5–5.7%) and about 13% per year for the 1.5 °C budgets (11.4–15.7%). By comparison, the contours in the figure show mitigation rates if no new emitting infrastructure is commissioned (10.1%; star in Fig. 3c), or if only already-proposed power plants but no other emitting infrastructure is commissioned (7.9%; star in Fig. 3d). Again, the international targets leave little or no room for new infrastructure if existing plants operate as they have historically (stars), unless fully compensated by negative emissions or retrofitted with carbon capture and storage technology.

Given the constraints of 1.5 °C and 2 °C carbon budgets, we also explore the economic value of existing infrastructure relative to its associated committed emissions. Figure 4a highlights the disproportionality of committed emissions per unit asset value. Together, power and industry infrastructure (purple and dark blue, respectively, in Fig. 4a) represent more than 75% of total committed emissions (519 Gt of 658 Gt CO_2), but less than 25% of the estimated economic value of CO_2-emitting energy infrastructure (roughly US $5 trillion of US $22 trillion; Extended Data Fig. 4 and Supplementary Table 3; see Methods for details of how asset values were amortized). By contrast, transportation infrastructure, with shorter average lifetimes but high capacity costs and a vast number of discrete units, represents roughly two-thirds of the value of emitting assets and less than 10% of committed emissions (Fig. 4a). This analysis suggests that efforts to reduce committed emissions might cost-effectively target the early retirement of electricity and industry infrastructure—despite their often powerful influence on policy and institutions[6,21,22]—if non-emitting alternative technologies are affordable: the magnitude of commitments in these sectors is large and a single dollar of asset value is related to more than 10 kg of future CO_2 emissions (Fig. 4b, red rectangle). Industry and electricity sectors in China represent especially prime targets for unlocking future emissions: nearly half (46%) of these sectors' global committed emissions are associated with Chinese infrastructure (Fig. 4a).

Detailed and up-to-date analysis of existing and proposed CO_2-emitting energy infrastructure worldwide reveals incredibly tight constraints for present international climate targets, even if no new emitting infrastructure is ever built. Although climate and energy analysts have emphasized that avoiding, for example, 1.5 °C of warming remains "technically possible"[5], our results lend vivid context to that possibility: we would have a reasonable chance of achieving the 1.5 °C target with, first, a global prohibition of all new CO_2-emitting devices (including many or most of the already-proposed fossil-fuel-burning power plants); and second, substantial reductions in the historical lifetimes and/or utilization rates of existing industry and electricity infrastructure.

Barring such radical changes, the global climate goals adopted in the Paris Agreement are already in jeopardy and may be contingent upon widespread retrofitting of existing emitting infrastructure with carbon capture and storage technologies (which would be tremendously expensive[30]), large-scale deployment of negative emissions technologies[16], and/or solar-radiation management[4]. On the other hand, our results suggest that the precise level of future warming in excess of the Paris targets depends largely on infrastructure that has not yet been built (Extended Data Fig. 5).

Some important caveats and limitations apply to our findings. The trajectory of future emissions depicted in Fig. 1 represents a scenario in which existing (and proposed) emitting infrastructure 'ages out', and no new emitting infrastructure is ever commissioned. These constraints are not intended to be realistic; rather, they allow

us to isolate and quantify infrastructural—and related economic—lock-in of energy-related emissions[22]. Indeed, technological trends and climate-energy policies that encourage growth in renewable electricity (for example, solar and wind) may lead to early retirement of existing fossil-fuel power plants in some regions (although recent growth of renewable electricity generation has not always displaced fossil-fuel generation[18]). It is also instructive to compare our estimates of committed emissions with plausible energy-emissions scenarios generated by much more sophisticated (but less transparent) IAMs that calculate infrastructure lifetimes and capacity factors endogenously. For example, a recent IAM study of 1.5 °C scenarios found that large-scale CO_2 removal may be necessary to compensate for 'residual' emissions from long-lived and difficult-to-decarbonize sectors of the energy system (for example, freight, aviation and shipping[4])[31].

The size of carbon budgets associated with a given temperature target is also a complicated matter that is sensitive to a host of factors, such as climate sensitivity and non-CO_2 emissions[14,15]. The budgets from the recent IPCC special report[5] are estimates of cumulative net global anthropogenic CO_2 emissions from the start of 2018 until net-zero global CO_2 emissions are achieved (that is, climate is stabilized) with a 66%–50% probability of limiting an increase in mean near-surface air temperatures to 1.5 °C or 2 °C, with limited (less than 0.1 °C) or no overshoot (see Methods for further discussion).

Although ambitious climate targets such as 1.5 °C may help to motivate and accelerate the transition towards net-zero energy systems, their feasibility is often evaluated by the existence of consistent scenarios from IAMs. However, these models have been used to analyse a very large possibility space, and some scenarios may thus reflect aspirational trajectories of energy demand or technological progress and scale whose likelihood may be difficult to evaluate[32,33]. Our data-driven assessment of existing, operating and valuable energy infrastructure may therefore help to elucidate the infrastructural and economic implications of such targets, and also help to identify targeted regional and sectoral opportunities for unlocking future CO_2 emissions.

Online content

Any methods, additional references, Nature Research reporting summaries, source data, statements of code and data availability and associated accession codes are available at https://doi.org/10.1038/s41586-019-1364-3.

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Competing interests The authors declare no competing interests.

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METHODS

Committed emissions from existing and proposed infrastructure. We extend the approach of ref. [9] to quantify the committed emissions from existing energy infrastructure by integrating more-detailed and up-to-date available data on energy infrastructure, including country- and duty-specific vehicle sales data, and unit-level details on global power plants and Chinese cement kilns and blast furnaces[10,34–39]. We also estimate committed emissions from proposed power plants by collecting information on all proposed power generators from the latest available databases[34,37], in recognition of substantial changes in the pipeline of planned power plants (especially coal) in recent years[34]. Energy infrastructure as quantified in this study is categorized into eight sectors: (1) electricity, (2) industry, (3) road transport, (4) other transport, (5) international transport, (6) residential, (7) commercial and (8) other energy infrastructure (see Supplementary Tables 4 and 5).

Electricity infrastructure. Emissions from electricity infrastructure in this study include all emissions under category 1A1 of the IPCC's revised guidelines[40]. Electricity infrastructure here mainly includes main activity electricity and heat production (1A1a) and petroleum refining (1A1b), as well as the manufacturing of solid fuels and other energy industries (1A1c) (Supplementary Table 5).

Emissions intensities of electricity infrastructure. Previously, we built and published a comprehensive global thermal power plants database (named the Global Power Emissions Database, or GPED) of the year 2010 by integrating high-quality national databases (from China, India and the USA)[10]. Here we update the GPED database to the year 2018 (named GPED-2018) using the latest power plant database from China (CPED)[36] and the Platts World Electric Power Plant (WEPP) database for other regions[37], including all retired and operating units through to the end of 2018. We obtain data and estimates of unit-based CO_2 emission intensity (that is, grams CO_2 per kilowatt-hour) for all units that were operating in 2010 from GPED. For units retired before 2010 or commissioned since 2010, we estimate unit-level CO_2 emission intensity by the methods of ref. [9] on the basis of the Carbon Monitoring for Action (CARMA) database[35] (for older units), or else use national or regional average CO_2 emission intensity for units with the same fuel type and similar nameplate capacity. As prior studies have done, we assume these emissions intensities are constant over a unit's lifetime[8,9].

Assumed lifetime of electricity infrastructure. In the resulting GPED-2018, the global average lifetimes of retired coal-, natural-gas- and oil-fired power units are 35.9, 37.1 and 33.9 years, respectively. Consistent with ref. [9], we simplify these ranges to a single reference lifetime of 40 years for all electricity-generating units for our 'as historically' case, and show the sensitivity of committed emissions to this assumption in Fig. 3. When units are already operating beyond their assumed lifetime, we randomly retire them over the next five years in order to avoid unrealistically abrupt changes in emissions between 2018 and 2019.

In addition, we assume that the age structure and lifetime of autoproducers (industrial and commercial facilities that generate their own electricity on-site)[40] and other energy industries are similar to the main-activity power plants in each region. Therefore, committed emissions from existing electricity infrastructure are quantified by using the survival curves derived from main-activity power plants, scaled to include these other types of electricity infrastructure by using country-level electricity emissions totals in 2018 from the International Energy Agency (IEA). Note that, because of data availability[41], we derived the country-level CO_2 emissions from fossil-fuel combustions for 2018 by multiplying country-level CO_2 emissions in 2016 by projected change rates during 2016–2018.

Finally, we quantify cumulative future CO_2 emissions from proposed power plants by the same procedure (assuming historical average unitization rates and lifetimes), using a database of proposed coal-fired units that has been developed by CoalSwarm[34] and the planned units fired with other fossil fuels from the 2018 (fourth quarter) WEPP database[37].

Industry infrastructure. Industrial emissions in this study include all emissions under category 1A2 of the IPCC's revised guidelines[40]. For all countries but China, we estimate cumulative future emissions from industry infrastructure by using country-level emissions data for the year 2018 obtained from the IEA, assuming that the age distribution and survival curves of each region's industry infrastructure are consistent with its electricity infrastructure. To derive China's industrial survival curves, we use unit-level details of cement kilns and blast furnaces (iron and steel) that are currently operating in China (Extended Data Fig. 2), obtained from China's Ministry of Ecology and Environment (MEE) (our unpublished data, referred to hereafter as the MEE database).

Our detailed data on Chinese infrastructure represent an important improvement over prior estimates of committed emissions, as China alone accounts for roughly 47% of total industrial emissions[41]. In particular, the iron/steel and non-metallic minerals (for example, cement and glass) industries account for about 50% of all industrial CO_2 emissions in recent years[41], and China produced 49.6% of the world's raw steel and 57.3% of the world's cement in 2016 (ref. [42]). The unit-level data on China's industrial infrastructure thus substantially decrease the uncertainty of committed industry emissions, by alleviating the need for assumptions related to almost half of global industry infrastructure (that is, 9.0% of global CO_2 emissions from all sources[41]). Moreover, we observe that the age distributions of electricity and industry infrastructure in China are quite similar (Extended Data Fig. 6), which lends support to our assumption that this is the case in other regions for which we lack detailed data on industrial infrastructure.

Transportation infrastructure. Transport emissions in this study include all emissions under category 1A3 of the IPCC's revised guidelines[40], which includes emissions from road transport, other transport and international transport (Supplementary Tables 4, 5).

We calculated cumulative future emissions from road transport following the approach in ref. [8] and further updating the activity rates with updated country-, region- and duty-specific vehicle sales data[38,39] (that is, 18% of global CO_2 emissions from all sources[41]). Specifically, we use the number, class and vintage of motor vehicles sold during 1977–2017 from 40 major countries and regions[38,39] (information for 2018 was derived by projecting 2016–2017 rates of change one additional year; Extended Data Fig. 3). Owing to data availability, we estimate the number of vehicles remaining on the road over time by using class and model year-specific survival rates of US and Chinese vehicles to represent developed (the USA) and developing (China) countries or regions[43,44]. We then calculate annual vehicle emissions by using the average miles driven per year (MPY) per vehicle by class, and carbon emission factors of 10.23 kg and 11.80 kg CO_2 per gallon of gas and diesel, respectively, and scale our estimated emissions to match country-level road-transport emissions in 2018 as reported by the IEA[41].

'Other transportation' infrastructure includes existing aviation, rail, pipeline, navigation and other non-specified transport. International transport infrastructure includes international marine bunkers and international aviation bunkers (Supplementary Table 4). Again, we follow ref. [8], estimating cumulative future CO_2 emissions from existing other and international transport by using country-level emissions data for 2018 from IEA, and assuming lifetimes and age distributions similar those of to motor vehicle fleets in each country/region.

Residential, commercial and other energy infrastructure. Residential and commercial emissions are included under category 1A4 of the IPCC's revised guidelines[40], and 'other energy' emissions include, for example, emissions from agriculture, forestry, fishing and aquaculture under category 1A4, as well as stationary, mobile and multilateral operations under category 1A5. We calculated cumulative future emissions from this infrastructure by using country-level emissions data for 2018 derived from the IEA[41], and assuming that age distributions and lifetimes of residential, commercial and other energy infrastructure in each region were similar to electricity infrastructure in the same region in the absence of better information.

The least-supported methodological assumptions that we make thus concern this residential, commercial and other energy infrastructure (representing around 10% of total fossil fuel CO_2 emissions in 2016; ref. [41]), where we lack any unit-level data. In order to test the sensitivity of total committed emissions from this infrastructure, we performed additional analyses of different assumed lifetimes. We found the committed emissions from residential, commercial and other energy infrastructure to be 29, 74 and 135 Gt CO_2 when lifetimes of respectively 20, 40 and 60 years are assumed (Extended Data Fig. 7). That is, our estimates of total committed emissions from all existing energy infrastructure decrease by 7% (to 613 Gt CO_2) if lifetimes of residential, commercial, and other energy infrastructure are assumed to be 20 years, and increase by 9% (to 719 Gt CO_2) if the lifetimes are assumed to be 60 years. In comparison with the carbon budgets associated with targets of 1.5 °C and 2 °C, these are relatively small effects, and not substantial enough to affect the main conclusions of our study.

Comparison of cumulative future emissions estimates. Other studies[8,9,11–13] have analysed committed emissions from various infrastructures in different ways, as mentioned in the text and summarized in Extended Data Table 1.

For example, refs [11,12] both reported committed emissions relating to existing and planned power plants using 2016 data. Although the latter analysed committed emissions from all fossil electricity infrastructure[12], the former focused particularly on coal-fired units[11]. Importantly, the 2018 data used herein reveal that substantial cancellations of proposed plants have occurred over the intervening two years: whereas the previous studies estimated that around 150 Gt CO_2 (ref. [11]) and 210 Gt CO_2 (ref. [12]) were committed by proposed coal plants, we estimate only around 100 Gt CO_2—that is, 50–100 Gt CO_2 less (or 10%–20% of the remaining carbon budget that is consistent with 1.5 °C warming). Moreover, our study contains more-detailed estimates of regional commitments and the sensitivity of these commitments to assumed lifetime and capacity factor.

