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PACIFIC ISLANDS BRIEFING PAPER: KEY HARMS FROM CLIMATE CHANGE

There is little doubt that burning fossil fuels is the main source of the ever-increasing CO_2 levels in the atmosphere and associated temperature increase. The likely impacts of these changes on the worlds' oceans and the vulnerable island states that rely upon them are well documented. Although Small Island Developing States (SIDS) themselves emit negligible amounts of greenhouse gases, they face a disproportionately high level of impact from climate change[1].

Sea-level rise: Global average sea level is rising. This rise has accelerated since pre-industrial times and will accelerate further in this century, very likely rising at a faster then we have seen in the last 40 years. For high emissions scenarios the Intergovernmental Panel on Climate Change (IPCC) now predicts a 0.45 to 0.82m for the period 2081-2100. Even with aggressive emissions reductions, a rise of between 26 to 0.55m is projected for the same period.[2]

Sea levels are rising faster in the Pacific Islands than the rest of the world. According to the United Nations Environment Programme (UNEP), sea level in the island of Kosrae in the Federated States of Micronesia is rising at a rate of 10 mm per year, compared to a global mean sea level rise of 3.2mm per year. In the tropical western Pacific, where many small islands are located, the rate of sea level rise was 12 mm per year between 1993 and 2009 - about four times the global average.[3]

The IPCC recognises that island communities and low-lying areas are especially vulnerable to sea-level rise, which is expected to exacerbate inundation, storm surges, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of communities.

In 2009, a report by the International Fund for Agricultural Development (IFAD), estimated that in the Majuro atoll in the Marshall Islands and Kiribati, as much as 80% and 12.5%, respectively, of total land would be vulnerable under a 1m rise in sea level. Low-lying island states and atolls are likely to experience increased sea flooding, inundation and salinization as a direct consequence of sea level rise. In particular, estimated impacts of sea-level rise on Pacific Islands' coastal communities are quantified in 77,018 km of shoreline affected with direct costs of 1,419 million of USD per year at sub-regional level associated with 30-50 cm of sea-level rise according to the same report[4] Other dire consequences can be saline intrusion into freshwater lenses or more flooding from the sea in coastal communities.

Sea level rise could hurt valuable mangroves: Mangroves play an essential role in protecting coastlines from erosion and storms, supporting water quality and providing breeding grounds for fish. However, studies have suggested that mangrove forests in some areas will be lost as a result of elevated sea levels, with those on small islands in the Pacific being most vulnerable.[5] Using the IPCC's upper projection for global sea level rise through the year 2100, a 2006 UNEP report projected a reduction in area by roughly 12.9% of the current 524,369 ha of mangroves of the 16 Pacific Island countries and territories where

[1] UNEP 2014. Emerging issues for Small Island Developing States. Results of the UNEP Foresight Process. United Nations Environment Programme (UNEP), Nairobi, Kenya
[2] IPCC, 2014: Climate Change 2014: Synthesis Report Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, SPM 2.2 http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_All_Topics.pdf
[3] UNEP 2014. Emerging issues for Small Island Developing States. Results of the UNEP Foresight Process.
[4] IFAD "Climate Change Impacts- Pacific Islands" www.ifad.org/events/apr09/impact/islands.pdf
[5] Alongi, D.M. (2008) mangrove Forests: Resilience, protection from tsunamis and responses to global climate change. Estuarine, Coastal and Shelf Science 76: 1-13

mangroves are indigenous. . The report estimates that the loss of a single hectare of mangroves will cost local communities between 200 and 900 thousand US dollars in lost revenues, due to the importance of these plants to local ecosystem products and services.[6]

IFAD has projected a decline of mangrove area in the Pacific Islands of between 1% and 13% associated with an increase of 2 C° and 4 C° temperature increase respectively. [7]

Sea-temperature rise: The IPCC has also revealed that between 1971 and 2010, our oceans took up 93% of the heat trapped by industrial greenhouse gas emissions. Initially absorbed by surface waters, the heat is increasingly moving into the deep ocean[8]. This warming leads to rising sea levels, as well as significant impacts on biodiversity.

