Review Paper

Putting WASH in the water cycle: climate change, water resources and the future of water, sanitation and hygiene challenges in Pacific Island Countries

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ABSTRACT

The Pacific region presents some of the lowest water and sanitation coverage figures globally, with some countries showing stagnating or even declining access to improved water and sanitation. In addition, Pacific Island Countries (PICs) are among the most vulnerable countries on the globe to extreme and variable climatic events and sea-level rise caused by climate change. By exploring the state of water and sanitation coverage in PICs and projected climatic variations, we add to the growing case for conserving water, sanitation and hygiene (WASH) interventions within a holistic integrated water resource management (IWRM) framework. PICs face unique challenges of increasing variability in rainfall (leading to drought and flooding), increasing temperatures, and likely higher than average sea-level rise, all of which impact on freshwater security. Add to this geographic and economic isolation, and limited human and physical resources, and the challenge of WASH provision increases dramatically. In this setting, there is a stronger case than ever for adopting a holistic systems understanding, as promoted by IWRM frameworks, to WASH interventions so that they consider past and current challenges as well as future scenarios.

Key words | adaptation, adaptive capacity, integrated water resource management, sustainable development, vulnerability

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INTRODUCTION

The delivery of water, sanitation and hygiene (WASH) services represents a significant challenge in many developing countries, including those in the Pacific (WHO 2013). Although water and sanitation coverage is increasing in many regions around the globe, overall conditions remain poor and many Pacific Island Countries (PICs) are far from reaching their Millennium Development Goals (MDGs) by 2015 (WHO 2013). While there is great diversity within the 15 PICs, six of these are rated as Least Developed Countries according to the United Nations (UN 2014). The isolated geography of PICs, combined with small and predominantly rural populations, limited resources and diverse

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cultures make the provision of WASH services challenging. PICs can also be typified as having costly access to markets and supply chains (affecting investment in WASH infrastructure and maintenance) as well as limited human and technical resources (Briguglio 1995).

For more than 20 years now the WASH challenges already faced by communities within the Pacific have been intensified by climate change impacts (Meehl 1996; Mimura *et al.* 2007). Indeed, in 2013, a report from the World Health Organization (WHO) Regional Office for the Western Pacific stated that '…WASH statistics, associated with a less than optimum management of water resources may aggravate the gloomy perspectives brought about by climate change, which appears to be exacerbated in the Pacific islands. Drinking-water and sanitation relies on water governance and water resources management and this is closely linked with climate change in the Pacific islands' (WHO Regional Office for the Western Pacific 2008). This tight relationship between water availability (and accessibility), water quality, sanitation and hygiene underpins the need for WASH interventions and continued investment in Pacific communities (Meehl 1996). In addition to non-climatic pressures, the long-term pressures from climate change further threaten the sustainability of water and sanitation services in many vulnerable PIC communities (Meehl 1996; Mimura *et al.* 2007). This is not just through incremental changes in climate that have been projected, but also through extreme events such as floods, cyclones and droughts associated with climate change which can render safe communities more vulnerable to WASH-related problems during extreme events (White & Falkland 2010).

To better incorporate issues of water security, water quality and climate change into WASH activities, there is a case for a broadening of the focus of WASH to encompass a 'whole of catchment' and more integrated understanding of the water cycle. Critically, there may be a number of places within the water cycle where interventions can improve the availability and quality of water resources. These interventions may in turn reduce risks within WASH systems. For example, if actions are taken to protect water quality, possibly through riparian restoration and improved land management practices (Dosskey *et al.* 2010), the health risks associated with poor water quality can be reduced (Jagals *et al.* 1997). Furthermore, by adopting a more holistic approach to WASH, services may be designed and delivered in a way that builds resilience in communities, potentially buffering them from some of the impacts of climate change and associated extreme events like droughts and floods (Hadwen *et al.* 2012).

The purpose of this paper is to: (1) review the current state of WASH in PICs; (2) review the threat that climate change poses to water security (and therefore WASH success) in PICs; and (3) outline the case for an integrated water resource management (IWRM) approach to WASH, with a view to building resilience and adaptive capacity in Pacific communities, especially those that are particularly vulnerable to the water-related impacts of climate change.