Most recently, ref. [13] estimated the global warming related to committed emissions by using a reduced-complexity climate model (Finite Amplitude Impulse Response, or FaIR). Their study also included estimates of committed emissions from all sectors, but these relied on past estimates of the age distribution of fossil-fuel infrastructure and an idealized, linear phase-out of such infrastructure[13]. Because turnover of infrastructure has decreased the median

age of electricity-generating capacity in many regions (Fig. 2), our estimates of electric power sector commitments (358 Gt CO_2) are about 13 Gt CO_2 greater than those used in ref. [13] (345 Gt CO_2). Our data-driven approach also permits region-specific results, analysis of the trend in commitments over time, inclusion of proposed power plants, and an assessment of the economic value of underlying infrastructures. Yet, because the estimates of CO_2 emissions committed by other infrastructure in ref. [13] are larger than our bottom-up estimates (Extended Data Table 1), the overall estimate reached by their idealized approach (715 Gt CO_2) is nonetheless similar to ours (658 Gt CO_2).

The authors of ref. [13] assess global climate responses to committed CO_2 increases and conclude that the world is not yet committed to a 1.5 °C warming. However, it is difficult to directly compare the magnitude of the CO_2 emissions in the phase-out scenarios of ref. [13] with the 1.5 °C carbon budgets in the IPCC's special report[5] (SR1.5), for two reasons. First, although SR1.5 also used the FaIR model in its procedure for evaluating non-CO_2 forcing, it did not use the FaIR model's transient climate response to cumulative emissions (TCRE), which is smaller and would have led to considerably larger carbon budgets. Second, the mitigation scenarios evaluated ref. [13] also assumed that non-CO_2 emissions are completely phased out in parallel to CO_2 emissions, but the integrated assessment model scenarios on which SR1.5's non-CO_2 forcing (and carbon budgets) are based do not completely eliminate non-CO_2 emissions this century[45].

Variation in utilization rates and assumed lifetimes. As described above, cumulative future committed emissions from electricity and industry infrastructure depend on present utilization rates and assumed lifetimes. The longer the assumed lifetime and higher the utilization, the greater the estimate of committed emissions will be. Therefore, we test the sensitivity of committed emissions to assumed lifetimes and utilization rates of energy and industry infrastructure across lifetimes from 20 years to 60 years, and utilization rates of 20% to 80%.

Remaining carbon budgets to limit mean warming to 1.5 °C and 2 °C. As described in the text and discussed in recent literature, the size of carbon budgets associated with a given temperature target is a complicated matter that is sensitive to a host of factors[14,15], including: (1) whether the budget reflects cumulative net emissions until the temperature target is exceeded, or cumulative net emissions that limit the global temperature increase to below the target (that is, climate is stabilized); (2) whether there can be a temporary overshoot of the temperature target (and by how much)[46]; (3) the climate responses to CO_2 and non-CO_2 forcings[47]; (4) the magnitude and Earth-system response to negative emissions[48]; (5) how global temperature is calculated; (6) the pre-industrial baseline used[49]; (7) whether Earth-system feedbacks such as permafrost thawing are included[50–53]; and (8) future emissions of non-CO_2 greenhouse gases and aerosols[54,55].

The magnitude of non-CO_2 forcing is particularly relevant to assessments of committed emissions, because non-CO_2 forcing is inversely related to the remaining carbon budget[54,55], and because some non-CO_2 greenhouse gases and aerosols are directly related to the current energy system (for example, fugitive methane[56]) or are co-emitted with CO_2 by fossil-fuel-burning infrastructure. Other large sources of non-CO_2 gases and aerosols exist outside of the energy system, such as agriculture[57]. For the SR1.5 budgets[5], non-CO_2 forcing was estimated using integrated assessment model scenarios and a pair of reduced-complexity climate models (Model for the Assessment of Greenhouse-gas Induced Climate Change (MAGICC) and FaIR), with substantial uncertainties associated with both scenario variations (± 250 Gt CO_2) and climate responses (−400 Gt to 200 Gt CO_2) for the 1.5 °C budget. Non-CO_2 greenhouse gases and aerosols decline but do not reach zero in any of the scenarios assessed in the SR1.5 report. By contrast, ref. [13] modelled the complete phase-out of non-CO_2 emissions in parallel with energy-related CO_2 emissions—a formidable scenario that was found to have a high probability (64%) of limiting warming to 1.5 °C.

In this study, we compare our estimates of committed emissions to the SR1.5 budgets[5]. As defined in SR1.5, 'remaining' carbon budgets are the cumulative net global anthropogenic CO_2 emissions from a given start date (1 January 2018) to the year in which such emissions reach net zero that would result, at some probability, in limiting global warming to a given level[5]. By this definition, budgets are not simply cumulative emissions until the time at which mean temperature exceeds a given threshold[14], but rather what have been called 'threshold avoidance' or 'stabilization' budgets. The SR1.5 budgets were derived from the transient climate response to cumulative CO_2 emissions in climate model simulations that have been further adjusted to include additional climate forcing related to non-CO_2 greenhouse gases and aerosols[45]. They do not include Earth-system feedbacks (which SR1.5 suggests could reduce the remaining budgets by 100 Gt CO_2 over this century).

However, as remaining budgets associated with a mean surface warming of 1.5 °C dwindle, uncertainties in transient climate responses to CO_2 emissions[15,47] and the current and future non-CO_2 forcing loom large[53–55]. In order to make our results as useful, transparent and comparable as possible, we report positive, CO_2-only commitments from existing and proposed fossil-fuel-burning infrastructure, and compare these to the remaining (stabilization) carbon budgets reported by SR1.5 to give a 66%–50% probability of limiting warming to 1.5 °C and 2 °C with little (0.1 °C) or no overshoot: that is, 420–580 Gt CO_2 and 1,170–1,500 Gt CO_2, respectively (see table 2.2 in ref. [5]). Thus, if not offset by negative emissions, the total committed emissions that we estimate if existing infrastructure operates as it has historically (that is, 658 Gt CO_2) would make it likely that global temperatures will exceed 1.5 °C unless the remaining carbon budgets in SR1.5 are substantially wrong. For example, the climate response to CO_2 could be less than expected on the basis of the climate model simulations assessed in SR1.5, and/or non-CO_2 forcing in the future could be much less than it is on average in the integrated assessment model scenarios that were assessed by SR1.5. Indeed, ref. [13] analysed a future in which both are true.

Estimates of the annual rate of emission reductions. We estimate annual rates of emissions reduction ('mitigation rates') following ref. [29]:

$$f(t) = f_0(1 + (r+m)t)\exp(-mt)$$

where $f(t)$ is the emissions at time t; f_0 is the emissions at the start of mitigation ($t = 0$); r is an initially linear growth rate; m is the annual rate of emission reductions; and r and m both have units of 'per year'. We calculate the annual rate of emission reductions needed to meet a quota, q, from $t = 0$ onward (with emission time $T = q/f_0$) as:

$$m(q) = \frac{1+\sqrt{1+\frac{rq}{f_0}}}{\frac{q}{f_0}} = \frac{1+\sqrt{1+\frac{r}{T}}}{T}$$

We use initial emissions, f_0, at 2018 (32.7 Gt) and growth rates, r, averaged over 2013–2018 (0.028%) (obtained from the IEA[41]) to estimate mitigation rates under different cumulative CO_2 emissions, which we assumed to be equivalent to the carbon quota, q.

Estimates of asset value from existing infrastructure. We estimate the asset value by sector and by country/region using the following equation:

$$\mathrm{AV}_{i,s} = \sum_{n=\mathrm{PY}-\mathrm{LT}}^{\mathrm{PY}} \sum_{y} \{\mathrm{TC}_{i,s,n,y} \times \mathrm{CC}_{i,s,n,y} \times [(1-\mathrm{RV}) \times \mathrm{DR}_{i,s,n,y} + \mathrm{RV}]\}$$

where i, s, n and y represent the country/region, sector, years and combustion/production technology, respectively; AV is the asset value; TC is the equivalent total capacity/numbers; CC is the capital costs; RV is the ratio of residual value, with 5% applied for all infrastructure; DR is the depreciation rate; PY is the present year (2018 in this study); and LT is lifetime.

We adopt a sector-dependent method, and apply straight-line and geometric models for different infrastructures, as in Supplementary Table 6. We collected data on capital costs used to estimate asset values from previous literature[12,21,23–25,58,59] and various reports[60–64]. Wherever possible, we use interannual and national average capital costs for different combustion/production technologies and equipment. Where interannual and national averages are not available, we instead use an average for all of the countries in the same region for which capital cost data are available.

Electricity infrastructure. We estimate the total value of fossil-fuel-based electricity-generating assets according to each unit's power-generating capacity (in kilowatts) and age, as well as fuel- and technology-specific capital costs (in dollars per kilowatt).

The assumed lifetime of coal power plants is 40 years. Although plants can operate for considerably longer periods, shutting down a plant after its assumed lifetime will not result in any stranded capital investment, since the initial capital cost will have been fully paid[24]. Thus, our estimates only include the asset value of operating electricity-generating units that are now less than 40 years old. Unit-level details of electricity-generating technologies were obtained from the GPED-2018 database.

In addition, part of the committed CO_2 emissions in electricity infrastructure is from heating plants. We have evaluated the asset value of combined heat and power (CHP) plants along with that of other power plants, but we estimate the asset value of individual heating plants separately, using IEA data on heating output (in terajoules, TJ)[65,66] to estimate the capacity of such heating plants and converting this to an equivalent power capacity (in GW) by assuming that they operate with the average utilization rates of power-generating units in the same region. Supplementary Table 6 summarizes our assumptions in estimating asset values for individual heating plants.

Industrial infrastructure. 'Industrial infrastructure' includes various facilities and systems from different subindustrial sectors (Supplementary Tables 4 and 5). Considering the difficulty of collecting the operating capacity for all of the subindustrial sectors, we estimate the value of industry infrastructure as the combined asset values of cement, iron and steel plants, and industrial boilers. As described above, we estimated the asset values for cement, iron and steel capacity that has

been operating less than 40 years only. We quantified asset values from the cement, iron and steel industries through total capacity and capital investment per unit (Supplementary Table 6).

We estimate total capacities (in tonnes per hour, t h^{-1}) of industrial boilers at country- or region-specific level by fuel type, using total energy consumptions obtained from the IEA[65,66]. We assume the utilization rates of industrial boilers to be the same as the average utilization rates of electricity infrastructure. The related assumptions are shown in Supplementary Table 6.

Transport infrastructure. We quantify the asset values from road transport, other transport and international transport separately. For road-transport infrastructure, we estimate asset value using the number of annual vehicle sales, annual average new car prices, and a depreciation-rate function. The data sources for the number of annual vehicle sales are described above, and we further collect annual average new car prices by vehicle type and country/region[39]. Because depreciation rates tend to be considerably lower in developing countries than in industrialized countries[67], we adopt different depreciation-rate functions for developing and developed countries[67].

For international-transport infrastructure, we estimate the value of international ships and international airplanes. Owing to limited data availability, we use the same approach as with heating infrastructure, basing our estimates on the total energy consumption (fuels) for international aviation and international navigation from the IEA, and converting to the number of reference narrow-body aircraft and standardized international freight ships by such fuel consumption. Specifically, we assume 2 million kilometres per year for each aircraft, and 149 megajoules per airplane kilometre, for reference narrow-body aircrafts[21] (Supplementary Table 6); and 940 million annual tonnes per kilometre, and an average ship energy intensity of 0.125 megjoules per tonne kilometre, for international freight ships[21]. We use the same total average depreciation rates for international transport as we do for road-transport infrastructure.

We use a similar approach for other transport (that is, domestic ships, domestic airplanes and non-specific transport), adopting the same assumptions applied for international transport for domestic ships and domestic airplanes. For non-specific transport, we quantify asset values by converting to the number of conventional diesel heavy-duty freight trucks. The corresponding assumptions are shown in Supplementary Table 6.

Residential, commercial and other energy infrastructure. We quantify the asset values of residential, commercial and other energy infrastructure separately using sector- and fuel-specific energy-consumption data from the IEA[65,66].

Residential and commercial infrastructure uses energy for space heating, heating water, and cooking. Other energy infrastructure includes uses of energy for agriculture, fishing and other activities. Given very limited data, we quantify the value of residential and commercial infrastructure by using an equivalent capacity of normalized space heating units, water-heating units and cooking equipment. For the 'other energy' infrastructure, we quantify the asset value by converting to normalized agriculture machines, fishing boats and boilers. We then apply the total average depreciation rates of electricity infrastructure to these residential, commercial and other energy infrastructures.

