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RESEARCH LETTER

Renewable energy can enhance resilience of small islands

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Abstract
This paper summarizes some of the ways in which increased use of renewable energy can reduce vulnerability of nations and communities to hydro-meteorological disasters (i.e. enhance their *resilience*). It uses examples mainly from the small island countries of the Pacific, as the issues raised are particularly pertinent there. In particular, distributed electricity generation reduces vulnerability of supply to severe weather.

Keywords Resilience · Small Island Developing States · Renewable energy · Remote islands · Hydro-meteorological disasters

1 Introduction

This paper summarizes some of the ways in which increased use of renewable energy (RE) can reduce vulnerability of nations and communities to hydro-meteorological disasters (i.e. enhance their *resilience*). It uses examples mainly from the small island countries of the Pacific, as the issues raised are particularly pertinent there.

Energy security refers to the reliability of energy supplies on which modern economies rely. It is a major issue in many countries after a disaster event. A well-documented case is the small Caribbean island of Puerto Rico in the months following Hurricane Maria in 2017. Even though it is a US Territory, most families and businesses there remained without power, cell phone service was limited, and clean water, food, medicine and fuel were all in very short supply (Mercy Corps 2020). The performance then of photovoltaic systems, installed either before or shortly after the hurricane, offers lessons for other island countries, including Small Island Developing States (SIDS) (Limperis 2017).

Modern interest in energy security dates from the dramatic increases in price and decreases in availability of petroleum products in the 1970s. The primary concern then was on ways in which countries could reduce the cost of the imported oil on which their economies depended (Foley and Nassim 1976; Laird 2001). This included even Small Island

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Developing States, in many of which the cost of imported oil was comparable to the value of all their exports (Newcombe et al. 1982). This prompted an interest in ‘new and renewable’ sources of energy. Moreover, it has become increasingly clear since the IPCC’s First Assessment Report in 1990 that climate change, driven by the still increasing use of fossil fuels, is making climatic disasters more intense and (in some areas) more frequent, such as from hurricanes, floods, droughts and wildfires (IPCC 1992, 2014).

2 Pacific Islands: vulnerability and political framework

The 14 independent Pacific Island Countries (PICs) comprise many islands scattered across a very large area of ocean. For example, Fiji has over 300 islands, though two are much larger and more heavily populated than the rest. The geographical fragmentation of the Pacific island countries, their remoteness and their small size are fundamental constraints on their economic development (Briguglio 1995; Connell 2013).

These island countries are particularly vulnerable to climate change and sea-level rise (Nurse et al. 2014). Hydro-meteorological disasters (especially cyclones) already hit economies and populations hard. Cyclones are projected to become stronger under climate change (IPCC 2019, sec B3.6). Saltwater inundation due to sea-level rise (coupled with storm surges) threatens all atolls (which includes 3 whole Pacific countries: Kiribati, Tuvalu and Marshall Islands) (Storlazzi et al. 2018; Weir and Virani 2011). Also threatened are coastal settlements (which is where most traditional villages are located even in the hillier countries, such as Fiji). This vulnerability results in high economic and non-economic costs. It has been estimated that since 1950, extreme events have affected approximately 9.2 million people in the Pacific, with 9811 reported deaths and damages of USD 3.2 billion (World Bank 2012). Some PICs have experienced natural disaster losses that, in any single year, have approached and in some cases even exceeded their Gross Domestic Product (GDP) as illustrated by super-cyclones Pam (GOV 2015) and Winston (GOF 2016). With Cyclone Harold, which hit Vanuatu in 2020, losses were accentuated by the COVID-19 pandemic, which had forced tourism (the main industry) to shut down.

Consequently, Pacific Island governments, and the various regional organizations that serve them, are very concerned about sustainable development, and in particular about the extent to which it is threatened by climate change (Pacific Islands Forum 2018). A key document is the *Framework for Resilient Development in the Pacific*, developed and agreed in 2016 by the main regional organizations working on climate change (FRDP 2016). The Framework outlines an ‘integrated approach to address climate change and disaster risk management’. It offers to island governments (and regional organisations) a set of ‘voluntary guidelines for the Pacific region’. Of particular relevance is Goal 2, Low Carbon Development, about which the Framework notes:

> ‘This goal will contribute to having more resilient energy infrastructure in place, and to increase energy security, while decreasing net emissions of greenhouse gases’.