A REVIEW OF WASH IN THE PACIFIC

Drinking water and sanitation coverage in most PICs falls short of global averages. The MDG target of halving the proportion of the global population without access to improved drinking water was met in 2010 (WHO & UNICEF 2014). While sanitation will miss the global MDG target, nearly 2 billion people gained access from 1990 to 2013; additionally, a target that also included access to shared sanitation facilities would have been met in 2014 (Cumming *et al.* 2014). While this global progress is a major achievement, it is not consistent for all regions. The MDG region of Oceania (American Samoa, Cook Islands, Fiji, Guam, Kiribati, Marshall Islands, Micronesia (Fed. States of), Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea (PNG), Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, and Vanuatu), which includes 15 PICs, lags behind in drinking water and sanitation access (Table 1).

The 2012 Joint Monitoring Programme (JMP) data on drinking water and sanitation coverage illustrates the deficit between the Oceania region and the rest of the world. Oceania has the lowest proportion of population (56%) with improved drinking water, lower than Sub-Saharan Africa and South Asia, with over 30% relying on raw surface water. The 2012 sanitation data are also dire, with only 35% using improved facilities and 12% practicing open defecation (WHO & UNICEF 2014). Progress in sanitation has been stagnant in Oceania with the percentage using improved facilities declining slightly between 1990 and

Table 1 | Percent improved water and sanitation coverage in PICs (data from the WHO & UNICEF Joint Monitoring Program – JMP 2014)

		% Water coverage (total improved)		% Sanitation coverage (total improved)	
Country	**Population (×1,000)**	**Urban**	**Rural**	**Urban**	**Rural**
American Samoa	70.7	100	100	62.5	62.5
Cook Islands	20.5	99.9	99.9	97.2	97.2
Fiji	874.7	100	92.2	92.1	81.7
French Polynesia	273.8	100	100	97.1	97.1
Guam	162.8	99.5	99.5	89.8	89.8
Kiribati	100.8	87.4	50.6	51.2	30.6
Marshall Islands	55.7	93.4	97.5	84.2	55.5
Micronesia (Fed. States of)	103.4	94.8	87.4	85.1	49.0
Nauru	10.4	96.3	ND	65.6	ND
New Caledonia	253.2	98.5	98.5	100.0	100.0
Niue	1.4	98.5	98.6	100.0	100.0
Northern Mariana Islands	62.2	97.5	97.5	79.7	79.7
Palau	20.8	97	ND	100.0	100.0
Papua New Guinea[a]	7,167.0	88	32.8	56.4	13.3
Samoa	188.9	97.4	98.8	93.3	91.1
Solomon Islands	549.6	93.2	77.2	81.4	15.0
Tokelau	1.1	ND	97.4	ND	92.9
Tonga	104.9	99	99.4	99.4	88.9
Tuvalu	9.9	98.3	97	86.3	80.2
Vanuatu	247.3	97.8	88.3	65.1	55.4
Total	10,279.0	94.3	44.5	75.7	23.6

[a]The comparatively large population of Papua New Guinea has a strong influence on the statistics of total water and sanitation coverage for the region.
ND signifies situations where there are no, or insufficient, data.

2012, in stark contrast to the progress made in all other MDG regions (Figure 1). The reality may be even worse than reported; key local stakeholders have expressed concern that JMP estimates of sanitation coverage for Oceania seem 'exceedingly optimistic' (WHO & SOPAC 2009).

While regional averages provide insight into the need for drinking water and sanitation progress, they also mask the differences between and within PICs (Table 1). Regional averages are strongly influenced by coverage in PNG, which represents approximately 70% of the population of the Oceania MDG region.

The proportion of investment of overseas development aid (ODA) into water and sanitation in Oceania is high (>10%), but the amount spent per capita is relatively low – one of only three MDG regions with spending in water and sanitation below USD100 per capita over 2000–2010 (Bain *et al.* 2013).

Particular challenges in the Pacific include a high reliance on community rather than household connections for water, in countries that are still predominantly rural. During the MDG period a 'surprise' of increasing access was household connections, an increase that did not translate to the Pacific context (Bain *et al.* 2013). This is partly due to the challenging complexity of freshwater resources throughout the Pacific and the limited human and financial capacity of many countries. Commonly, small rural communities are too remote and, therefore, expensive to equip with improved water and sanitation, while urban centers struggle to deliver the same services because infrastructure consistently lags behind urban expansion (Poustie & Deletic 2014). Despite regional efforts and frameworks for action (SOPAC & ADB 2003), there remains a lack of planning specifically directed to advance communities towards global water and sanitation