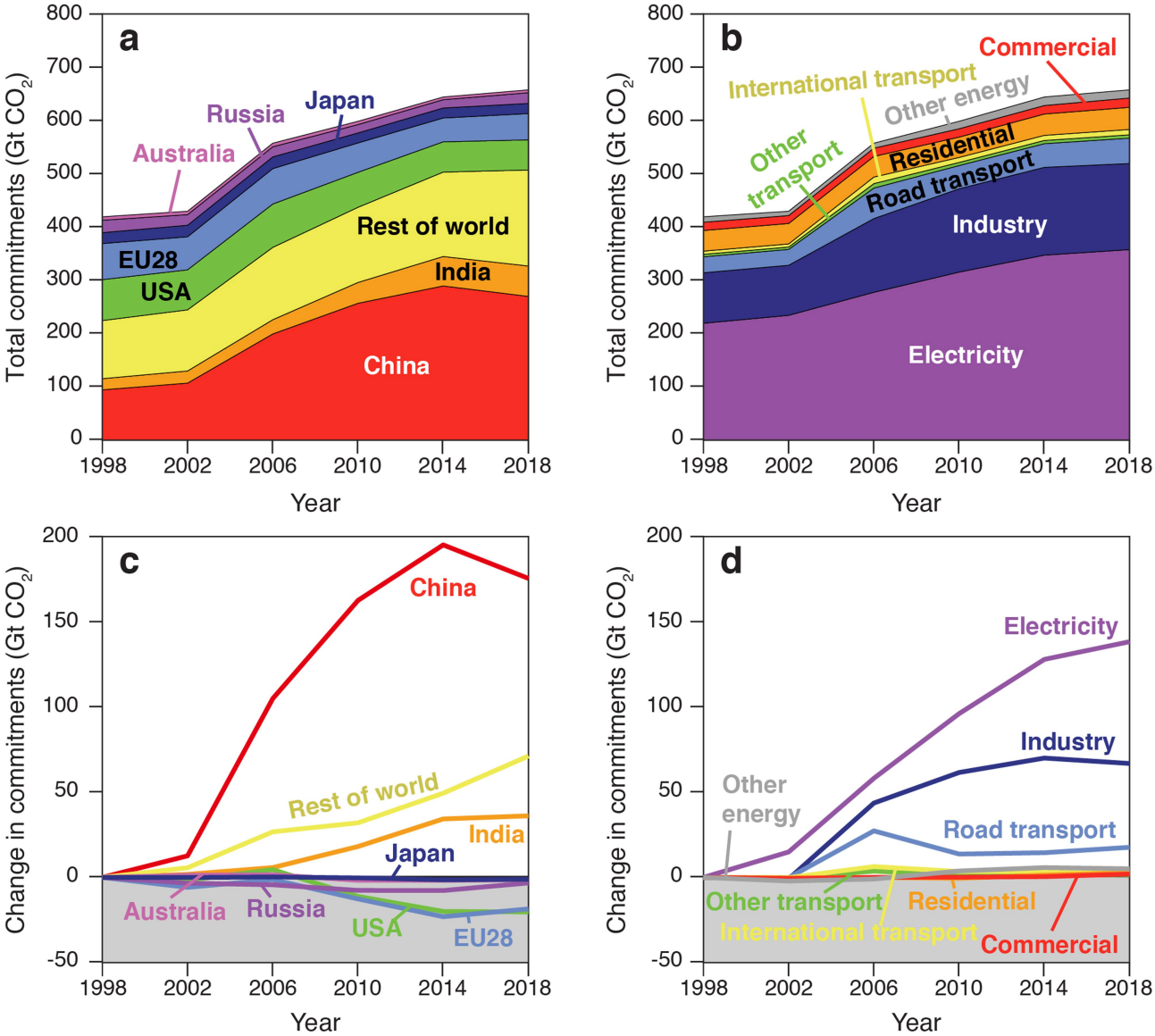
Uncertainty estimation. Our estimates of asset values are subject to uncertainty owing to incomplete knowledge of operating capacities, age structure and capital costs per unit. In order to more completely assess uncertainties in our results, we perform a Monte Carlo analysis of asset values by sector and by country/region, in which we vary key parameters according to published ranges[58,68,69] and collected capital costs data as above. The error bars in Fig. 4 depict the results of this analysis, showing the lower and upper bounds of a 95% confidence interval (CI) around our central estimate. The Monte Carlo simulation uses specified probability distributions for each input parameter (for example, capital cost per unit, and the ratio of residual value) to generate random variables[68]. The probability distribution of asset values is estimated according to a set of runs ($n = 10{,}000$) in a Monte Carlo framework with probability distributions of the input parameters. The ranges of sector and region parameter values vary in part because of the quality of their statistical infrastructures[69]. Supplementary Table 7 summarizes the probability distributions of the asset value estimation-related parameters.

Data availability

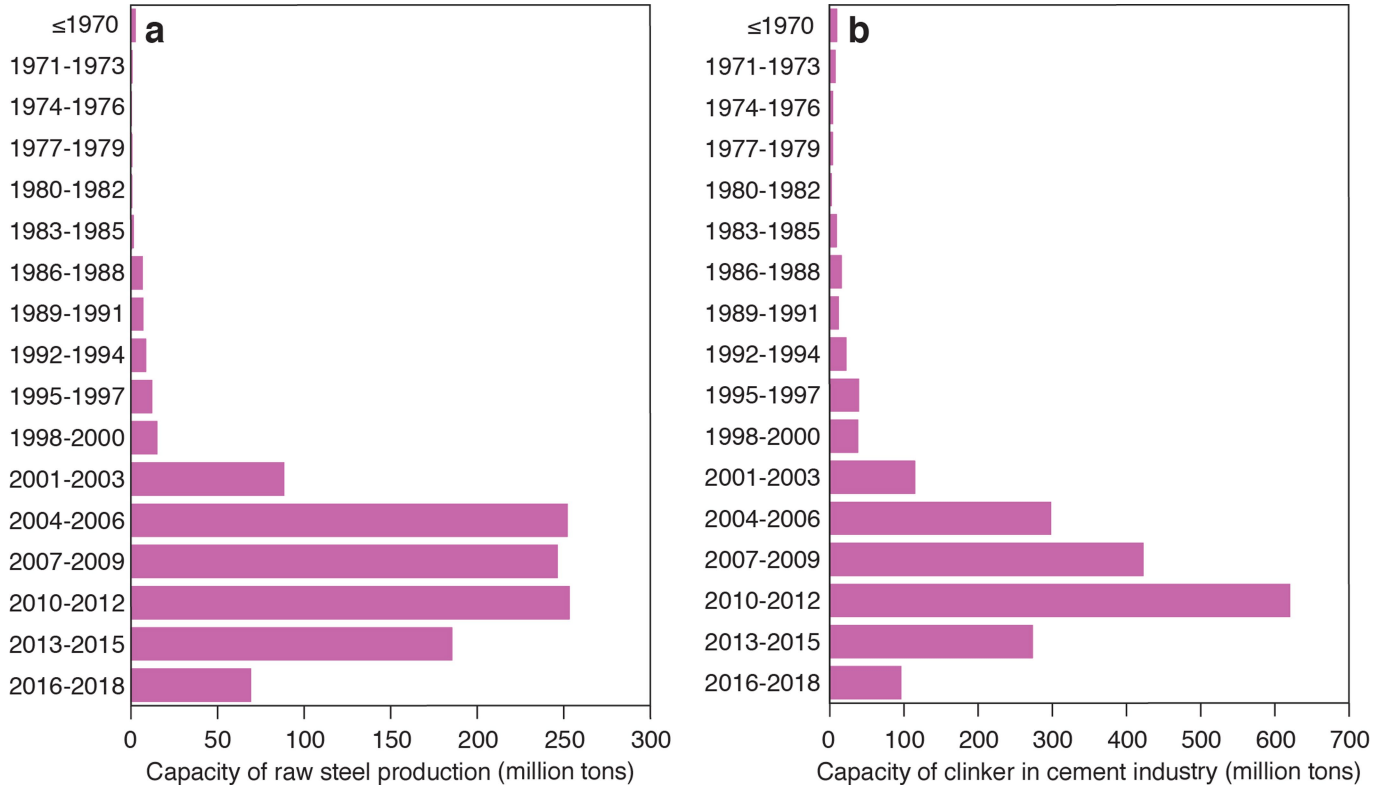
The numerical results plotted in Figs. 1–4 are provided with this paper. Our analysis relies on six different data sets, each used with permission and/or by license. Five are available from their original creators: (1) the GPED database: http://www.meicmodel.org/dataset-gped.html; (2) Platt's WEPP database: https://www.spglobal.com/platts/en/products-services/electric-power/world-electric-power-plants-database; (3) the Carbon Monitoring for Action (CARMA) database: http://carma.org/; (4) the CoalSwarm database: https://endcoal.org/tracker/; and (5) vehicle sales data: https://www.statista.com/markets/419/topic/487/vehicles-road-traffic/. The sixth data set includes unit-level data for Chinese iron, steel and cement infrastructure, which we obtained directly from the Chinese Ministry of Ecology and Environment. We do not have permission to share the raw data, but we provide it in an aggregated form (Extended Data Fig. 2).

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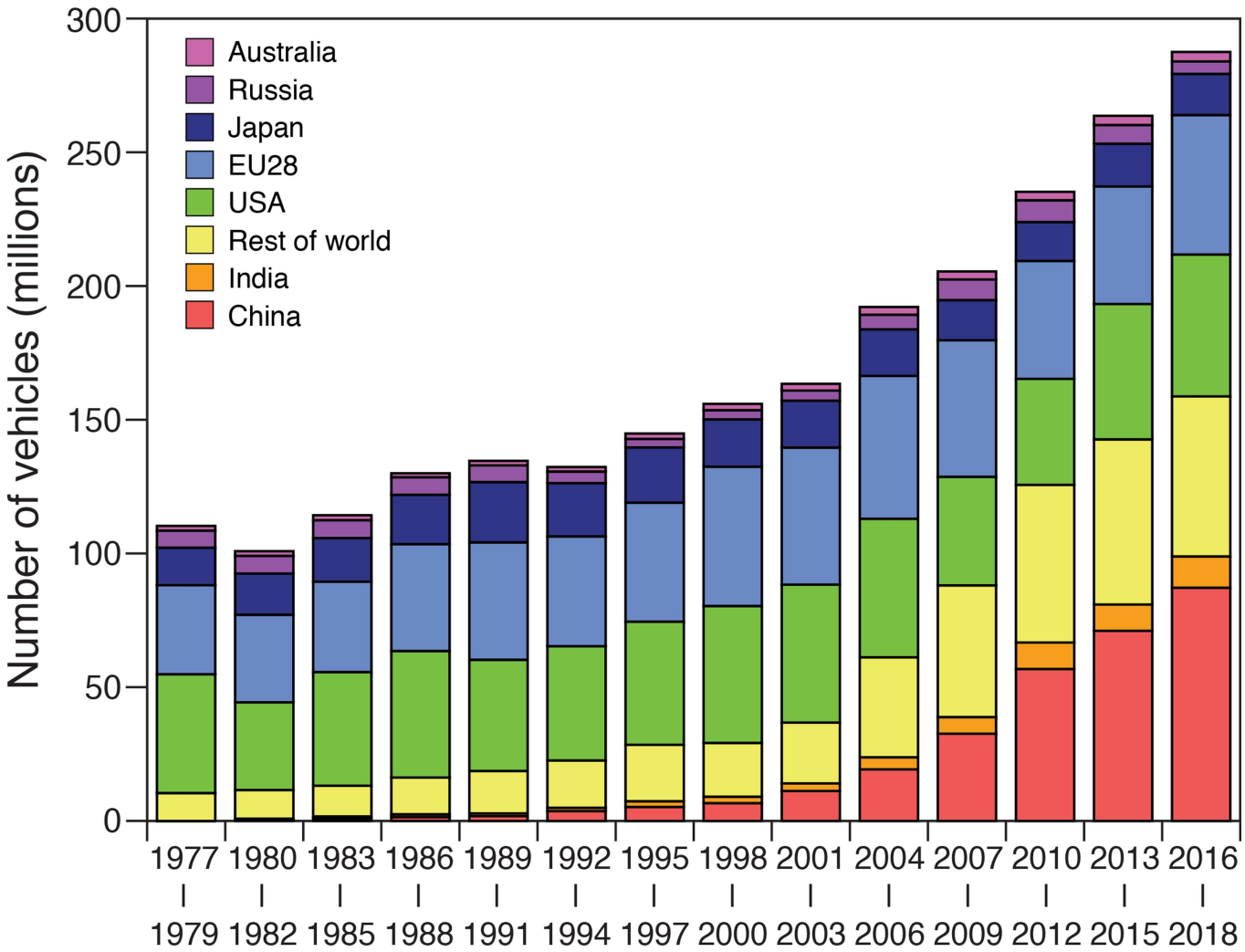
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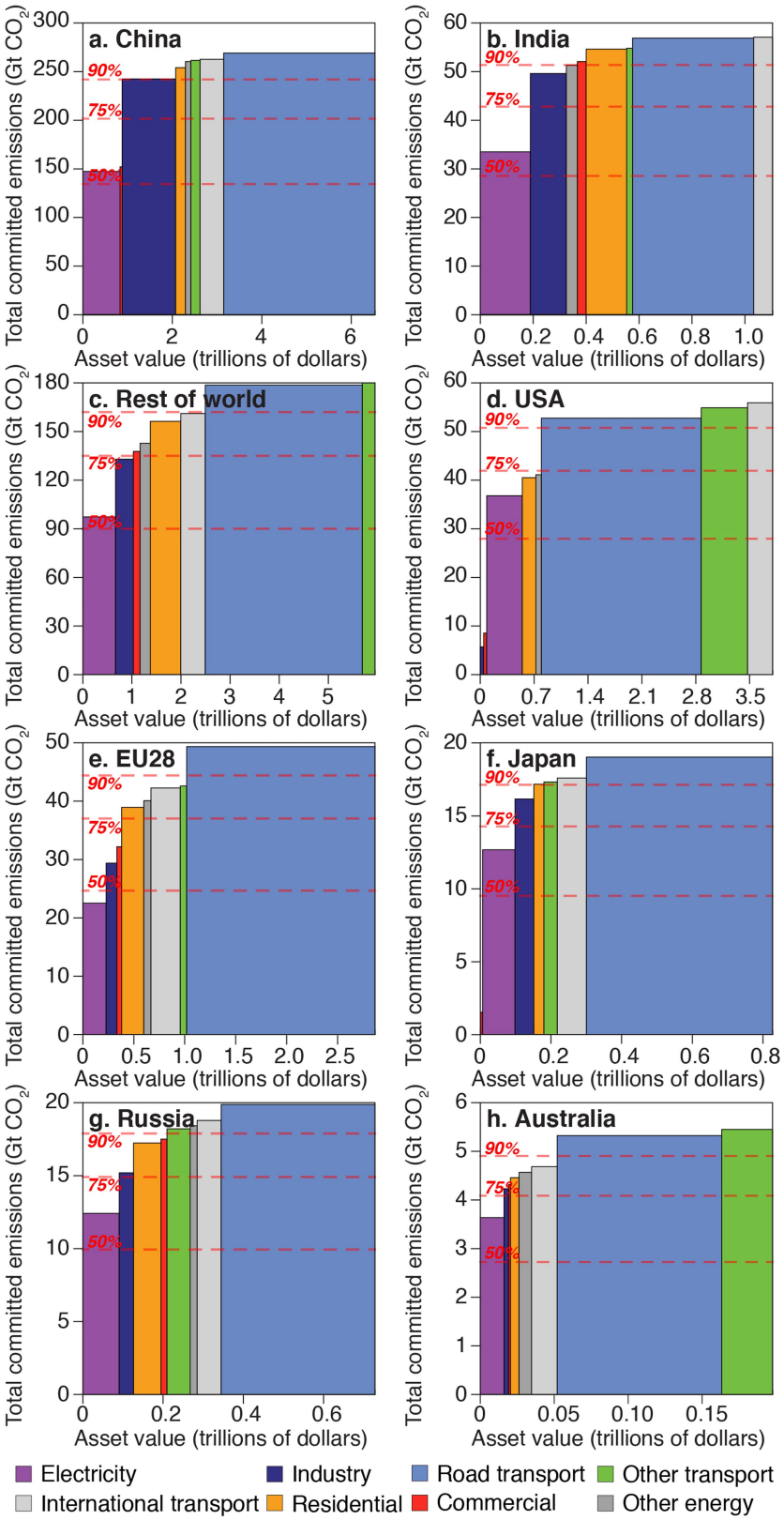
Extended Data Fig. 1 | Changes in commitments from existing energy infrastructure. a, **b**, Estimates of future CO_2 emissions every four years (1998, 2002, 2006, 2010, 2014 and 2018) by industry sector (**a**) and country/region (**b**), assuming historical lifetimes and utilization rates. **c**, **d**, Corresponding changes in remaining commitments by industry sector (**c**) and country/region (**d**).