In particular, there is already significant RE installed in most Pacific Island countries, especially in the form of ‘centralized’ hydropower on the larger hillier islands and solar photovoltaic (PV), which in the form of small-scale ‘solar home systems’ sets is widespread especially in more remote areas and islands (Weir 2018), but has also been taken up in Suva’s informal settlements (Devi et al. 2017). With the price of PV having greatly fallen over the past decade, expansion of PV capacity—including grid-connected

PV—is expected to increase further, usually with assistance from external donors such as the World Bank, the Asian Development Bank and the aid agencies of Korea, Australia, New Zealand and Japan.

Greenhouse gas emissions from PICs are only a tiny contribution to global emissions ($<0.1\%$). So, even cutting island GHG emissions to zero would make negligible physical impact on sea-level rise, which coupled with storm surges, threatens to make much of Kiribati and other atoll states uninhabitable within 30 years (Storlazzi et al. 2018). But such action can nevertheless increase resilience in the medium term and set a strong moral example to those larger nations which dominate global emissions, as recognized by the 2018 meeting of island leaders (Pacific Islands Forum 2018).

3 Some specific examples

More specifically, we list here some examples of how RE is already contributing to energy security and disaster recovery, and can do so even more in future.

Distributed RE is less vulnerable than centralized systems to storm damage to electrical transmission lines. In Puerto Rico after Hurricane Maria, several PV-based microgrids were installed. These proved able to isolate themselves from the main grid and continue to provide power, when the grid was damaged again by an earthquake in January 2020 (Peters 2020). As an example of the vulnerability of centralized systems, a storm brought down the lines from eastern Australia to the state of South Australia in 2016, which triggered automatic shutdown of the wind turbines in SA, which were then providing most of the power in SA (AEMO 2017). Resetting the thresholds and installing a large storage battery have since stabilized the SA supply (Parkinson 2019). On the hilly main island of Fiji, centralized hydropower is a major source of electricity but the heavy rain associated with tropical cyclones usually brings down by landslips the pylons and transmission lines in the rugged country between the mountains where the hydro-dam is located and the main towns on the coast. In our personal experience, it routinely takes 2–3 weeks to restore power and water supply (pumped by electricity) to the main towns, but recovery can take much longer where a strong cyclone makes landfall (e.g. TC Harold in Vanuatu in 2020).

Photovoltaic (PV) panels can withstand cyclones if well fastened. For example in Tonga, there was 3 MW of grid-connected PV on the island of Tongatapu, essentially all of it in ground-based ‘solar farms’ operated by the national utility, Tonga Power Ltd. These installations notably survived Tropical Cyclone Gita, which went over them in 2018. On that flat island, the distribution system (which is readily accessible) was restored in a few days. Following Hurricane Maria, NREL and others analysed which PV installations survived or failed to survive in Puerto Rico, Antigua and Barbuda and the US Virgin Islands. The best were ground-based systems with strong and deep foundations (up to 2 m) and robust bolting together of the metal framework holding the panels (Burgess and Goodman 2018; Hotchkiss 2018; Limperis 2017).

There are now tens of thousands of ‘solar home systems’ operating in the rural areas and remoter islands of the Pacific. Each comprises a small PV panel, with batteries and ancillaries sufficient to meet the basic needs of a single house for lighting, cooling (fans) and recharging of small devices, at much lower cost than fossil alternatives (Marshall Islands 2018). In the newer installations, the PV panels are mounted on the ground or on special poles which withstand cyclones better than most Pacific rooftops (Weir 2018). Many

households also have at least one portable 'solar lamp'. All this enables repairs and other services (e.g. nursing and communications) to operate when they are most needed.