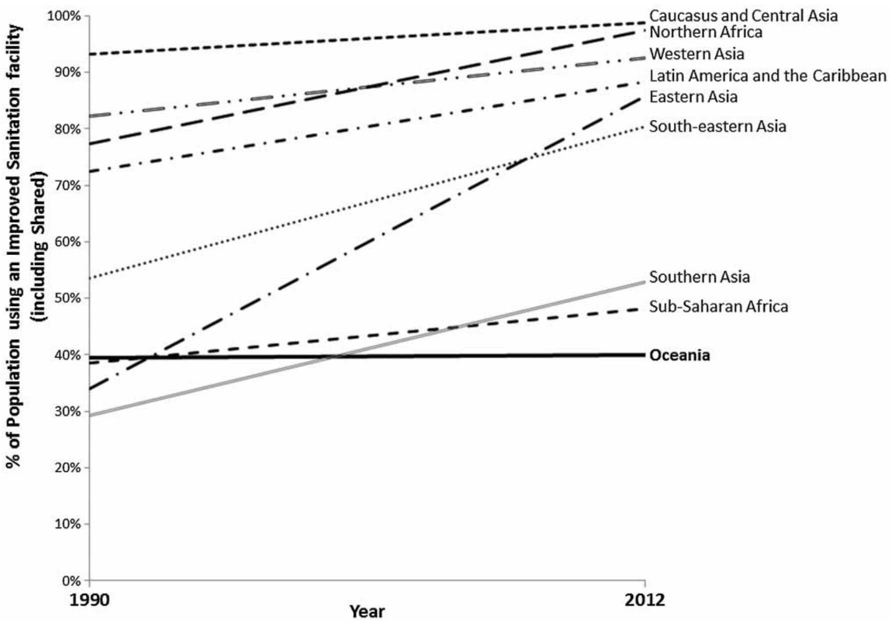

Figure 1 | Percentage of population in MDG regions using an improved sanitation facility (including shared) between 1990 and 2012.

goals (WHO & SOPAC 2009). One particular challenge is the poor absorptive capacity of governments in the Pacific to build, operate, and maintain, and provide supportive enabling environments, and many (for example, the Solomon Islands) provide examples where the disbursements of ODA funding cannot keep up with ODA commitments. Additionally, and as this paper describes, many of these states are vulnerable – not only to climate change impacts, but also to unstable political environments (particularly in Melanesia where cultural won tok allegiances are often stronger than nation allegiances) and conflict (WHO & SOPAC 2009).

A REVIEW OF CLIMATE CHANGE IN THE PACIFIC WITH EMPHASIS ON WATER RESOURCES

Due to their limited size, geology, and topography, freshwater resources on small islands are extremely vulnerable to changes in climate and rainfall (Mimura *et al.* 2007; Hanna 2013). Multi-model global climate projections point to increases in global average water vapor, evaporation, and precipitation over the 21st century (IPCC 2013a; Kirtman *et al.* 2013). The outputs also suggest that precipitation will generally increase in the areas of regional tropical precipitation maxima, including the tropical/equatorial Pacific in particular, where increases in annual precipitation may exceed 20% (Perkins *et al.* 2012; IPCC 2013a). Heavy precipitation events are very likely to become more frequent, and the intensity of these events is projected to increase, particularly in the tropics (IPCC 2013a, 2013b). A range of models also indicate tropical cyclones will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases in tropical sea surface temperatures (IPCC 2013b). With the caveat of a large uncertainty in projections for this region, the ensemble projections for the group of South Pacific nations including the Cook Islands, the Solomon Islands, and Tuvalu, are that average rainfall during the wet season is projected to increase; while for Vanuatu, Tonga, Samoa, Niue, and Fiji, this increased rainfall during the wet season is accompanied by a decrease in dry season rainfall (Christensen *et al.* 2013).

Immediate/direct climate change impacts on water resources can occur via: (1) precipitation (Meehl 1997; Perkins *et al.* 2012); (2) the resultant intense runoff (Samaniego & Bardossy 2006; Arnell *et al.* 2011) and flash flooding leading to the temporary contamination of drinking water supplies impacting on water quality; (3) the safety of groundwater, including slower recharge as well as saline intrusion from reduced freshwater flow (Roy & Connell 1991; Chui & Terry

2013); and (4) changes in seasonality/timing of precipitation (Meehl 1996; Irving *et al.* 2011). Impacts on atolls may be particularly severe, e.g., a 10% reduction in average rainfall (by 2050) would lead to a 20% reduction in the size of the freshwater lens on Tarawa Atoll, Kiribati (Mimura *et al.* 2007).