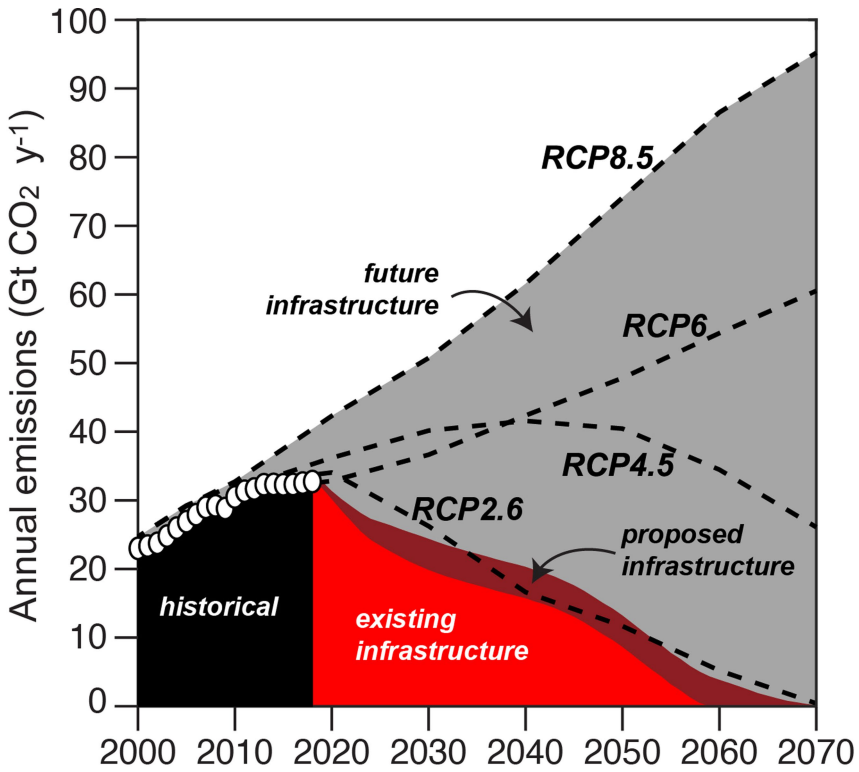
Extended Data Fig. 2 | Age structure of Chinese major industrial capacity. a, **b**, The operating capacity of raw steel in the iron and steel industry (**a**) and clinker in the cement industry (**b**). The youngest units are shown at the bottom.



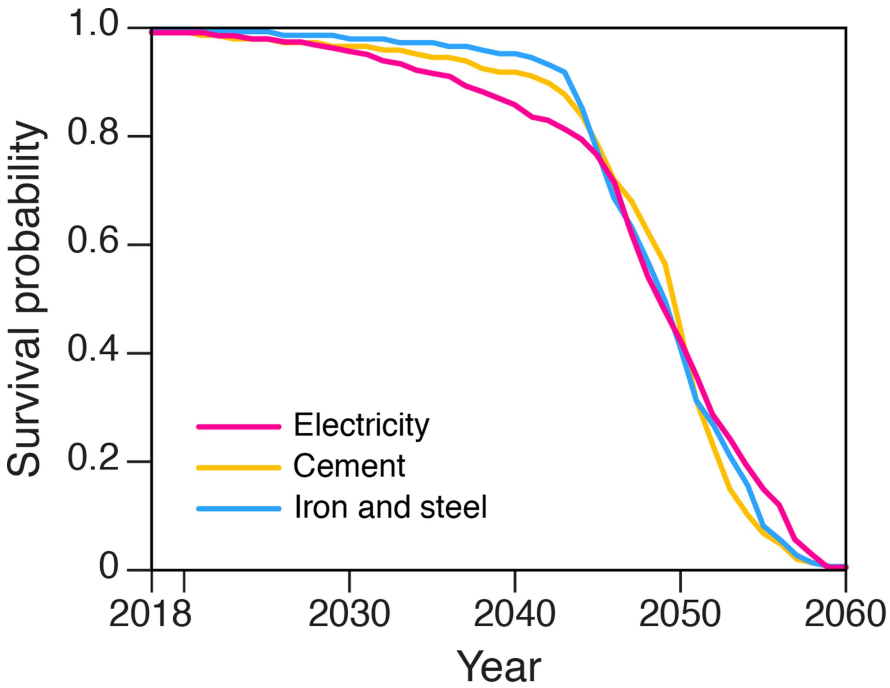
Extended Data Fig. 3 | Age structure of existing road-transport infrastructure. This figure shows the numbers of vehicle sales by country/region.



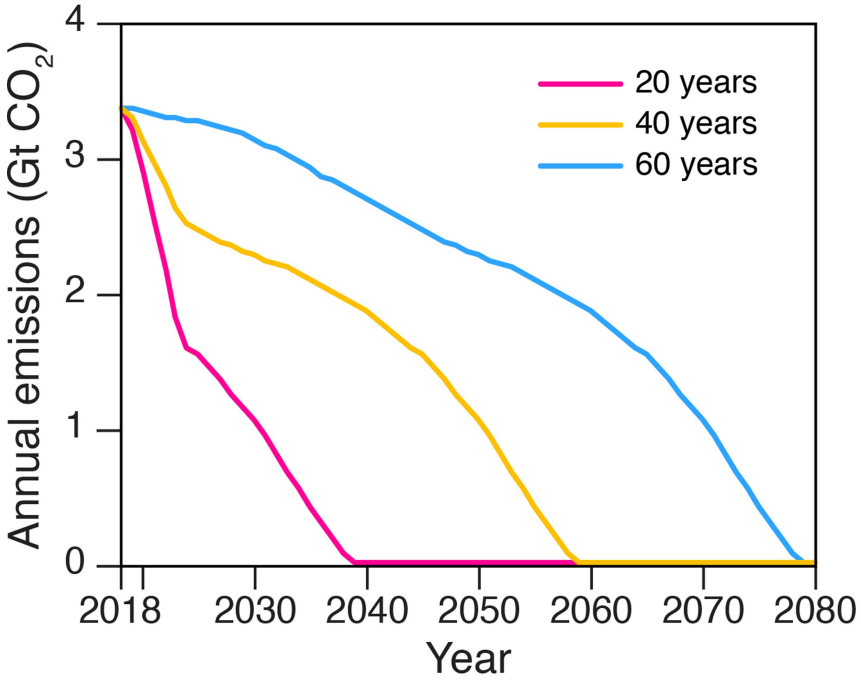
Extended Data Fig. 4 | Asset values and committed emissions for existing infrastructure. Total committed emissions are plotted against asset value, by country/region and sector. Dashed horizontal lines indicate 50%, 75% and 90% of total committed emissions if operated as historically.



Extended Data Fig. 5 | Annual emissions from existing, proposed and future infrastructure. The figure shows historical CO_2 emissions from fossil-fuel energy infrastructure (black), and future CO_2 emissions from existing (red) and proposed (dark red) energy infrastructure, as well as future infrastructure (dark grey) under particular representative concentration pathways (RCPs: RCP8.5, RCP6, RCP4.5 and RCP2.6).



Extended Data Fig. 6 | Survival curves for power and major industries in China. This figure shows survival curves for the electricity sector, cement industry, and iron and steel industry in China under the assumption of 40-year lifetimes.



Extended Data Fig. 7 | Annual emissions from residential, commercial and other energy infrastructure. The figure shows future annual CO_2 emissions from residential, commercial and other energy infrastructure under the assumptions of 20-, 40- and 60-year lifetimes.

Extended Data Table 1 | Comparison of committed emissions

		Ref. 8		Ref. 9		Ref. 11		Ref. 12		Ref. 13		This study	
		Gt CO_2	Year of dataset	Gt CO_2	Year of dataset	Gt CO_2	Year of dataset	Gt CO_2	Year of dataset	Gt CO_2	Year of dataset	Gt CO_2	Year of dataset
Existing	Electricity	224	2009	307	2012	-	-	308	2016	345 (261-451)	2009 *	358 (240-493) †	2018
	Coal		2009	206	2012	190	2016	220	2016	-	-	260 (175-358)	2018
	Gas, oil, and other fuels		2009	100	2012	-	-	88	2016	-	-	98 (65-135)	2018
	Industry	104	2009			-	-	-	-	154 (117-191)	2009	162 (110-219)	2017
	Transport	116	2009			-	-	-	-	92 (73-110)	2017	64 (53-75)	2017
	Residential, commercial, and other energy	53	2009			-	-	-	-	121 (91-158)	2009	74 (52-105)	2018
	All Sectors	**496 (282-701)**				-	-	-	-	**715 (546-909)**	-	**658 (455-892)**	-
Proposed	Electricity					-	-	271	2016	-	-	188 (142-234)	2018
	Coal					150	2016	210	2016	-	-	97 (74-121)	2018
	Gas, oil, and other fuels					-	-	61	2016	-	-	91 (68-113)	2018
All Sectors + Proposed Electricity												**846 (597-1,126)**	

Comparison of committed emissions by sector, estimated here and previously[8,9,11–13]. Note that, in some cases, the totals may not correspond to the sum of the underlying sectors, owing to rounding.
*The age distribution of infrastructure is the same as in 2009, but annual emissions from the infrastructure were adjusted up to 2018 levels.
†The range represents the committed emissions estimated under the assumption of 30–50-year lifetimes for all sectors except transportation (12–18-year lifetimes).

Annex Z

4

Climate-Induced Community Relocation in the Pacific: The Meaning and Importance of Land

JOHN CAMPBELL

I Introduction

In this chapter, the role of community relocation as an adaptation to climate change and variability is examined. In particular, the chapter addresses the importance of land to Pacific island communities, and the implications of this for those who may be forced to sever ties with it (in some extreme cases it is conceivable that land may even disappear). It also addresses the converse of this process—the implications for communities in Pacific island countries that may be required to provide resettlement areas to relocatees who have no traditional rights of access to that land.[1]

The Pacific Islands (see Figure 1) have been singled out as being among those places that may be rendered uninhabitable by the effects of climate change. In particular, it is anticipated by many that Pacific island communities may be among the vanguard of those who become environmentally forced relocatees.[2] Not all observers accept this view,[3] and while some leaders of atoll states earlier toyed with the notion of environmentally forced relocation (perhaps as a means of leverage to gain immigration access for their citizens in countries such as Australia and New Zealand),[4] many now reject such a response as unacceptable.[5] Nevertheless, the

[1] The term 'relocatee' is used in this chapter to refer to members of communities that are relocated as a group, as opposed to individual migrants. For a more detailed discussion of terminology, see section II below.

[2] See, eg N Myers, 'Environmental Refugees: A Growing Phenomenon of the 20th Century' (2002) 357 *Philosophical Transactions of the Royal Society B* 609; F Biermann and I Boas, 'Protecting Climate Refugees: The Case for a Global Protocol' (2008) 50 *Environment* 8.

[3] C Mortreux and J Barnett, 'Climate Change, Migration and Adaptation in Funafuti, Tuvalu' (2009) 19 *Global Environmental Change* 105.

[4] See Statement by the Hon Teleke P Lauti (Tuvalu) at COP 6 (The Hague, November 2000), cited in Climate Change Secretariat (UNFCCC), *Climate Change: Small Island Developing States* (Bonn, UNFCCC, 2005) 13.

[5] J McAdam and M Loughry, 'We Aren't Refugees', *Inside Story* (30 June 2009), http://inside.org.au/we-arent-refugees/.

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Figure 1: Map of the Pacific Islands region. Map drawn by Max Oulton.

habitability of many settlement sites and the sustainability of their inhabitants' livelihoods may well be placed at risk by the effects of global warming. In some cases this may require people to move to more environmentally secure locations.

II Community Relocation

There are a number of terms used in the context of environmental variability and change and the movement of people.[6] The term 'relocation' is often used in relation to a variety of these concepts. For the purposes of this chapter, it is important to distinguish community relocation from other concepts such as evacuation, displacement, migration and the so-called 'environmental refugee', although there is often some overlap in the meanings of these notions. Lieber uses the general term 'resettlement' to refer to 'a process by which a number of homogenous people from one locale come to live together in a different locale'.[7] Building on Lieber's definition, the term relocation is used in this chapter to refer to the permanent (or long-term) movement of a community (or a significant part of it) from one

[6] Biermann and Boas, 'Protecting Climate Refugees', above n 2; D Kniveton, K Schmidt-Verkerk, C Smith and R Black, *Climate Change and Migration: Improving Methodologies to Estimate Flows* (Geneva, IOM Migration Research Series No 33, 2008).

[7] MD Lieber (ed), *Exiles and Migrants in Oceania* (Honolulu, University of Hawaii Press, 1977) 343.