Ocean acidification: The oceans currently absorb approximately a quarter of the CO_2 produced by burning fossil fuels. When CO_2 dissolves in sea water it forms carbonic acid and as more CO_2 is taken up by the oceans' surface, the pH decreases, moving towards a less alkaline and therefore more acidic state. Given the most recent estimates for annual global emissions of CO_2 (around 32 Gt in 2014), it can be estimated that human activities are contributing around 1 million tonnes of CO_2 pollution to the global oceans every hour[9]. The resulting increase in acidity (decrease in pH) observed over the last 200 years likely exceeds pH changes experienced at any time over at least the last 55 million years, in terms of both extent and speed of change[10].

Such a monumental alteration in basic ocean chemistry is likely to have wide implications for ocean life, especially for those organisms that require calcium carbonate to build shells or skeletons. Ocean acidification, combined with sea surface temperature rise and sea level rise, is likely to heavily impact coral reefs, fisheries and other marine-based resources.

Coral reefs have value: Tropical coral reefs are among the most bio-diverse systems on the planet, supporting one quarter of all marine species. They sustain human society through a range of ecosystem services, such as livelihoods and food security from fisheries, revenue from tourism, erosion prevention and protection from extreme weather events through dissipation of wave energy and lessening inundation and damage during storms.

Not only do coral reefs have important biodiversity value but the ecosystem services they provide have been valued at billions of dollars a year. Approximately 850 million people live within 100 km of and derive some benefits from, coral reefs, with at least 275 million depending directly on reefs for

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[6] Gilman E, Van Lavieren H, Ellison J, Junglut V, WilsonL, Areki F, Brighouse G, Bungitak J, Dus E, Henry M, Sauni Jr I, Kilman M, Matthews E, Teariki-Ratau N, Tukia A, Yuknavage K, 2006 Pacific Island Mangroves in a Changing Climate and Rising Sea. UNEP Regional Seas Reports and Studies No 179, United Nations Environment Programme, Regional Seas Programme, Nairobi, Kenya. http://www.unep.org/pdf//mangrove-report.pdf

[7] IFAD "Climate Change Impacts- Pacific Islands" www.ifad.org/events/apr09/impact/islands.pdf

[8] Rhein, M., S.R. Rintoul, S. Aoki, E. Campos, D. Chambers, R.A. Feely, S. Gulev, G.C. Johnson, S.A. Josey, A. Kostianoy, C. Mauritzen, D. Roemmich, L.D. Talley and F. Wang, 2013: Observations: Ocean. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V.
Bex and P.M. Midgley (eds.) http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter03_FINAL.pdf

[9] Brewer, P. G. (2009) A changing ocean seen with clarity. Proceedings of the National Academy of Sciences of the United States of America 106: 12213–12214

[10] Ridgwell, A., & D. N. Schmidt (2010). Past constraints on the vulnerability of marine calcifiers to massive carbon dioxide release. Nature Geoscience 3: 196–200

livelihoods and sustenance. Reef-dependence, and consequently vulnerability to reef loss, is particularly high in small-island states, among many countries in the coral triangle (,a marine area located in the western Pacific Ocean that includes the waters of Indonesia, Malaysia, the Philippines, Papua New Guinea, Timor Leste and Solomon Islands) and among coastal populations in developing countries.[11]

In the Marshall Islands, the average height of land above sea level is approximately 2 metres[12]. Fragile fringing coral reefs are the only lines of defence against the ocean surge, and the clearance over the reef in the sections that are covered by water is usually no more than a couple of feet. As reefs like this are destroyed, and in combination with sea-level rise, these fragile defences will no longer be sufficient to protect the Islands.[13]