Less reliance on erratic supplies of imported fuel. PV systems enable power for telecommunications, lighting and refrigeration (especially of fish and medicines) to continue after fuel supplies are cut off. This is particularly important for communities on islands away from the main port of a country, as all fuel for such places, used for outboard motors and also for diesel generators (where they have not been replaced by PV) has to be trans-shipped by small boats, whose service is often erratic at the best of times. In the current pandemic, quarantine rules discourage even supplies to the main port.

Cost variations in energy have a drastic impact on the budgetary provisions for disaster recovery in small economies. Since RE costs are mainly capital and thus fixed, this is a further reason to diversify into renewables and reduce dependency on imported fossil fuels.

Drinkable water is often paradoxically difficult to find after a cyclone or other disasters. Although they are fairly rare in the Pacific because of the high average rainfall on most islands, robust solar-powered water pumps and desalination units can meet this need; such units are commercially available and in wide use in Africa (Qazi 2017, ch 5).

4 Discussion

The concept of resilience, though closely related to 'adaptive capacity', is often taken to have more emphasis on capacity of a community to cope in the immediate aftermath of a hazard event. Short-term needs include having on the spot a trained first aider and supplies kept specially of drinkable water and preserved foods. Various national organizations, notably the Red Cross, strongly support such preparedness. For energy, it requires the robust energy equipment to be already in place, and not contingent on delivery from some aid centre in the capital as some of the literature envisages [e.g. (Boguess 2017)], as such delivery can take weeks or even months to 'outer islands' in some PICs.

In the Pacific Islands, resilience on all time frames is greatly assisted by social capital in the form of the still strong traditional culture of self-help across a community (village) (Nakamura and Kanemasu 2020; Neef et al. 2018; Warrick et al. 2017). This factor may not be so strong elsewhere.

How can sustainable and reliable energy supplies be further encouraged in the islands? Hydroelectric systems have been funded mainly by loans to utilities. In several PICs, official foreign aid has provided the capital for solar farms on the main island at what, in the island context, is utility-scale (0.5–5 MW). These are all operated by the local utility with trained technicians; more such installations are planned. In countries where the demand warrants it (e.g. Fiji) consideration should be given to encouraging feed-in systems, including by commercial operations such as hotels, as well as by households (who are thus spared the cost of batteries); this may need more suitable tariffs than now offered. Current policies inhibit such feed-in. In smaller countries, the utility is concerned about possible lack of reliability and stability; for this reason, Marshall Islands has regulations against such feed-in connections (Marshall Islands 2018). In Fiji, the main source for the national utility (EFL) is a large hydroelectric plant, so stability is less of a concern, but 'independent power producers' who had intentions to provide PV or biomass power to supplement EFL's traditional sources have been discouraged by the legal 'exclusivity' that the utility has and other rather stringent requirements, such as ensuring that it is 'beneficial to Fiji from a system-integrity perspective'.

Aid and internal government funding have also provided the capital cost of many small solar home systems for off-grid locations, though many others have been privately funded; a major issue for these is ensuring maintenance and cash flow for continuing operation, including battery replacement as required (Weir 2018). Particular consideration should be given to microgrid systems which would normally be grid-connected but can be operated independently as separate 'islands' if the grid goes down in an emergency.

The book by Qazi (2017) is a useful text on the basics of a variety of PV systems, but his discussion of PV use in disasters emphasizes the use of 'mobile systems' (e.g. mounted in a shipping container) which can be quickly deployed to areas needing power but still fairly accessible by road or other transport. Such areas are rare in archipelagic island states like most of the Pacific Islands. A report for the World Bank on resilience of power systems focuses on large-scale utilities, for which it rightly emphasizes the importance of system-wide risk analysis (Brown et al. 2016).

5 Conclusions

Renewable energy (RE), coupled with improved energy efficiency, can enhance island resilience to natural hazards and economic shocks by reducing the need for expensive and sometimes unreliable fuel imports. There is significant use of RE in the Pacific Islands already and potential for more. Distributed electricity generation reduces vulnerability of supply to severe weather.

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