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location to another, in which important characteristics of the original community, including its social structures, legal and political systems, cultural characteristics and worldviews, are retained: the community stays together at the destination in a social form that is similar to the community of origin. Community relocation, especially over long distances, may be considered as among the most radical forms of adaptation to climate change.

'Adaptation' has been defined by the Intergovernmental Panel on Climate Change (IPCC) as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities'.[8] The IPCC acknowledges that adaptation may have costs, which include the 'costs of planning, preparing for, facilitating, and implementing *adaptation* measures, including transition costs'.[9] This implies that the costs of adaptation are finite and cease once the measure has been implemented. In this chapter I argue that community relocation cannot be achieved without long-term costs that may continue to be incurred over many generations. In the rural context of the Pacific Islands region, the relevant 'human systems' will be village communities, which may be seen as groups of people connected by kinship and linked by birthright and/or kinship to local land and sea resources.[10] Urban communities may also be impacted, but they are not considered in this chapter other than to note that most urban dwellers are migrants or the descendants of migrants, and therefore still have 'rights' to their ancestral homelands. The chapter seeks to identify some of the social costs of community relocation as an adaptive option. If a community is not able to re-establish itself in a new location, it may be considered to have failed to adapt successfully to change and variability. This is a distinct likelihood for the Pacific Islands region. Other forms of migration, which tend to be either individual or household-based, enable the possibility of individual people or households to be accommodated by host communities—an outcome that is much less likely for entire communities.

III Relocation as a Disaster-Reduction Measure

One of the most effective ways of reducing the impacts of extreme events is to avoid living in areas where they are common. In some jurisdictions (mostly in developed countries where land is held in fee simple and can be bought and sold), local government bodies encourage people living in hazardous sites to relocate through voluntary acquisition schemes, in which exposed properties are

[8] Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: Impacts, Adaptation and Vulnerability*: *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, Cambridge University Press, 2008) 869.

[9] ibid.

[10] P Hunnam, *Lessons in Conservation for People and Projects in the Pacific Islands Region* (New York, United Nations Development Programme, 2002).

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purchased (generally by the government), enabling the owners to purchase elsewhere in a safer place.[11] Moreover, in many such places, planning mechanisms exist that restrict subdivision and building on hazardous sites. Such approaches are viable in places where the dominant form of land ownership is through individual property rights. They are much more difficult to implement in places where property rights are not located in the marketplace but come under customary forms of tenure. In these settings, restricting land use on customary lands would place inequitable burdens on different communities, and those whose land is heavily exposed might find no alternatives for their settlements. The same considerations apply for communities that may find themselves increasingly exposed to the negative effects of climate change: coastal erosion and inundation, increased river flooding, and increased incidence of tropical cyclones and droughts.

There is no shortage of examples of Pacific island communities that have relocated to sites that are believed to be less exposed to natural extremes. Most commonly, such movements are to nearby locations that lie within customary land boundaries. However, in pre-colonial times and probably well into the colonial era, it was not unusual for communities to move on to neighbouring lands with the acknowledgement of the original landowners. Usually this was achieved through customary forms of negotiation and exchange. Less common, but by no means totally unusual, were movements across greater distances.

IV The Meaning of Land in Pacific Islands

Land in Pacific island countries tends to have meanings to those who 'belong' to or are 'part of' it that are often difficult to encapsulate in English or other colonial languages. Land has multiple meanings in the majority of Pacific island countries, and in many cases cannot be separated from those who 'belong' to it (see Box 1). By and large, most Pacific land is not, and cannot be, owned in fee simple or as freehold. While it can be exchanged, this is nearly always only possible under traditional arrangements. As Figure 2 shows, the great majority of land in the Pacific Islands region is held under customary forms of tenure, though these may differ from the arrangements that existed prior to contact and colonisation. Indeed, in those few countries where customary tenure accounts for less than 90 per cent of the land, 'public' forms of ownership make up the difference. By contrast, 'freehold' land makes up less than 10 per cent of land in the region. Most countries experienced some alienation of land prior to colonial rule, following which remaining areas of traditionally tenured land often became protected or, in some

[11] RW Perry and MK Lindell, 'Principles for Managing Community Relocation as a Hazard Mitigation Measure' (1997) 5 *Journal of Contingencies and Crisis Management* 49; NJ Ericksen, *Creating Flood Disaster? New Zealand's Need for a New Approach to Urban Flood Hazard* (Wellington, Water and Soil Directorate, Ministry of Works and Development, 1986).

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Box 1: Expressions of the importance of land

> Land to a ni-Vanuatu is what a mother is to a baby. It is with land that he defines his identity and it is with land that he maintains his spiritual strength. Ni-Vanuatu do allow others the use of their land, but they always retain the right of ownership.

The Hon Sethy Regenvanu, First Minister of Lands, quoted in HN van Trease, *The Politics of Land in Vanuatu: From Colony to Independence* (Suva, University of the South Pacific, 1987) xi.

> For example, in Cook Islands Maori, 'enua' means 'land, country, territory, after-birth': in Futuna (Wallace) 'fanua' means 'country, land, the people of a place'; in Tonga, 'fonua' means 'island, territory, estate, the people of the estate, placenta' and 'fonualoto', 'grave'. We can see that in some Polynesian languages, proto-fanua is both the people and the territory that nourishes them, as a placenta nourishes a baby.

W Pond, *The Land with All Woods and Water* (Waitangi Tribunal Rangahaua Whanui Series, Waitangi Tribunal, Wellington, 1997) 32, quoted in K Batibasaqa, J Overton, and P Horsley, '*Vanua*: Land, People and Culture in Fiji' in J Overton and R Scheyvens (eds), *Strategies for Sustainable Development: Experiences from the Pacific* (London, Zed Books, 1999) 100.

> The people of Nakorosule [a village in Fiji] cannot live without their physical embodiment in terms of their land, upon which survival of individuals and groups depends. It provides nourishment, shelter and protection, as well as a source of security and the material basis for identity and belonging. Land in this sense is thus an extension of the self; and conversely the people are an extension of the land.

A Ravuvu, *Development or Dependence: The Pattern of Change in a Fijian Village* (Suva, University of the South Pacific, 1988) 7.

> The land has even been viewed as possessing a sacred or spiritual quality, expressed in the mental attitudes of Marshallese when they think of the land as the very root of their worldly existence.

L Mason, 'Tenures from Subsistence to Star Wars' in RG Crocombe (ed), *Land Tenure in the Atolls: Cook Islands, Kiribati, Marshall Islands, Tokelau, Tuvalu* (Suva, University of the South Pacific, 1987) 4.

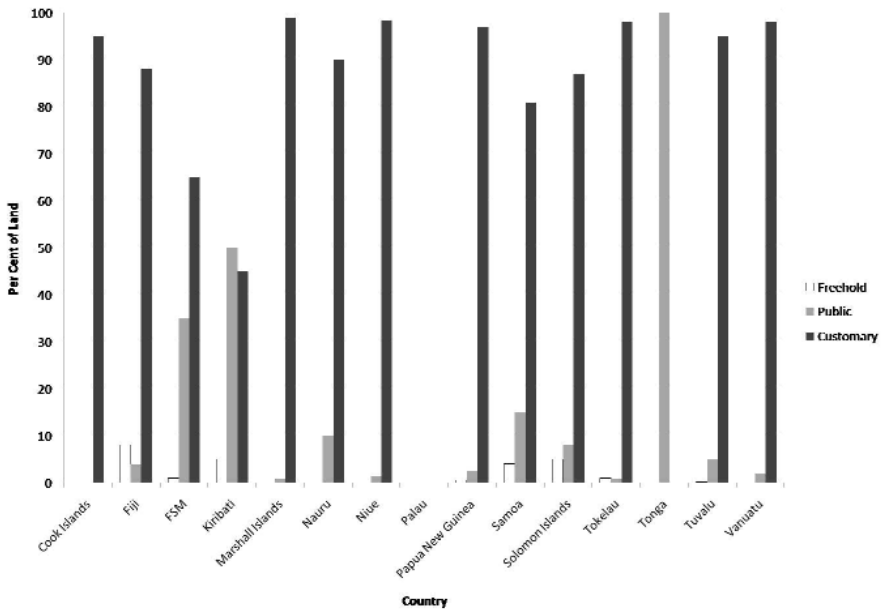
> For the people of Kapingamarangi Atoll, no other single concern seems to be as omnipresent and anxiety-provoking as their concern over land. No other single concern generates the intensity of interest and emotion as does land. People may insult one another, but the insults will be forgiven; tempers sometimes flare and end in fist fights, but others will intervene, and the opponents will apologize and forget the incident; marriages break up, but the wounds heal. But a land dispute is never forgotten, nor do the opponents forgive each other, nor is the matter ever really settled, even when the litigants are long deceased.

MD Lieber, 'Land Tenure on Kapingamarangi' in HP Lundsgaarde (ed), *Land Tenure in Oceania* (Honolulu, University Press of Hawaii, 1974) 70.

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cases, were returned to the original owners after independence. Thus Fiji, for example, has about 8 per cent of its land under freehold ownership. Much of this is prime land 'purchased' or taken for plantations by early colonists and coastal land that is now valued for resort subdivisions.

Figure 2: Broad land ownership categories in the pacific islands region



Source: Australian Agency for International Development (AusAID), *Making Land Work: Volume 1: Reconciling Customary Land and Development in the Pacific* (Canberra, Commonwealth of Australia, 2008) 4.

The nature of land 'boundaries' in Pacific island countries also needs to be considered, as relocation may involve crossing such borders. They exist in a variety of forms. The most highly codified system is in Fiji, where lands have been surveyed, boundaries established and the land registered according to *mataqali* (clan) membership, which for most children is registered at birth. In many other countries no such arrangements exist; boundaries may be flexible or fuzzy, and knowledge regarding them is transmitted orally. For many Pacific societies, particularly those on large land masses such as in Melanesia, landowners recognised a clear centre but their relationship to the land became increasingly vague with distance from it.[12]

[12] A Abramson, 'Bounding the Unbounded: Ancestral Land and Jural Relations in the Interior of Eastern Fiji' in A Abramson and D Theodossopoulos (eds), *Land, Law and Environment: Mythical Land, Legal Boundaries* (London, Pluto Press, 2000).

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The forms of customary tenure vary across the region, ranging from arrangements for individual rights to land through to communal ownership. Despite this, the idea that people are intimately connected to their land was, and to a large extent remains, widespread, as indicated in Box 1. In many parts of Polynesia and Melanesia the linkage between land and placenta is strong, and is encapsulated in the New Zealand Maori term *whenua*, which refers to both the land and placenta. The placenta is returned to the ancestral land following birth, and for many, their final resting place is on the ancestral *whenua* as well.[13] Bonnemaison uses the notion of being rooted to the land to describe the linkage of ni-Vanuatu men to their land, although women (who were traditionally likely to marry outside of their birthplace) are metaphorically described as birds that may flee their home.[14] While men were able to leave their land, long absences and distances were not encouraged. However, in other parts of the region long-distance travelling was not uncommon and the region was characterised by a very large number of trading networks, some of which covered considerable distances.[15]

It is important here not to represent Pacific people and their communities as being somehow physically bonded by their location. Waiko outlines the movement of his village in north-eastern Papua New Guinea, named Tabara, which had a 'history of fusion, division and travel' that extended over 130 kilometres in distance.[16] Jolly points to the co existence of mobility and stability in many Pacific places and invokes the paradoxical notion of both roots and routes as important aspects of Pacific island lives.[17] But venturing on routes does not suggest the loss of roots, the perhaps less tangible, but nonetheless visceral, bonds that exist and connect people with their place. Many migrants, even long-term ones, still consider themselves to belong to their land, even if they are physically dislocated from it.[18]

Accordingly, while this chapter examines the role of land tenure, or the meaning of land, in Pacific island countries, it is important to add the cautionary note that the region cannot be easily generalised into a single representation of land, nor any other characteristic—it is remarkably heterogeneous. While the specifics vary considerably, there are nevertheless some commonalities regarding the

[13] A Mikaere, *The Balance Destroyed: Consequences for Māori Women of the Colonisation of Tikanga Māori* (Auckland, International Research Institute for Māori and Indigenous Education, 2003); N Simmonds, 'Mana Wahine Geographies: Spiritual, Spatial and Embodied Understandings of Paptūānuku' (unpublished Masters Thesis, Department of Geography, Tourism and Environmental Planning, University of Waikato, New Zealand, 2009).

[14] J Bonnemaison, 'The Tree and the Canoe: Roots and Mobility in Vanuatu Societies' (1985) 26 *Pacific Viewpoint* 30.

[15] E Hau'ofa, 'Our Sea of Islands' in E Waddell (ed), *In a New Oceania: Rediscovering Our Sea of Islands* (Suva, University of the South Pacific, 1993); GR Lewthwaite, 'Geographical Knowledge of the Pacific Peoples' in HR Friis (ed), *The Pacific Basin: A History of Its Geographical Exploration* (New York, American Geographical Society, 1967).

[16] JD Waiko, 'Na Binandere, Imo Averi? We Are Binandere, Who Are You?' (1985) 26 *Pacific Viewpoint* 9, 9 (Special Issue: Mobility and Identity in the Island Pacific).

[17] M Jolly, 'On the Edge: Deserts, Oceans, Islands' (2001) 13 *The Contemporary Pacific* 417.

[18] AD Ravuvu, *Development or Dependence: The Pattern of Change in a Fijian Village* (Suva, University of the South Pacific, 1988).

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cultural links to land. The specific characteristics of the links may differ, but in a great many places they are very important in terms of identity, spirituality, culture and subsistence.

The effects of climate change upon the land, and the land's ability to sustain these myriad linkages, cannot be easily ignored. One of the outcomes may be that communities will have to move. Such climate-induced migration may have very serious implications, both for relocating communities and those who may have to make land available for them in their destinations. Above all, community relocation means that an important aspect of rootedness, having at least some people (kinfolk) there, sustaining the relationship with the land, or 'keeping the home fires burning', is lost. Secondly, where relocatees are moved to another place within their own country or elsewhere in the Pacific, the communal lands of other groups may need to be used. To leave one's roots is perhaps no more difficult than giving them up—in either case, there will be considerable loss: of cultural values, livelihoods, spirituality and identity. In the latter case, tensions may arise when people at the destinations feel aggrieved at having to give up land.

