Chapter 9

Fresh Lessons on Preparedness for Disasters

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9.1 Best buys in disaster risk reduction?

Until now, the smart money in disaster risk reduction (DRR) has been assiduously built on the evidence of studious cost-benefit studies and other research (Hugenbusch and Neumann 2016; Mechler 2016; Adhikari et al. 2018; Eckhardt et al. 2018; Dudley et al. 2015). This has given rise to the best present and robust practices of early warning systems, community education, evacuation, emergency shelter, high technology-assisted search and rescue, retrofitting, 'building back safer', and family, business and sovereign insurance.

Notwithstanding this solid basis for current policy, after the impact of Hurricane Maria in Puerto Rico in 2017 and the political contretemps that emerged from the publication of the epidemiological studies of the huge burden of secondary mortality in the aftermath of Maria (Kishore et al. 2018), DRR strategy is clearly due for substantial reassessment. Current investments in DRR are important and necessary, but after Maria, no longer sufficient.

The unravelling of the true impact of Hurricane Maria provides a key to open the door for more research and review of the operational and policy implications of the hitherto somewhat neglected long tail of the aftermath of disasters. This applies to hurricanes in particular and to natural disasters in general. Much of the true social, economic and environmental damage of the aftermath of disasters has been undocumented and more needs to be explored on the vulnerability of small and island states, where retreat from the threat is not an option and where those most at risk to the impact of the aftermath may be left unattended and at critical risk.

This review cites evidence from a range of documented disasters, where the fatalities in the aftermath have been recorded. This can amount to over 70 per cent of the total death toll. Some of this arises from the destruction of basic service infrastructure and the disruption of services, when staff, if they can get about, discover vital elements of services which may be damaged or destroyed beyond effective operational use and cannot be fixed. Such breakdown of medical, pharmaceutical and other social services can result in death and serious harm to those whose survival depends on them. The size of this vulnerable group may depend on the stage of development of the country and the extent to which the survival of elderly and people with a disability is dependent on the seamless provision of certain critical services.

While the traditional DRR strategy has been on prevention, search and rescue, and 'building back better', it is clear that more attention needs to be given to focus research and resources on the impact of the aftermath of disasters. This chapter examines the nature of disaster risk (Roberts J L, 2010), and offers fresh analysis and recommendations for action with special reference to small and island states, to avert and mitigate the wide-ranging service implications of the aftershocks of disasters.

9.2 The long tail of the aftermath of disasters

Recent environmental disasters from hurricanes have evidently tested, beyond their limits, existing prevention and preparedness systems. Hurricane Irma in Puerto Rico in 2017 resulted in 52 direct deaths plus 82 indirect deaths, with an estimated US$64.76 billion in damage. Hurricane Maria, a category 5 hurricane, which followed on closely in September 2017, resulted in 64 direct deaths, but an estimated over 4,000 indirect deaths[1] from secondary and tertiary impacts (Kishore et al. 2018) and variously estimated US$68–102 billion in damage (Pasch et al. 2018; Wallemacq and House 2018), (UNISDR, 2018).

There was an early warning system alerting people to the approach of Maria, 35 hours before its impact. Then, on the small island of Puerto Rico and in neighbouring sites on the storm path, there was wide-scale destruction of homes and business premises; extensive flooding from heavy rain and sea surges up to three metres above ground; mudslides; severe damage to roads and fallen trees inhibiting transport; severe damage to harbours and marinas; and crops destroyed. Around 80 per cent of poles carrying utility services were blown down, with power and communications blackout fatally affecting people dependent on medical care and other vital services for survival; water supplies were cut for long periods in many places. The subsequent slow re-establishment of basic services still left thousands of homes and businesses without power, affecting 3.4 million people nine months after the initial impact. Hurricane Maria was the third costliest hurricane in US history (Pasch et al. 2018).