Coral bleaching and destruction: Unfortunately, coral reef ecosystems, are particularly vulnerable to changes in sea temperature, sea level and oceanic chemistry. A 1ºC to 2ºC change in local temperature above the normal summer maximum can lead to 'bleaching' - a stress response by the coral. Coral bleaching in 1998 and 2010 caused large-scale coral deaths in reef systems around the globe, with the 1998 event heavily impacting Palau in the Western North Pacific sub-region, and Palmyra Atoll in the Central North Pacific sub-region. In the Republic of Palau, nearly one-half (48%) of 946 surveyed colonies were totally bleached, and a further 15% were partially bleached. Coral bleaching has also been observed elsewhere in the Micronesian, Marianas, Samoan, and Hawaiian archipelagos[14]. The *Reefs at Risk Revisited*[15] report (Burke et al., 2011) predicts that by 2050 many of the reefs in the Pacific will bleach annually. This frequency of bleaching is worrying because it allows little time for corals to recover. Annual summer bleaching has already been reported from some parts of American Samoa[16].

While corals can recover from these events, repeated episodes are likely to weaken the coral ecosystem, causing a loss of biodiversity and making them more susceptible to disease. Even at the lower range of the IPCC scenarios, the world's coral reefs are facing serious and potentially devastating consequences, with one to two-thirds projected to be subject to long-term degradation.[17]

Climate change will harm key fisheries: Fisheries play a critical role in food supply and economic development in many coastal and islands states. In the Pacific, for example, per capita consumption of fish is very high by global standards; recent figures suggest that per capita annual consumption of fish ranges from an estimated 13 kg in Papua New Guinea to more than 110 kg in Tuvalu.[18] A significant

[11] UNEP Coral Reef Unit: http://coral.unep.ch/Coral_Reefs.html
[12] Environmental Issues in the Marshall Islands, at http://www.rmiembassyus.org/Environment.htm
[13] *ibid*
[14] Keener, V. W., Marra, J. J., Finucane, M. L., Spooner, D., & Smith, M. H. (Eds.). (2012). Climate Change and Pacific Islands: Indicators and Impacts. Report for The 2012 Pacific Islands Regional Climate Assessment. Washington, DC: Island Press
[15] Burke, L. M., et al. "Reefs at risk revisited: World Resources Institute." Washington, DC (2011). http://www.wri.org/sites/default/files/pdf/reefs_at_risk_revisited.pdf
[16] Keener, V. W., Marra, J. J., Finucane, M. L., Spooner, D., & Smith, M. H. (Eds.). (2012). Climate Change and Pacific Islands: Indicators and Impacts. Report for The 2012 Pacific Islands Regional Climate Assessment. Washington, DC: Island Press
[17] Arent, D.J., P. Döll, K.M. Strzepek, B.E. Jiménez Cisneros, A. Reisinger, F.L. Tóth, and T. Oki, 2014: Cross-chapter box on the water–energy–food/feed/fiber nexus as linked to climate change. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change[Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastran-drea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 163-166.
[18] FAO. 2014 The State of World Fisheries and Aquaculture 2014. Rome.223 pp: Part 3, Highlights of Special Studies

proportion of this is fish caught in near-shore habitats, including the highly vulnerable coral reef environments, with subsistence fishing being extremely important.

Climate change is projected to impact coral reef fishes by affecting their behaviour, recruitment, physiology and reproduction. This may lead to declines in abundance or changes in their distribution[19]. The FAO Expert Workshop on Climate Change Implications for Fisheries and Aquaculture[20] stated that climate change is already altering the distribution patterns of marine species, as well as changing the size and productivity of their habitats[21]. Moreover, productivity is likely to be reduced in most tropical and subtropical oceans. This report notes that 'climate change is already affecting the seasonality of particular biological processes, radically altering marine and freshwater food webs, with unpredictable consequences for fish production'[22]

Coastal erosion, infrastructure damage, property damage: While climate change is not the only reason for land loss and infrastructure damage in coastal and island communities, it is certainly an exacerbating factor. The IPCC, for example, concludes that it is *'virtually certain'* that the rates of global mean sea level rise are accelerating. Projected increases to the year 2100 superimposed on extreme sea level events (e.g. swell waves, storm surges, El Nino/Southern Oscillation) present severe sea flood and erosion risks for low lying coastal areas and atoll islands and wave over-wash of seawater will degrade fresh groundwater resources.[23]