V Migration in and from Pacific Islands

As the discussion of roots and routes suggests, many Pacific island peoples have a great history of migration, and the ocean may be seen as a linking mechanism, a series of routes, rather than a barrier to mobility.[19] This may seem somewhat paradoxical given the strong ties to land outlined in the preceding sections. Following a symposium held in 1983 on the topic of population mobility, identity and politics, it was observed that 'if one theme overrode all the others . . . it was how the complex and deeply rooted meanings of land lay at the heart of islander identities and were in turn expressed through an astonishing diversity of movement behaviour'.[20]

The rootedness described by Bonnemaison helped explain the patterns of circular migration that were detected by early migration researchers in Pacific island countries (as well as Bonnemaison himself).[21] Migration has continued since these early studies, and for many Pacific island countries has expanded to international destinations such as Australia, New Zealand and California in the United States. For example, in the 2006 New Zealand census, the 'Pacific peoples' ethnic group included 265,000 people, an increase of 59 per cent since the 1991 census. Interestingly, 60 per cent of the 2006 Pacific island population was born in New Zealand. As well, Pacific urban centres are rapidly growing in size. Twenty-three per cent of the region's population is urban, and 10 out of 22 of the countries have

[19] Hau'ofa, 'Our Sea of Islands', above n 15.

[20] M Chapman, 'Introduction' (1985) 26 *Pacific Viewpoint* 1, 4 (Special Issue: Mobility and Identity in the Island Pacific).

[21] See, eg R Bedford, *New Hebridean Mobility: A Study of Circular Migration* (Canberra, Australian National University, 1973); Bonnemaison, 'The Tree and the Canoe', above n 14.

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more than half their populations living in urban areas away from their villages and customary lands.[22] The rapid urbanisation of the majority of Pacific island countries, and the burgeoning populations of Pacific islanders in the Pacific rim, does not, however, necessarily imply that the important link to land is lost. In many cases it remains just as strong and is sustained by remittances and return visits of individuals and households, as well as family reunions—often including hundreds of people, often spanning three or more generations, many of whom are returning from their Pacific rim homes.[23] Just as migrants and their descendents provide remittances, the non-migrants sustain the link to the homelands by supplying traditional foods and other products from the land to their urban and international kin.

VI Likely Effects of Climate Change on Migration

So, against this backdrop of mobility, what are the implications of climate change effects on Pacific island migration patterns? The most significant effects of climate change include reductions in agricultural productivity; coral reef and mangrove degradation, and associated reduction of marine productivity; reductions in water quantity and quality, with associated impacts on agriculture and health; increases in the frequency and magnitude of some climatic events; and coastal erosion and inundation as a result of extreme events and sea-level rise. In some cases the very habitability of places will be compromised, and in many others the combination of economic and spatial marginality (which has increased since the days of colonisation and continues to do so in the post-colonial globalised world) and increasing environmental marginality may provide sufficient 'push' factors to cause significant migrant flows. A major question is: where will such people go?

There are a number of possibilities for relocation, as shown in Figure 3. The path of least resistance, where possible, will be for communities to relocate within their own land boundaries. The link to land need not be broken and the likelihood of tensions arising from landowners who may have to cede land is negated. This kind of relocation is not at all uncommon in the Pacific Islands region and examples may be found in a number of countries. In many cases, such relocations take place after devastating climatic extremes, such as tropical cyclones with their associated river flooding and storm surge. The typical movement is inland and up to higher elevations, though it has not been unusual for lateral relocations to take place (for example, along the coast or river), only for more devastation at a later date when more climatic extremes occur. An example is the inland village of

[22] Secretariat of the Pacific Community, *Pacific Island Populations 2008* (Noumea, Secretariat of the Pacific Community, 2008).

[23] R Bedford, 'Pasifika Mobility: Pathways, Circuits and Challenges in the 21st Century' in A Bisley (ed), *Pacific Interactions: Pasifika in New Zealand, New Zealand in Pasifika* (Wellington, Institute of Policy Studies, 2008).

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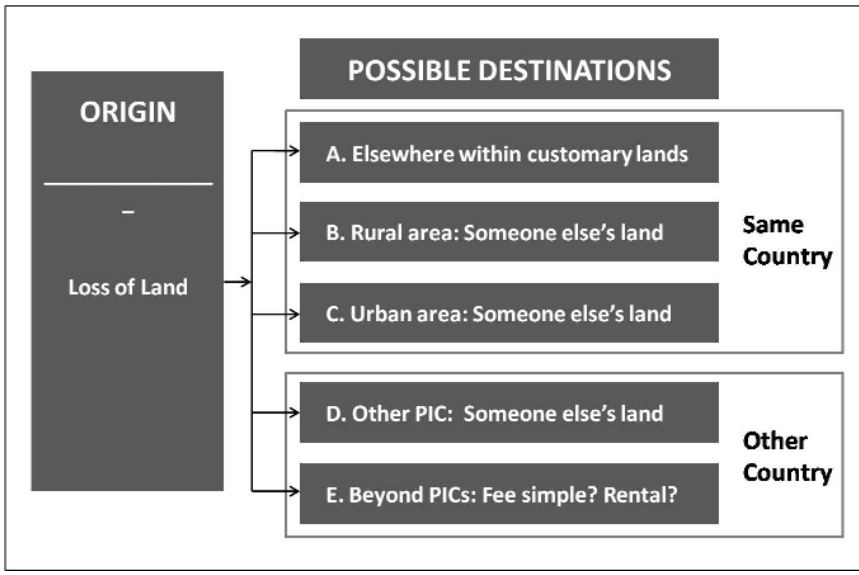


Figure 3: Options for relocation in and beyond Pacific island countries

Biausevu, located by the Biausevu River on the island of Viti Levu, in Fiji. The village occupied four different sites between 1881 and 1983, when it was finally established on a hill above the seemingly gentle river which was prone to flash flooding during tropical cyclones.[24]

Where such intra-communal shifts are not possible or feasible—the community may not have suitable options—resettlement elsewhere within the country may be required. This may range from being relocated on a neighbouring community's land, to a rural area some distance away, and even on another island. Such relocations are problematic because of the land issues discussed above. Even neighbouring communities guard their land jealously—it is 'part of' them and accordingly not something that can simply be given away or sold. Traditional means of exchange, where customary items of significant value (for example *tabua* or whale's teeth in Fiji), when presented to landowners may have enabled some relocation, are often now challenged by younger members of the 'host' or destination landowners who want evidence that legal transfer took place, even if it was generations ago when the relocation occurred.[25]

An alternative is relocation to an urban area. However, in most Pacific island towns and cities the same rules regarding land apply. While many of the early colonial administrative centres were established on relatively small areas of alienated

[24] J Campbell, 'International Relocation from Pacific Island Countries: Adaptation Failure?' (Environment, Forced Migration and Social Vulnerability Conference, Bonn, 9–11 October 2008).

[25] See, eg V Cagilaba, 'Fight or Flight? Resilience and Vulnerability in Rural Fiji' (unpublished Masters Thesis, University of Waikato, New Zealand, 2005).

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land, they have since far outgrown their original dimensions, especially in the post-colonial era. While it is not uncommon to find settlements of people from the same island or village in urban areas, in most cases their situation is tenuous. Because all but a small proportion of land is communally owned, even in the towns, and especially in the peri-urban[26] areas where most urban growth is taking place, new migrants are forced to live in temporary arrangements (the landowners not being prepared to accept signs of permanent settlement). Squatter settlements in Oceania are typically neglected by urban and/or national government authorities, have low levels of infrastructure provision, high levels of unemployment and under-employment, and are often highly exposed to the possibility of extreme events, including flooding and tropical cyclones. Indeed the inhabitants of many existing squatter settlements, many of which are on low-lying swampy lands and unstable slopes, may well be adversely affected by climate change and also in need of relocation. Increasing the inflow from rural areas is likely only to increase the exposure and vulnerability of the communities in these locations.

The third set of migration options includes those incorporating international relocation. These are mostly foreshadowed in the academic and popular literature as being necessary for the inhabitants of countries that are entirely composed of atolls, in which there is no 'up' to go to. There are two sets of options. The first is to relocate to another Pacific island country where the environmental, social and cultural conditions are likely to be perhaps relatively close to the place of origin, and the social, cultural, spiritual and economic costs of relocation will not be too onerous. Again, the problem of land remains, and it is unlikely that communities from one Pacific island country will be happy to give up their land to newcomers in a way that enables the newcomers to maintain their social, cultural, political and economic ways.

The second international relocation option is to relocate the community outside the Pacific Islands region, most likely in New Zealand, Australia or the United States, the three metropolitan countries with strong links to the atoll states. The possibilities for international relocation outside the region (as opposed to other forms of migration) are extremely bleak. It is unlikely that any country, including those in the Pacific, would cede sovereignty over a part of their territory to a relocated group, and it is equally unlikely that a relocated group could sustain its 'way' in a foreign land that did not accept or understand many of their cultural beliefs or practices, including their bond to the land. Indeed, with the exception of relocation within communal lands, all other forms of relocation will be fraught, whether internal or international. This leaves the possibility of separate migration decisions by individuals or groups to a variety of destinations that will see community integrity weakened, if not badly damaged. Moreover, if the land is to become uninhabited, uninhabitable, or at worst non-existent, the critical people–land union may decline. Given the essential nature of this connection, it

[26] This term refers to areas that lie outside formal urban boundaries. Typically, such areas do not have access to urban services and infrastructure.

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may be expected that social, cultural, emotional and spiritual impacts will emerge. The following two cases studies indicate some of the land-related issues that can arise as a result of community relocation.

VII In-Country Relocation: From the Carterets to Bougainville

An interesting case of possible environmentally, if not climatically, induced migration in the Pacific Islands is that of the attempted relocation of atoll dwellers from the Carteret Islands to the large plate boundary island of Bougainville in Papua New Guinea (see Figure 4 on the following page). The Carterets have been affected by unusually high (king) tides and experiencing considerable loss of coastal land. Singled out by the media in 2008 and 2009 as the world's first 'climate refugees',[27] the people of the Carteret Islands were engaged, in 2009, in a resettlement scheme at Tinputz, on the island of Bougainville. The Carterets are subsiding, although there seems to be no scientific certainty as to the cause. The area is tectonically unstable and this may be the reason, although the possibility of climate change-driven sea-level rise is a popular attribution. Irrespective of the causes of the subsidence relative to sea level, the Carterets provide much food for thought on the efficacy of relocation in Oceania. The case is not a new one: a group of colonial officials conducted a resource survey of the Carterets in 1964 and reported that 'erosion is a constant menace in these islands'.[28] Three years later a colonial officer visited the atoll and reported that the islands had lost hundreds of coconut palms and had been exposed to 'ruinous erosion'.[29] Population growth was adding to the stress on the atoll environment. By the late 1960s Carteret Islanders 'were reported to have a unanimous desire for resettlement as "heavy seas . . . devastated gardens and there [was] an obvious shortage of food crops" '.[30]

The North Solomons Provincial Government in Papua New Guinea began to organise a resettlement scheme in 1979 and land was set aside for the establishment of a village, but the first group of 10 families from the Carterets did not arrive until 1984. As O'Collins reported, while some dislocation was expected, the transition proved more difficult than anticipated:

[27] A Morton, 'First Climate Refugees Start Move to New Island Home', *The Age* (29 July 2009), www.theage.com.au/national/first-climate-refugees-start-move-to-new-island-home-20090728-e06x.html; N MacFarquhar, 'Refugees Join List of Climate-Change Issues', *The New York Times* (28 May 2009), www.nytimes.com/2009/05/29/world/29refugees.html.

[28] HJ Redmond, J Curran and T Sweeney, 'Resources Survey, Carteret Islands, Bougainville District' (unpublished report to District Commissioner, Kieta, 1964) quoted in M O'Collins, 'Carteret Islanders at the Atolls Resettlement Scheme: A Response to Land Loss and Population Growth' in J Pernetta and P Hughes (eds), *Implications of Expected Climate Changes in the South Pacific Region: An Overview* (Nairobi, United Nations Environment Programme, 1990) 253.

[29] Quoted in O'Collins, above n 28, 253.

[30] ibid, 250 (Letter from KJ Hanrahan, Assistant District Commissioner to the District Commissioner at Sohano, Buka Island, 11 January 1968).

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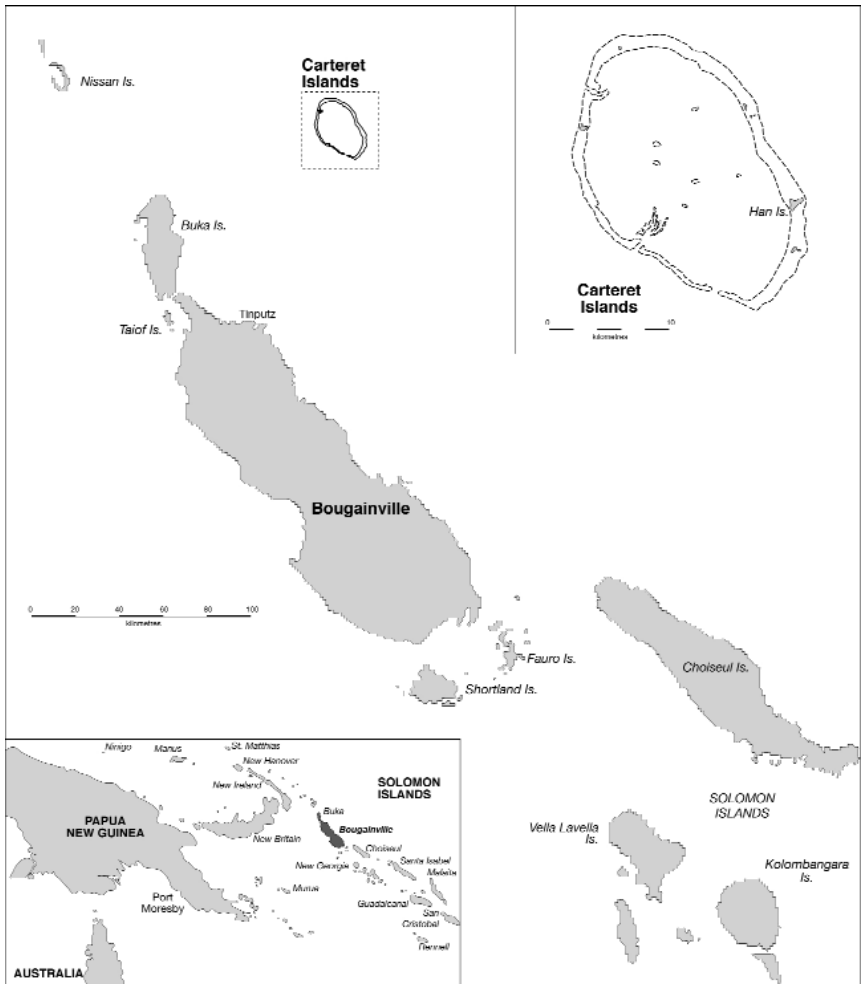


Figure 4: The Carteret Islands and Bougainville. Map drawn by Max Oulton.