Pasch and his colleagues found after Hurricane Maria in Puerto Rico in 2017, vulnerable groups were the main victims of this long tail in the timeline of mortality after the initial impact of the disaster. The vulnerable groups included those on low incomes, older adults, people with chronic medical conditions, and patients with ongoing specialist treatment requiring prescription medicines.

Similarly, Ho and colleagues studying adult mortality after the major earthquake and tsunami affecting the Indian Ocean 2004/5, found that factors associated with death after the immediate impact of the event included age, gender and isolated people without available help (Ho et al. 2017).

Carroll, a professor from the Indiana School of Medicine, reporting on the long-term health consequences of the urricane Harvey in the USA impact of Hurricane Harvey in the USA, cited the importance of the subsequent impact of waterborne and communicable diseases, including respiratory and gastrointestinal conditions arising from pollution and industrial and hazardous waste, and the high density of homeless people surviving for long periods in emergency shelters. Specifically, Carroll cited

the lack of necessary medical services for people with chronic conditions such as asthma, heart disease and those with kidney failure on dialysis and worse pregnancy outcomes. Carroll stated that after the Hurricane Katrina in 2005, the mortality rate reached 47 per cent above normal in New Orleans, ten months after the storm, suicide rates peaked and post traumatic stress disease (PTSD) appeared among police officers and rescue volunteers, (Carrol A E and Frankt, 2017) (West C et al. 2008).

The detailed study of the aftermath of Hurricane Maria called for improvements in the training of physicians in the certification of deaths associated with the disaster, emphasising the long-term impact, which had been initially masked (Pasch et al. 2018).[2]

Saulnier and colleagues in their paper, 'No Calm after the Storm', a systematic review of human health following natural disasters, called for further research into the long-term effects on mortality (Saulnier D D et al. 2017). It is also clear that in the light of this pattern of cascading fatal impact on vulnerable people, more attention is needed to devise preventive measures and improved preparedness that could reduce these longer-term risks to human health, often overlooked in the long mortality tail of the aftermath of disasters.

While the focus here is on storms, the indirect impact of other types of disaster may well follow a similar pattern in affecting the survival of vulnerable people.

9.3 Adapting DRR strategy from the lessons from Hurricane Maria 2017

Such reports on recent disasters provide vital lessons for reviewing the emphasis on the range of elements encompassed in the Sendai Framework for strengthening resilience, especially in small island states. The detailed epidemiological study on the impact of Maria highlighted the inadequacy of an organised command structure for disaster response and emergency communication; serious flaws in the links between central and local government; out-dated emergency planning, not designed for greater than category 1 hurricanes; and weaknesses in the mortality reporting systems – all revealing a picture of an island, 'not prepared for multiple cascading failures of critical infrastructure and key resources sector' (Santos-Burgoa C et al. 2018).

In particular, recent disasters have highlighted the intensity and extensive penetration of such natural phenomena, the cumulative impact of their destructive forces, and the limited protection that early warnings and infrastructure protection can provide. Moreover, following the political controversy over the assessment of their human impact[3] in which the long-term impact of Hurricane Maria was revealed, fresh attention should now be given to the cascading impact of destruction in leaving vulnerable people without vital facilities and services on which their continued post-disaster survival depends, including safe water and sanitation, power, shelter, nutrition and medical services.

These lessons need to be incorporated into global DRR strategy and at the local level in the Indian Ocean Commission (IOC) countries. This will require improving systems of data collection on the secondary and tertiary effects of disasters, developing ways

of identifying those most at risk and providing standby emergency support suited to their needs.

9.4 Three phases of preparedness

Patterns of death, injury, disease and disablement follow a general course of impacts after a storm. These embrace three stages into which differing forms of preventive action and response have been classified (Keim 2018); these are, broadly, the primary, secondary and tertiary stages/effects.

Primary effects involve the immediate potential impact of the hazard, for which preventive measures include the design of cyclone-proof buildings and their maintenance, early warning systems, safe emergency shelter, and the setting back of infrastructure from the coast and rivers that might flood.