Indirect impacts of climate change on water resources are likely to occur due to: (1) pressure on ecosystems and biodiversity and subsequent changes, e.g., changes in favored forest/tree species, desertification (Amadore *et al.* 1996); (2) demographic changes as populations are displaced, including the resultant increase in urbanization; (3) changes to agro-ecosystems and implications for food security (World Bank 2000; Hanna 2013); (4) potential for contamination of water resources as changes/pressures occur, e.g., changes to runoff and sedimentation under changed precipitation intensity, frequency, and locations; changing sanitation patterns/practice and public health with demographic and temperature change (Singh *et al.* 2001; Miller *et al.* 2013); and (5) sea-level rise (WHO & SOPAC 2009).

The global mean sea level is projected to rise by 40–63 cm by the year 2100, mainly due to thermal expansion of the ocean (IPCC 2013a), with some estimates of up to an 88 cm sea-level rise in the PICs by 2100 (Miller *et al.* 2013). Sea-level rise is predicted to have significant impacts in four main areas: (1) coastal wetland change (Ellison 2009); (2) increased coastal flooding (Pittock *et al.* 1996); (3) increased coastal erosion (Leatherman 1996); and (4) saltwater intrusion into estuaries, deltas, and groundwater (McLeod *et al.* 2010; Chui & Terry 2013; Morgan & Werner 2014). Reduction in the size of individual islands as a result of sea-level rise is likely to reduce the size of the freshwater lens on atolls by as much as 29% (World Bank 2000), above and beyond any changes in recharge rates due to changes in precipitation.

INTEGRATED WATER RESOURCE MANAGEMENT FOR IMPROVED WASH SUCCESS AND CLIMATE CHANGE RESILIENCE

In order to build community resilience, improve progress towards MDG targets for water and sanitation, and negotiate the anticipated impacts of climate change, WASH activities must be considered in an integrative, holistic way (WHO 2013). One way of tackling this challenge is to consider WASH (and all other activities) within an integrated water resource management (IWRM) framework. The IWRM framework promotes a process for integrated and inter-sectoral decision-making for water for people and human health (in which WASH falls), as well as other competing water-use sectors such as agriculture, industry, and the environment (GWP 2010). The approach encourages explicit understanding and consideration of the relationships between all activities in a catchment prior to management intervention (Al Radif 1999). IWRM is a systems approach, rather than a traditional approach, which focuses on discrete components of the system, like sanitation, for instance (Al Radif 1999; Biswas 2008). The IWRM approach is also appealing in that it enables managers to consider WASH and climate change challenges (and the risks associated with their management solutions) concurrently and not independently of each other.

IWRM is based on the concept of sustainability, which is, of course, also an objective that falls under the goals associated with both WASH (WHO 2013) and climate change adaptation (Hadwen *et al.* 2012). The approach aims to achieve balance across the three Es: (1) economic efficiency, (2) social equity, and (3) environmental sustainability (Lenton & Muller 2009). WASH overlaps all three of these objectives, but is traditionally most strongly aligned with matters of social equity, i.e., ensuring that all people have access to services. In contrast, much of the work in climate change adaptation has, to date, focused on either environmental resilience or economic aspects of societal response (Hadwen *et al.* 2012), but generally this has been undertaken with insufficient integration and inclusion of issues of social equity (Adger 2000). Taking an IWRM approach enables both of these disciplines to be explicitly evaluated under all three objectives, with an eye on achieving economic, social, and environmental sustainability (Al Radif 1999).

While some authors have questioned the utility of IWRM (Biswas 2008), others have argued for its scope to broaden and mainstream climate change within the IWRM framework (He 2013). Indeed, as Ludwig *et al.* (2013) recently stated in their review of the differences between climate change adaptation approaches and the integrated water resource framework, the main difference between the approaches is based on the temporal scope, whereby IWRM looks at historical and current issues while climate change adaptation looks at future changes. Decision-making for WASH that combines both a holistic catchment view of water resources and climate change would, in an ideal world, improve services and adaptation measures, thus increasing community resilience. In reality, the scale of climate change predictions is often too coarse to be applied at a local level, and often water managers must make decisions in the short to medium term (Smits *et al.* 2009).

Water management and delivery of WASH services in challenging contexts, and with climate change overlayed, is the kind of complex challenge that falls under the guise of 'wicked problems' as described by Rittel & Webber (1973), in that the solutions are not right or wrong, but can rather be characterized as better or worse. The aim of IWRM is to use a holistic systems approach to ensure that management decisions do not push any parts of the system towards the worse end of that spectrum. An integrated assessment of WASH that includes information about water resources (type, number, volumes, recharge rates, etc.), water protection (water quality), climate change threats to water (floods, droughts, extreme events), and other uses of water will, therefore, generate different, and more sustainable, solutions to WASH in vulnerable communities. Greater systems understanding will ensure that the implementation of WASH services will be done in a deliberate and strategic manner, ensuring that management decisions consider resilience of communities, infrastructure, institutions and governance arrangements (formal or informal). A calculated decision to adopt an integrated approach reduces the likelihood of maladaptive interventions and can build resilience in communities to current and future climatic and non-climatic threats (Hadwen *et al.* 2012).