> The families and particularly those members engaged in clearing and establishing food gardens and in building houses, had to become used to many new food crops, new building materials and different techniques. Upon arrival the families had to accustom themselves to living under an iron roof, out of sight of the sea and surrounded by unfamiliar and rather frightening thick bush. . . . Children had to walk 6 km to school and this was a great distance for those who had no opportunity to walk any distance on their small atolls. Road traffic hazards, for those who had no experience of roads or vehicular traffic; fear of snakes for those who had no experience of walking on paths through thick bush; and the experience of being surrounded by tall trees, all required individual and community adjustment. … Many women sat for long periods of time thinking about their island homes.[31]

[31] O'Collins, above n 28, 253.

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By 1987, two of the original families had returned home. Others had adjusted relatively well, although there were concerns at delays in obtaining land on Bougainville for cocoa and copra production (their sole opportunity for cash production), and some worried that they would also lose their usufruct rights to the small and decreasing amounts of land left on the atoll. Moreover, there were serious concerns at the lack of support given to them to become self-sufficient.[32]

Little further information is available on the fate of these initial relocatees, and it is not clear what happened to the resettlement scheme. However, it was not long after this that Bougainville became involved in a prolonged and severe civil conflict (lasting from 1988 to 1997),[33] and in 1989 the people from the Carterets fled home.[34] A new group of relocatees has since reappeared, and these people have perhaps been reinvented in the news as the world's first 'climate refugees'. But given the reporting by O'Collins, we can see that this new wave is not the first group of environmentally induced relocatees, and this perhaps also casts doubt on whether or not the sole reason for their relocation is climate change, although it may well have an exacerbating effect. Nevertheless, the case study is instructive and we can also learn from the more recent scheme. Land was again to be made available, again on Bougainville, and an initial group of five male household heads moved to the new site in late April 2009.[35] But, like the 1980s attempt, success was hard to come by and by July 2009 it was reported that the men had returned:

> Three of these families complained that they were in frequent arguments with Tinputz landowners over land and that they were finding it difficult because they did not have gardens, sometimes no food and most of them no proper house.
>
> Earlier this year, acting administrator . . . told the *Post-Courier* that legal issues were hindering the efforts to resettle Carteret Islanders [and others from low-lying atolls] to Bougainville. He said that the Government's efforts on the resettlement exercise were being blocked as they were having trouble getting the legal rights to the land they needed.[36]

This article in Papua New Guinea's national press appeared three months to the day after the men arrived, indicating that the project had failed in a very short space of time. Moreover, it indicates the major difficulties likely to be encountered when relocating communities within Pacific island countries, when the relocation is on a different community's communal land. While most observers focus on the likely international relocation needs of atoll dwellers, internal relocation may be just as difficult, with the possibility of significant numbers of groups of internally displaced persons emerging. This issue has hardly been addressed in the discussion

[32] ibid, 267.

[33] P Reddy, 'Reconciliation in Bougainville: Civil War, Peacekeeping and Restorative Justice' (2008) 11 *Contemporary Justice Review* 117.

[34] U Rakova, 'How-to Guide for Environmental Refugees' (OurWorld 2.0, 16 June 2009).

[35] 'Carteret Islanders Become First Climate Refugees: PNG Relocates Families as Island Home Disappears', *Pacific Island Report* (4 May 2009), http://archives.pireport.org/archive/2009/may/05-04-09.htm, reporting a story from the *Papua New Guinea Post-Courier* (1 May 2009).

[36] T Vainerere, 'Climate Change Refugees Return to Bougainville Atolls', *New Guinea Post-Courier* (22 July 2009), http://lists.spc.int/pipermail/ppapd-fpocc_lists.spc.int/2009-July/000233.html.

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of the implications of climate change in Pacific island countries. The second case study below looks at the possibilities for relocation within the region drawing on the experiences of the Banaban community, relocated from what is now Kiribati, to Rabi in Fiji.

VIII International Relocation: Banaba to Rabi

There have been three cases of international relocation of Pacific island communities, all involving atoll or raised limestone island communities (see Figure 5). The first of these is a Micronesian community from Banaba (now part of Kiribati), which was devastated by phosphate mining since its discovery in 1900 through to 1979. Most members of this community now live on Rabi island in northern Fiji. The second instance is a Polynesian community from Vaitupu (now part of Tuvalu) which resettled on Kioa island in northern Fiji. The island was purchased in 1946 and settlement began on 26 October 1947.[37] The final case is that of the Gilbertese (I-Kiribati) communities in Wagani and Gizo, Western Province, Solomon Islands.[38] This last group of relocatees was placed in areas where land quality was poor, and in many cases they did not have security of land tenure.[39] Despite these disadvantages for the migrants, the relocation has also been a source of tension in the destination communities, and 'while saying they were not hostile to the Gilbertese as such, Western [Province] leaders resented the fact that their province took all the burden of Gilbertese resettlement'.[40]

The focus here is on the first case, the relocation from Banaba to Rabi (see Figure 6). The transfer to Kioa from Vaitupu was a partial one, with a substantial and sustainable population remaining in the home island. This enabled the link to land to be sustained, as well as the assurance of a community 'keeping the home fires burning'. The relocation to the Solomon Islands was also partial, and no single communities were completely translocated. In comparison, the relocation from Banaba to Rabi was to all intents and purposes complete, although some 'caretakers' have returned to their home island, particularly since the 1970s. Accordingly, it gives us considerable insights into the likely effects of complete community relocation, should it be required as a result of climate change. This section is based on the work of a number of authors who have written about

[37] K-F Koch, *Logs in the Current of the Sea* (Canberra, Australian National University Press, 1978).

[38] KE Knudson, 'Making Sense: A Study of a Banaban Meeting' in Lieber (ed), *Exiles and Migrants in Oceania*, above n 7.

[39] J Fraenkel, 'Minority Rights in Fiji and the Solomon Islands: Reinforcing Constitutional Protections, Establishing Land Rights and Overcoming Poverty' (Paper prepared for United Nations Commission on Human Rights, Sub-Commission on Promotion and Protection of Human Rights, Working Group on Minorities) UN Doc E/CN.4/Sub.2/AC.5/2003/WP.5 (5 May 2003).

[40] R Premdas, J Steeves and P Larmour, 'The Western Breakaway Movement in the Solomon Islands' (1984) 7 *Pacific Studies* 34, 45.

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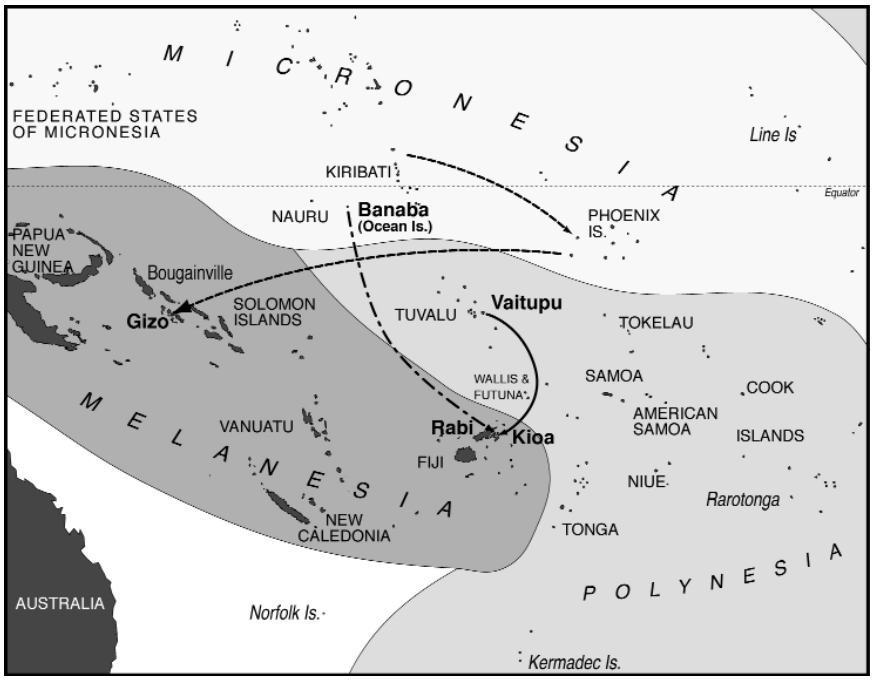


Figure 5: The 'international'-type relocations that took place during the colonial period under the colonial governance of the United Kingdom. The map shows the broad 'cultural regions' of Oceania and indicates that the three communities were relocated to quite distinct cultural milieux from their own. Map drawn by Max Oulton.

Banaba and Rabi.[41] Their work is summarised here as it is of considerable relevance to the issue of community relocation in Pacific island countries.

Banaba (also known as Ocean Island) is a raised limestone island lying close to the equator, a little less than 300 kilometres to the east of Nauru. Like Nauru, Banaba was covered by a thick layer of phosphate, and like Nauru this resource was mined aggressively, mostly to support the pastoral agricultural industries of New Zealand, Australia and the United Kingdom. Apart from some small

[41] W Kempf and E Hermann, 'Reconfigurations of Place and Ethnicity: Positionings, Performances and Politics of Relocated Banabans in Fiji' (2005) 75 *Oceania* 368; W Kempf, 'The Drama of Death as Narrative of Survival: Dance Theatre, Travelling and Thirdspace among the Banabans of Fiji' in T van Meijl and J Miedema (eds), *Shifting Images of Identity in the Pacific* (Leiden, KITLV Press, 2004); S King and K Sigrah, 'Legacy of a Miner's Daughter and Assessment of the Social Changes of the Banabans after Phospate Mining on Banaba' (Islands of the World VIII International Conference, 'Changing Islands: Changing Worlds', Kinmen Island (Quemoy), 1–7 November 2004); B Macdonald, *Cinderellas of the Empire: Towards a History of Kiribati and Tuvalu* (Suva, University of the South Pacific, 2001); MG Silverman, *Disconcerting Issue: Meaning and Struggle in a Resettled Pacific Community* (Chicago, University of Chicago Press, 1971); KM Teaiwa, 'Our Sea of Phosphate: The Diaspora of Ocean Island' in G Harvey and C Thompson (eds), *Indigenous Diasporas and Dislocations* (Aldershot, Ashgate, 2005).

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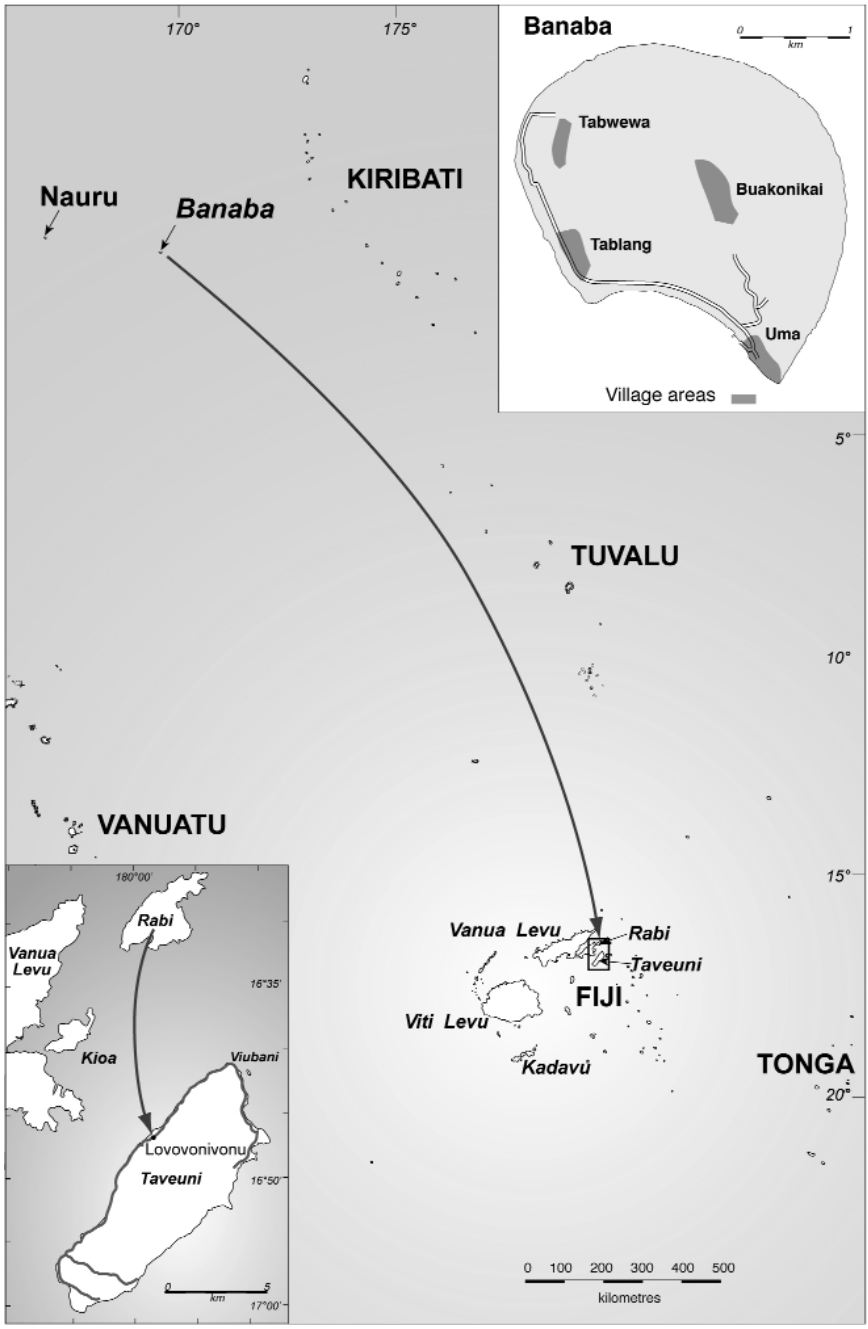


Figure 6: Banaba and Rabi. Map drawn by Max Oulton.