Secondary effects are those that follow on from the immediate impact of the disaster, for which response and prevention measures include efficient, well-co-ordinated search and rescue operations, rapid first aid and trauma care, clearing of debris, and the proper identification and disposal of those with fatal injuries. Secondary response also involves the emergency re-establishment of important basic services, such as power, lighting, ventilation, information, security and communication services. Secondary action includes maintenance of emergency shelter and transfer to more suitable accommodation, with the provision of social care, child care and education services, and the rapid and accurate diagnosis and appropriate management of non-fatal injury or disease, after the initial impact of the disaster. This may require emergency nutrition and shelter adapted to the needs of differing groups of people, with access to specialist care by traumatic orthopaedic and ophthalmic services, burns and heart care and lung emergency care for those suffering from the effects of toxic smoke, for example.

Tertiary effects can require longer-term support measures for the permanent rebuilding of infrastructure, re-establishing businesses and jobs destroyed by the disaster, rehousing homeless people and ensuring special social care, and education and medical care for those in need who have been deprived of vital support systems, including power and medical supplies. This requires advance identification of the most vulnerable and personal support and care for them, especially disabled and elderly people whose survival may be dependent on specific care regimes that have been disrupted or cut-off. In this phase of response, there may be disease epidemics arising from the destruction of crucial infrastructure. The mitigation of tertiary impact has yet to be widely accepted as an important gap in preparedness.

9.5 Current emphasis on capacity building for DRR

Before Hurricane Maria in 2017 and the research showing the long tail of mortality from secondary and tertiary effects (Pasch et al. 2018), the focus of DRR has properly been on post-disaster rescue, recovery and rehabilitation as the strategy for strengthening resilience and risk reduction. Moreover, the weight of research has focused investment on DRR to avert the immediate impact of the disaster, through

heroic efforts in salvaging lives from the debris and tending them in shelters, where primary prevention has been inadequate; then comes much physical reconstruction, retro-fitting and incorporating in new design of infrastructure protection against storms, flooding and the other hazards that overwhelmed communities. A probabilistic cost-benefit analysis approach has become common to yield the best results in policy formation from DRR research (Ye et al. 2106).

Such assessments tend to put disaster insurance premium relief above investment in retrofitting, but encourage public–private partnerships to cover the risks. The results, however, mask the importance of fatalities. Physical capacity building, early warning systems, and training for search and rescue are all important and necessary elements in a DRR strategy; however, they are not sufficient in the light of the lessons learned from Hurricane Maria.

Using the US Department of Transport value of a statistical life (Moran and Monje 2016), the human cost in fatalities of Hurricane Maria rises from the cost of US$614 million for directly attributed deaths to US$29 billion for indirectly attributed deaths. That takes the human cost from additional 0.7 per cent of the total of that hurricane in terms of cost of loss and damage, to a hugely increased 34 per cent.[4]

Such new lessons from Hurricane Maria must shake up much research assessments of where to place the critical investment for DRR and what technologies to apply. Saving the lives of those who are continually dependent on life-support services, requires quite a different pattern of operational response compared to the standard evacuate, search and rescue, rehabilitate and rebuild stronger. It requires being alert to the needs of those people who may not be vulnerable to the direct impact of a hurricane, and who may not need to be rescued from the debris, but who then become vulnerable and exposed to its aftermath.

9.6 Planning, investment and action after the storm: protecting the most vulnerable

It is well over a decade since James Shultz and his colleagues published their iconic paper on tropical cyclones (Shultz et al. 2005). In that review, they drew attention to the weaknesses in the process of existing studies, especially in monitoring a post-cyclone population through their long secondary and tertiary impact and extended periods of recovery. It is evident from recent events that more attention should be given to these aspects in the strategy of prevention and response, to anticipate and obviate the long-term health impact, the psychological consequences, behavioural patterns and the effects on elderly people, recent immigrants, single parent families, poor people and those with special medical needs. The Schultz review called for longitudinal investigations of high-risk zones, especially those people living in coastal areas. It also called for multidiscipline studies, including studies of the impact on health of the methods of disaster management. Their call for a more integrative approach to assessment of the lessons learned from cyclones remains a continual challenge.