PIC communities are already among the most isolated and vulnerable globally, and the already difficult task of servicing these communities with water and sanitation is further exacerbated by climate change (Carpenter & Jones 2004). Given this context, it is essential that integrated management approaches are adopted, which incorporate adaptive management based on risk assessments which capture the uncertainty and vulnerabilities in the system of interest (Smits *et al.* 2009). Furthermore, these integrated approaches must be intersectoral, cutting across all activities which use or influence water. As some countries in the Pacific already show evidence of moving from crisis to crisis (e.g., the Marshall Islands, which in 2013 suffered emergency drought and storm surge through the capital), it is also essential that social, economic, and environmental systems be considered together, as community resilience will require emergency support and adaptation measures across different areas at different times. Indeed, sustainable and widespread WASH coverage, by definition, must consider both short-term (disaster) and long-term (climate change) threats and pressures. IWRM approaches offer significant gains over traditional – single department – approaches in this space, by ensuring that the spatial and temporal scales of interest are understood with respect to how the water resource is being valued, used, and subsequently managed (Carpenter & Jones 2004).

INTEGRATED WATER RESOURCE MANAGEMENT IN THE PACIFIC

IWRM is already well known within the Pacific, with most countries having undertaken diagnostic studies and adopted IWRM plans with support from international donors (Overmars & Gottlieb 2009). In addition, IWRM has been recognized by the University of the South Pacific, which has been offering a training scheme on this topic, tailored to PICs and their water resource issues, since 2005 (Terry *et al.* 2007). While a broad appreciation of the value of IWRM has been achieved and a regional strategy to manage water using the IWRM principles has been developed (Carpenter & Jones 2004), large-scale projects adopting IWRM principles have been slow to eventuate at the national level. Indeed, many of the initial demonstration projects supported by SOPAC and GEF were small-scale applications which focused solely on a single aspect of water (i.e., water quality or wastewater treatment) (Carpenter & Jones 2004). To this end, some of the projects have not adequately addressed all of the issues that are likely to influence water and its quality and quantity in the study area. Part of this stems from the deliberate focus of the pilot projects on current issues of concern in particular communities in some instances, but there is also growing evidence that IWRM projects throughout the world often do not operate broadly enough to integrate land-based activities and their consequences for water (Falkenmark *et al.* 2014).

In order to tackle WASH and climate change adaptation in areas like the Pacific, IWRM needs to be broadened and mainstreamed into planning (for all activities) within catchments (Carpenter & Jones 2004; He 2013). This is no doubt a challenge for many PICs, especially since many are characterized as having government administrations with poor capacity and limited communication among and between departments (Carpenter & Jones 2004). Fortunately, there is evidence of a move towards a more holistic appreciation of water resources within the Pacific with the growing support and recognition of 'Ridge to Reef' approaches to managing water and land (GEF 2004; Overmars & Gottlieb 2009; IUCN 2013). This movement towards a catchment-based approach to water management, even in atoll settings within the Pacific, is a critical first step towards a truly integrated application of IWRM principles. Broad regional acceptance of this approach and its support from global organizations and donors (like GEF and the IUCN) mean that the PICs are well placed to adopt approaches that will integrate WASH and climate change decision-making processes.

CONCLUSIONS

In order to change the pattern of stagnating and, in worst cases, declining water and sanitation coverage in PICs, interventions must be mindful of how WASH sits in an increasingly unpredictable water cycle (Barnett 2001). The feasibility of taking an IWRM-based approach to tackle both WASH and climate change challenges is, therefore, worth considering for the Pacific region. Recent project experiences with IWRM have built a broad level of support for the philosophy (WHO & SOPAC 2009) and the more recent development of, and growing support for, the Ridge to Reef approach to land and water management (Overmars & Gottlieb 2009; IUCN 2013) shows much promise in terms of integrating the challenges (and solutions) of WASH and climate change adaptation in vulnerable communities. Through the adoption of a spatially (Ridge to Reef) and temporally (past, current, and future) integrated approach, based on IWRM principles, PIC communities will be able to develop sustainable practices with respect to WASH in the medium to long term that do not compromise other aspects of their lives or increase their vulnerability to climate change threats.

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