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amounts remaining on Nauru, these deposits have been largely exhausted, with the populations of both islands left with little to show for the massive environmental degradation caused by the mining. The Nauru case is relatively well known. Millions of dollars placed in trust were lost in a series of investment failures.[42] Nevertheless, the people of Nauru remain on their island and are citizens of their own sovereign state.

The case of the Banabans unfolded quite differently. Initially, Banaba was too small to excite British interest, and it was excluded from the British colonial entity, the Gilbert and Ellice Islands Protectorate, which was formed in 1892.[43] However, with the identification of phosphate on the island in 1900 it was not long before Banaba was included in the Protectorate, by 1907 having become its headquarters, so important was the phosphate industry.[44] The island became a bustling and multicultural economy as the British Phosphate Corporation (BPC) extracted the valuable mineral. However, as the extraction continued, the utility of Banaba as a home for the Banabans was declining, and by 1940 the Protectorate government was encouraging the people to consider relocating to another site. This would also enable the BPC to intensify its mining activities. Islands in Fiji, such as Wakaya and Rabi, that had been alienated from their customary owners prior to colonisation, were considered for relocation purposes. While some Banabans were keen to move, others were less enthusiastic, and most were concerned that if they did, they would lose sovereignty over Banaba.[45] However, plans were put on hold in 1942 when Banaba was occupied by Japanese forces, shortly after the phosphate company staff and colonial officials abandoned the 'Protectorate'. The following year the Japanese removed many of the Banabans from their island to three other locations in Micronesia: Kosrae (now part of the Federated States of Micronesia), Nauru, and Tarawa (now the capital of Kiribati, the former Gilbert Islands). In addition, almost 350 Banabans and I-Kiribati perished on the island during its occupation.[46] After the war, Australian forces reclaimed Banaba and, ostensibly because of the extent of war damage, rather than repatriate the Banabans, the British colonial government resettled them on the island of Rabi in north-eastern Fiji. The relocatees were given two years to decide whether they would stay on Rabi or return. Such an arrangement would enable the phosphate company to continue mining unhindered by the needs and presence of a local population.[47] While the majority of Banabans were opposed to relocation, they eventually conceded as a result of compulsory land expropriations and concern that an alternative environment would be necessary to sustain future generations.[48]

Rabi was an island owned by Lever Brothers, the huge British soap company which owned and operated a number of coconut plantations around Melanesia in

[42] J Connell, 'Nauru: The First Failed Pacific State?' (2006) 95 *The Round Table* 47.
[43] MacDonald, *Cinderellas of the Empire*, above n 41, 94.
[44] Silverman, *Disconcerting Issue*, above n 41, 99.
[45] ibid, 148.
[46] RK Sigrah and SM King, *Te Rii Ni Banaba* (Suva, University of the South Pacific, 2001) 257.
[47] ibid, 258–59.
[48] Kempf, 'The Drama of Death as Narrative of Survival', above n 41, 162.

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the first half of the twentieth century. Funds accumulated from phosphate royalties were used for the purchase, which was facilitated by the British colonial service in the form of the Western Pacific High Commission and the Governor of Fiji (one and the same person). The island had formerly been inhabited by Fijians, who were relocated in the village of Lovonivonu on the island of Taveuni to the south of Rabi in the pre-colonial era. Upon settling in Rabi, the Banabans set about reproducing a Banaban society in the new setting. A paradoxical condition ensued. Banabans set out to confirm both their status as the rightful inhabitants of Rabi, as well as retaining autonomy over Banaba (which was promised to them when the agreement to relocate to Rabi was settled). This proved to be less easily achieved than might have been expected. Their returns from royalties were much less than they anticipated, and at one point, the Gilbert and Ellice Islands Colony was receiving over 10 times the amount given to the Banabans.[49] By the end of the mining, the Banabans, while obtaining some payments for the phosphate, had received nothing in the order of royalties made available to the Nauru Trust Fund.

Seeking sovereignty for Banaba was a major way in which the link to the land could be sustained. It could also be used to leverage greater returns from the BPC in the mining era, and possibly as compensation in the future. In 1977, 100 young men, directed by their elders on Rabi, set up camp on Banaba while other representatives were taking legal action in London to have Banaba separated from the Gilbert and Ellice Island Colony.[50] Still more young people were sent to Banaba two years later, but on being informed that armed police might shoot to kill, the elders were forced to relent.[51] Meanwhile, the legal actions were to come to a head. They yielded relatively little joy for the Banabans, however, with the judge concluding that he was 'powerless to give . . . any relief', even though he considered that 'they have a raw deal'.[52] The finding did, however, assist in building political pressure in the United Kingdom and a A$10 million fund was established, although it took the Banabans four years before they would accept it.[53] When the last shipment of phosphate left Banaba, the machinery and plant was gifted to Kiribati, though from the perspective of King and Sigrah, this was merely a deft move to avoid spending millions of dollars in decommissioning plant and cleaning asbestos that had been used in some of the installations.[54] The island had been devastated, huge amounts of land removed and toxic waste left behind. The Banabans had no sovereign rights to the island, which became part of Kiribati upon its independence.

Anthropologist Martin Silverman wrote a detailed ethnology of Banaba/Rabi. He referred to the relationship between the people and the land of Banaba as one of mixed blood and mud—the two united and inseparable, as has been shown to

[49] Silverman, *Disconcerting Issue*, above n 41, 185.
[50] King and Sigrah, 'Legacy of a Miner's Daughter', above n 41, 950.
[51] ibid.
[52] ibid, 951.
[53] ibid.
[54] ibid.

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be the case in many other Pacific island countries.[55] People and the land were mutually constituted: blood mixed with the land and the mud was contained in the tissue of the people. Upon moving to Rabi, the mud of Banaba retained its primacy in the identity of the people and numerous strategies emerged to retain this essential linkage. Katerina Teaiwa observes a much more visceral aspect to the mud–blood thesis developed by Silverman. For her, the situation is much more complex, since a great proportion of the land (the mud) of Banaba has been removed from the island and has become scattered around the world. While acknowledging the value of Silverman's work, Teaiwa observes that he describes the mud–blood linkage, especially the notion of land, as symbolic (perhaps more socially constructed), rather than as material or real. This would infer that the link between Banaba and Banabans living in Rabi does not have a tangible reality. Reducing the link to being symbolic, or socially constructed, largely undermines its importance to those involved in the actual relationship. The mining saw 20 million tonnes of land removed from the island. This equates to roughly a little less than 32,000 tonnes per hectare. For Teaiwa, this has important consequences for the indelible mud–blood relationship. Just where is the mud now located? Obviously, a huge amount has been taken away from Banaba, just like the population. Given this, how can the mud–blood union enable the people now resident in Rabi to bond to Banaba? To what extent is the visceral connection broken, and what are the implications of this for Banaban people living away from their land? She also raises another intriguing question, though outside the scope of this chapter: how much of Banaba is now spread over New Zealand and Australia? A moot point is raised as to the possibility that this may serve as a basis for a claim to settlement in New Zealand or Australia!

The intricacies aside, it is clear that the situation for the Banabans of Rabi is ambiguous and paradoxical, even after more than 60 years have passed since their removal from Banaba. Numerous strategies have been developed to sustain the linkage to the original homeland, but the visceral mud–blood linkage may be seen as under threat. Moreover, for the people of Rabi, the ambiguity lies not only in relation to their own homeland, but to their new one as well. Fraenkel reports that the 'Banabans remain one of Fiji's most disadvantaged and politically marginalised communities. Affirmative action programmes for indigenous Fijian and Rotuman communities in the aftermath of the 1987 and 2000 coups have not been targeted at Banaban peoples.'[56] Moreover, the original inhabitants of Rabi, who were displaced to the nearby island of Fiji, are seeking to reclaim their island.[57] Kempf and Herman argue that the assertion of Banaban identity not only preserves the linkage with the land of Banaba, but is also important for Banabans positioning themselves in the context of post-colonial Fiji, which is partly marked by strong nationalist movements and coups which have the potential to threaten

[55] Silverman, *Disconcerting Issue*, above n 41, 72–79.

[56] Fraenkel, 'Minority Rights in Fiji and the Solomon Islands', above n 39, 12.

[57] 'Relocated Fiji Villagers Want Rabi Island Back', *Pacific Island Report* (5 June 2007), http://archives.pireport.org/archive/2007/june/06%2D05%2D06.htm.

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their security.[58] Clearly, the situation of these displaced people remains unsettled, both in terms of their dislocation from their original homeland and their security in their new island.

For climate migrants whose land no longer exists (either in its original state or through total inundation), Teaiwa's concerns have considerable resonance. How can this essential link exist if one of the elements no longer exists, or has been subjected to very high levels of environmental degradation? The case of Banaba/Rabi, then, should be of considerable relevance to those looking at community relocation in Pacific island countries as a response to climate change. The degradation of Banaba is not replicated in the other cases of long-distance intra-Pacific relocation. Climate change-induced degradation may be even more profound, and the implications for the relocatees even more devastating. Banaba has a 'caretaker' population physically sustaining the mud–blood union. Such arrangements may well also be the case for atolls that are facing inundation, coastal erosion or depletion, but in the end, under the most extreme scenarios, even that prospect may be rendered impossible.

All three of the international relocations discussed above took place in the context of colonialism, in particular the British colonial system in the Pacific, which included the Western Pacific High Commission (WPHC), responsible for Solomon Islands, New Hebrides (now Vanuatu), the Gilbert and Ellice Islands (now Kiribati and Tuvalu respectively) and the Colony of Fiji. The WPHC was based in Suva and at times the Governor of Fiji and the Western Pacific High Commissioner were the same individual. Movement of people among the colonies was orchestrated by the colonial services and did not require passports or contemporary protocols of residency, citizenship, visas and the like. Silverman noted a number of reasons why this is significant. Colonial administrations could make decisions about land and community locations with fewer constraints than is currently possible, where land is enshrined in laws established to protect customary land rights in the newly independent nations. Secondly, colonial administrations could easily move people across what are now international boundaries, as long as the territories were colonised by the same metropolitan power.[59]

While most Pacific island countries are now independent, as are all but one of the atoll countries (Tokelau), much can be learned from the colonial experiences. It is highly unlikely that it would be possible to transplant a community from one cultural and environmental setting to another in the contemporary Pacific. Where suitable land might become available (for instance, a freehold coconut plantation being sold, although they are no longer large in number), the descendants of the original inhabitants would most likely have priority in most countries in the region, if indeed the land was to be returned to customary ownership. Any community relocation that might take place could not be facilitated rapidly but would require

[58] Kempf and Hermann, 'Reconfigurations of Place and Ethnicity', above n 41, 369.

[59] MG Silverman, 'Introduction: Locating Relocation in Oceania' in Lieber (ed), *Exiles and Migrants in Oceania*, above n 7, 2–4.

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a long period of negotiation—between sovereign states, between communities at both origin and destination and their respective governments, and ultimately between the relocating and recipient communities themselves. Large amounts of compensation might be required for both groups, given the losses they would incur. It is difficult to see rapid, if any, progress given the barriers, not the least of which is the embodiment of Pacific island people in their land.

Relocation outside the region, if possible, would most likely be to countries such as Australia, New Zealand and the United States, where land is held in fee simple and where the current political economy is capitalist and lifestyles are individualistic. In this sense, any form of population movement would be more likely to occur as migration, with original community characteristics being considerably transformed, if not completely destroyed.

IX Conclusions

The purpose of this chapter has been to illustrate the predicament of those Pacific island communities that may be faced with extreme climate change scenarios that render their homelands uninhabitable, or may even cause them to be inundated altogether. There have been numerous calls for countries such as New Zealand and Australia to make it possible for Pacific island communities to migrate to these two countries in particular. Such calls, while well meaning, fail to account for the extremely important losses that dislocation from the land will bring about. At the same time, many observers do not appreciate the difficulties for people who are displaced to find alternative sites in their own country, even where there are lands that are less likely to be exposed to the adverse effects of climate change. Internally relocated communities are likely to suffer great losses as well.

Migration and relocation may also have major effects upon the cultures of those who are forced to relocate. I am not arguing here that climate change will devastate some Pacific cultures. Culture is ever-changing, and the fluidity of cultures and social structures in the Pacific (as elsewhere) cannot be denied. It is possible after numerous generations that relocated people may find peace, no longer yearn for the land which was part of their ancestors, and build successful and prosperous lives in other environs. But, given the strength, tenacity and indivisibility of the person–community–land bond, relocation is bound to be disruptive for a considerable length of time over many generations. Moreover, relocation is not just about severing people from their land. It is also about drastic changes in lifestyle, economy, politics, legal systems and cultural norms. Diets will change and, in the most extreme cases, there will no longer be people at home to send the important foods to those who have migrated—whether it be varieties of taro and other root and tree crops, delicacies cooked in coconut cream, or the massive range of marine resources.

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In the most extreme scenarios, Pacific communities forced to relocate as an entity (if they are lucky), or simply displaced as individuals and households, may find themselves placed in situations that are in some ways likely to be more hopeless than those faced by refugees, for the possibility of return may well be negligible. The land, once a visceral component of community and individual physicality and identity, may indeed become only a symbol of a former status.

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