Coastal erosion affects communities and nations (borders can even be redrawn as islands are lost), as many vulnerable individuals experience major property damage that can tip them into poverty. On Tegua Island in Vanuatu in late 2005, an entire coastal village in the north was relocated to higher ground and UNEP has classified the 100 residents of Tegua Island as one of the first communities to be moved out of harm's way as a result of climate change. At that time, UNEP reported that:

"erosion rates around the village had accelerated to between two and three metres a year"

and that:

"the one metre high coral reef, the previous line of defence against high tides and waves, was being increasingly breached'.[24]

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http://www.fao.org/3/a-i3720e/i3720e03.pdf

[19] Munday, P.L., Jones, G.P., Pratchett, M.S. & Williams, A.J.(2008) Climate change and the future for coral reef fisheries. Fish and Fisheries 9: 261-285

[20] See FAO, Report of the FAO Expert Workshop on Climate Change Implications for Fisheries and Aquaculture, FAO Fisheries Report No. 870 (Rome: FAO, 2008) 32pp. See also, FAO/COFI, 28th Session, Climate Change and Fisheries and Aquaculture, COFI/2009/8 (2009).

[21] FAO, Fisheries Report No. 870, ibid.,

[22] Ibid

[23] Nurse, L.A., R.F. McLean, J. Agard, L.P. Briguglio, V. Duvat-Magnan, N. Pelesikoti, E. Tompkins, and A. Webb, 2014: Small islands. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on ClimateChange [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi,Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White(eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1613-1654 https://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap29_FINAL.pdf

[24] http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=459&ArticleID=5066&l=en

According to the Secretariat of the Pacific Regional Environment Programme (SPREP), 'people were being forced to build sea walls and other defences not just to defend their homes, but to defend agricultural land.'[25]

Other Pacific communities have experienced similar fates. The Environment Minister of the Solomon Islands described relocation for some places in his country as the only option because the alternative, 'building a seawall, is like putting everyone inside a swimming pool'.[26] Inundation from sea level rise could submerge or harm unique Pacific Island cultural artefacts and structures and lands vital for cultural traditions.[27]

Tourism faces profound impacts from climate change:[28] Travel and tourism play a vital role in the economies of the Pacific ACP countries (PACPs) and in most countries is the major driver of economic growth and foreign exchange earnings.[29] For example, in the Cook Islands, tourism produces 90% of foreign exchange earnings and 50% of GDP. For Samoa, Fiji and Vanuatu tourism has now passed all other export industries to become the leading income earner, while in the Solomon Islands it is becoming increasingly important as the country recovers from years of civil unrest. In Papua New Guinea, tourism is increasingly important in providing employment in many regions which accommodate few other commercially viable activities.[30]

According to a recent report by the Asian Development Bank, as the world warms up, the Pacific region as a whole becomes a lesser tourism attraction and its total tourism revenues are expected to fall. The situation would steadily worsen over the century, except for a brief period around 2025 when increases in international tourists from China would outweigh decreases of tourism from other regions. By the end of the century, tourist numbers are expected to fall by about one-third. Under all climate scenarios, the impact of climate change would be to reduce tourism revenues.[31]

When the effects of coastal inundation, coral bleaching, fisheries declines, and increased health risks are combined, the effects on tourism may be larger than those due to temperature alone.

In Pacific Islands, tourism often revolves around diving, snorkelling, and enjoyment of healthy reefs and marine environments. Tourism is, however, highly vulnerable to climate change, with the World Tourism Organisation predicting that 'in the decade ahead, climate change will become an increasingly pivotal issue affecting tourism development and management'.[32] The economies of countries like the Maldives and the Seychelles are largely dependent on coral reefs through diving and other coastal

[25] http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=459&ArticleID=5066&l=en
[26] Parliament of Samoa, Hansard, 6 April 2009; http://www.parliament.gov.sb/files/hansard/8th_session/9th_meeting/Hansard-06.04.09.doc
[27] Keener, V. W., Marra, J. J., Finucane, M. L., Spooner, D., & Smith, M. H. (Eds.). (2012). Climate Change and Pacific Islands: Indicators and Impacts. Report for The 2012 Pacific Islands Regional Climate Assessment. Washington, DC: Island Press
[28] http://www.cisl.cam.ac.uk/business-action/low-carbon-transformation/ipcc-briefings/pdfs/briefings/ipcc-ar5-implications-for-tourism-briefing-prin.pdf/view
[29] 2013 HOPS SPTO Tourism Statistics – An Assessment
[30] *ibid*
[31] http://www.adb.org/sites/default/files/publication/31136/economics-climate-change-pacific.pdf
[32] Climate Change and Tourism: Responding to Global Challenges; Summary October 2007 of Report prepared by the UNTWO, UNEP and WMO to provide background information for the 2nd International Conference on Climate Change and Tourism (Davos, Switzerland 1-3 October 2007), p4, http://www.unwto.org/climate/support/en/pdf/summary_davos_e.pdf

tourism[33] and the degradation and extinction of coral reefs, together with accelerated beach erosion, will severely affect the economies of countries in similar positions.

Extreme precipitation, flooding, drought: Pacific Island States, with scarce rainfall and small aquifers, can ill afford to cope with rainfall anomalies linked with climate change, droughts, extreme precipitation, and the associated flash floods. The latter can lead to loss of soil fertility and ruined crops as well as harm to people and infrastructure. Pacific Islands have very vulnerable water resources, especially smaller islands. Residents are mostly dependent on small, fragile freshwater-lens systems and rainfall catchments for their drinking water. During periods of low rainfall, rainfall catchment supplies become depleted leaving residents with groundwater from the freshwater lens as their sole source.

Droughts increase demand on low islands' limited freshwater resources, while sea-level rise, intense storms, and extreme tides threaten water quality and local agriculture, making these communities some of the most sensitive to climate-induced changes in water supply[34].

Pacific islands are vulnerable to tropical cyclones: In the last 60 years, the Pacific Region from Taiwan to New Zealand in latitude and from Indonesia to east of Hawaii in longitude has experienced more than 2,400 tropical cyclones – or about 41 per year. Almost 1,000 of these formed south of the equator and 1,400 formed north of the equator. The maximum wind speeds generated by these events range from 74-95 mph for a Category 1 storm to 155 mph for Category 5 storm (as measured on Saffir-Simpson scale)[35] .

The damaging factors of tropical cyclones are wind speed, precipitation and coastal surge and many of these storms have impacted one or more of the PICs[36] causing widespread destruction, high economic losses, and many casualties (injuries and fatalities).[37]

A study by the United Nations found that:

> "In the short to medium term destruction of standing crops, physical infrastructure threats and housing can be severe, calling for a substantial relief and rebuilding effort. GDP can decline sharply and remain depressed for some time and with the likely consequence of considerable macroeconomic instability. In the longer term, damage to productive assets can lead to serious loss of output and economic growth and living standards"[38].

[33] Westmacott, S, Cesar H Pet-Soede L (2000), "Socioeconomic assessment of the impacts of the 1998 coral reef bleaching in the Indian Ocean", in Westmacott, S, Cesar, H, Pet Soede, L, De Schutter, J, "Assessing the socioeconomic impacts of the coral reef bleaching in the Indian Ocean", CORDIO report submitted to the World Bank African Environment Department, Washington DC.

[34] Keener, V. W., Izuka, S. K., & Anthony, S. (2012). Freshwater and Drought on Pacific Islands.In V. W. Keener, J. J. Marra, M. L. Finucane, D. Spooner, & M. H. Smith (Eds.), Climate Change and Pacific Islands: Indicators and Impacts. Report for the 2012 Pacific Islands Regional Climate Assessment (PIRCA). Washington, DC: Island Press.

[35] The World Bank: PCRAFI Risk Assessment Summary Report 2013, http://reliefweb.int/sites/reliefweb.int/files/resources/PCRAFI_2013_Catastrophe_Risk_Assessment_Methodology28082013.pdf

[36] PICs - 15 Pacific Island Countries assessed for risk by Pacific Catastrophe Risk Assessment and Financing Initiative *(Cook Islands (New Zealand), Federated States of Micronesia, Republic of Fiji, Republic of Kiribati, Republic of Nauru, Niue (New Zealand), Republic of Palau, The Independent State of Papua New Guinea, Republic of the Marshall Islands, Samoa, Solomon Islands, Democratic Republic of Timor-Leste, Kingdom of Tonga, Tuvalu, and Republic of Vanuatu)*

[37] World Bank: PCRAFI Risk Assessment Summary Report 2013

[38] The Economic Impact of Natural Disasters In the South Pacific, http://ict.sopac.org/VirLib/DM0001.pdf

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In the future, as temperatures rise, climate change is likely to amplify the destructive effects of tropical cyclones. Theoretical and model experiments show warmer seas drive more intense storms in the future, although the total number is not expected to increase. According to the most recent IPCC Assessment, the global frequency of occurrence of tropical cyclones will either decrease or remain essentially unchanged but it is likely that both global mean tropical cyclone maximum wind speed and precipitation rates will increase[39] .

A recent study has indeed found that the intensity (wind speed) of cyclones of all strengths in the South Pacific has increased by 2.5 metres per second per decade, with the strongest 20% increasing by as much as 5 metres per second per decade[40] .

In a warmer world, a combination of rising sea levels and more-intense tropical cyclones may increase the damage caused by an individual cyclone, even if the overall number of cyclones decreases. As well as climbing temperatures creating stronger winds, rising sea levels mean that when storm surges hit, the flooding impact is likely to be higher.

In March 2015, the South Pacific basin witnessed the second most intense cyclone (by pressure) on record. Cyclone Pam was one of only ten storms in the waters east of Australia ever rated Category 5 by the Joint Typhoon Warning Center (JTWC). The official tropical cyclone warning centre for the area, the Fiji Meteorological Service, estimated that Pam's central pressure bottomed out at 896 mb, making it the second most intense tropical cyclone in the South Pacific basin after Cyclone Zoe of 2002. At least eleven were killed, 132,000 people impacted, and damages were at least USD100 million. Cyclone Pam also had the highest 10-minute sustained wind speed of any South Pacific tropical cyclone[41].

Agriculture and drinking water: Rising sea levels are having an impact on fresh water and food production in many Pacific Island States. According to a submission from the Pacific Small Island Developing States to the 64th Session of the UN General Assembly in September 2009, rising sea levels have left salt deposits in the soil and contaminants in the groundwater supply and additionally, floods and rogue waves raise the saltwater table under atolls, poisoning staple crops. Already some farmers are forced to grow their taro in tin containers. Additionally, some of the smaller islands in the atolls have lost their coconut palms to saltwater intrusion[42]

The majority of rural Pacific Islands' people live off of subsistence agriculture, making farming losses a food security issue for the most vulnerable. For instance, over 65% of Vanuatu's people rely on subsistence agriculture (yam, taro and banana).

[39] Christensen, J.H., K. Krishna Kumar, E. Aldrian, S.-I. An, I.F.A. Cavalcanti, M. de Castro, W. Dong, P. Goswami, A. Hall, J.K. Kanyanga, A. Kitoh, J. Kossin, N.-C. Lau, J. Renwick, D.B. Stephenson, S.-P. Xie and T. Zhou, 2013: Climate Phenomena and their Relevance for Future Regional Climate Change. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change[Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA http://www.ipcc.ch/pdf/assessment report/ar5/wg1/WG1AR5_Chapter14_FINAL.pdf

[40] Trend Analysis with a New Global Record of Tropical Cyclone Intensity, Journal of Climate, *Kossin et al,* http://www.ssec.wisc.edu/~kossin/articles/Kossin_et_al_2013_JClim.pdf

[41] Dr Jeff Masters, Weather Underground, http://www.wunderground.com/blog/JeffMasters/comment.html?entrynum=2960

[42] PSIDS (2009) Views on the Possible Security Implications of Climate Change to be included in the report of the Secretary General to the 64th Session of the United Nations General Assembly. http://www.un.org/esa/dsd/resources/res_pdfs/ga-64/cc-inputs/PSIDS_CCIS.pdf

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According to a 2011 report prepared for the Australian Government, changes in the time of fruiting of certain species have been reported; for example, breadfruit, mango and citrus, are fruiting over an extended period and/or are showing shifts in the fruiting season. In the Torres Group (Vanuatu), yams planted in the normal planting season are reported to be no longer performing well. Changes in weather patterns are likely to mean that farmers will have to reconsider planting seasons.

An increase in the minimum temperature could affect the spread of the taro leaf blight disease which, in 1993, destroyed taro cultivation in Samoa. The impact of a warmer night temperature will enable sporulation at night, increasing the incidence of the disease. Countries such as Fiji, Tonga and Cook Islands are all vulnerable to the disease due to the susceptibility of their taro varieties[43].

Besides food security, Pacific states depend on cash crops like sugar cane, banana and non-timber forest products for foreign exchange. IFAD concludes that, in the absence of adaptation, a high island such as Fiji, could experience damage of USD 23 million to 52 million per year by 2050. The overall change in agricultural welfare is expected to range between -8 and +4 billion USD per year facing with 2-4 C° temperature increase.[44]

Climate change negatively impacts health outcomes: Climate change will continue to affect human health on the Pacific Islands. Low islands and coastal communities in the WNP sub-region are especially vulnerable due to their low elevation, small land mass, geographic isolation, and limited potable water sources and agricultural resources. Sea-level rise and more frequent inundation by king tides and tropical cyclones may not only contaminate limited groundwater resources but also overcome basic sanitary systems and agricultural fields.

There is a growing concern in island communities in the Caribbean Sea and Pacific and Indian Oceans that freshwater scarcity and more intense droughts and storms could lead to a deterioration in standards of sanitation and hygiene. In such circumstances, increased exposure to a range of health risks, including communicable (transmissible) diseases would be a distinct possibility[45].

Given that many vector- and water-borne diseases are weather-influenced, climate change impacts on low islands and coastal communities allow for malaria, dengue, diarrhoea and other diseases to increasingly infect some Pacific Island populations. The young, the elderly, and those with pre-existing medical conditions are especially vulnerable to these diseases[46].

Ciguatera fish poisoning (CFP) occurs in tropical regions and is the most common non-bacterial food-borne illness associated with consumption of fish. Distribution and abundance of the organisms that produce these toxins are reported to correlate positively with water temperature. Consequently, there is

[43] Food security in the Pacific and East Timor and its vulnerability to climate change. © Commonwealth of Australia (Department of Climate Change and Energy Efficiency) 201

[44] IFAD "Climate Change Impacts- Pacific Islands" www.ifad.org/events/apr09/impact/islands.pdf

[45] Nurse, L.A., R.F. McLean, J. Agard, L.P. Briguglio, V. Duvat-Magnan, N. Pelesikoti, E. Tompkins, and A. Webb, 2014:Small islands. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on ClimateChange [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi,Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel,A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White(eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1613-1654.

[46] http://www.cakex.org/sites/default/files/documents/NCA-PIRCA-FINAL-int-print-1.13-web.form_.pdf

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growing concern that increasing temperatures associated with climate change could increase the incidence of CFP in Pacific island regions[47].

The IPCC also notes that in the Pacific many of the anticipated health effects of climate change are expected to be indirect, connected to the increased stress and declining well-being that comes with property damage, loss of economic livelihood, and threatened communities[48].

[47] Nurse, L.A., R.F. McLean, J. Agard, L.P. Briguglio, V. Duvat-Magnan, N. Pelesikoti, E. Tompkins, and A. Webb, 2014: Small islands. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi,Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White(eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1613-1654.

[48] ibid