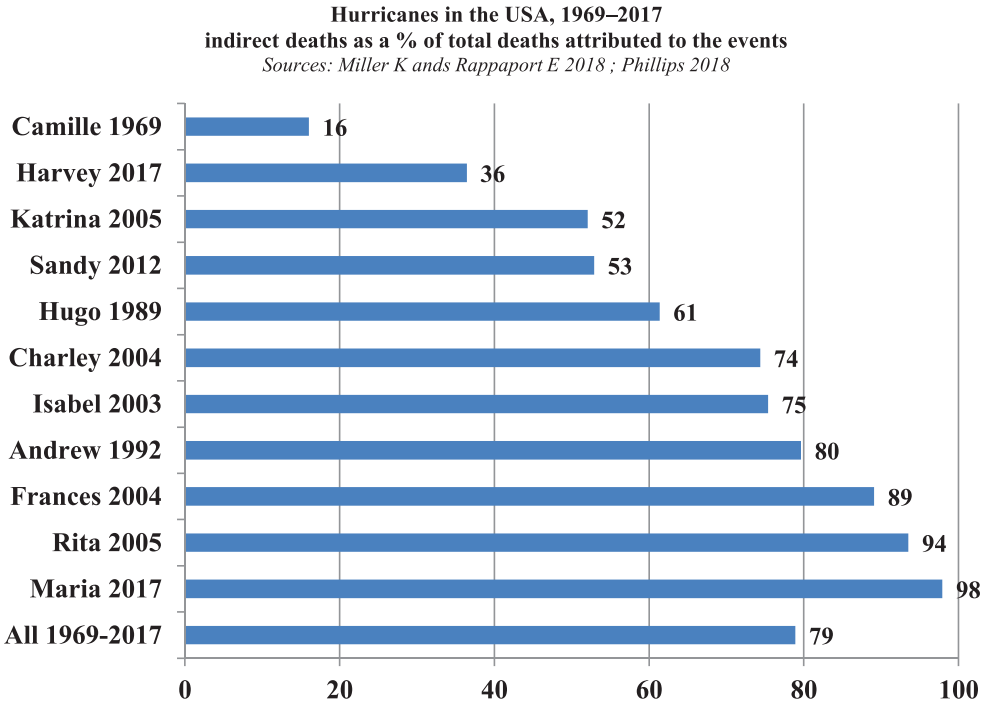
In their review of the outcome of 59 tropical storms in the USA in the last 50 years, Rappaport and his colleagues found that indirect fatalities associated with these

storms, though often under-recorded, were nearly as great as direct fatalities. Common factors included: loss of electricity leading to falls in darkness; hypothermia and hyperthermia due to loss of heating and air-conditioning; failure of life- sustaining medical equipment; carbon monoxide poisoning through misuse of generators; and deaths from cardiovascular failure in people with heart disease, resulting from overexertion in clearing damage, bailing out flood water, repairing buildings and heat stress (Rappaport and Blanchard 2016).

From Hurricane Harvey in Houston USA 2017, which was a category 4 storm, there were 107 reported deaths, of which 39 were classified as indirect, though this may be a conservative figure as the aftermath of the storm was considerable. Harvey caused severe chemical pollution of the air from damage to chemical plants, and sewage flowed on the streets causing substantial risks to health. Extensive gaseous benzene release put people with asthma and chronic obstructive lung disease at risk, increasing the frequency of cardiovascular events (Phillips 2018).

Figure 9.1 shows the indirect deaths from selected hurricanes in the USA 1969–2017 as a percentage of the total deaths from these events. Overall, 79 per cent of the deaths were indirect. With Maria, in 2017, 98 per cent of deaths were indirect; with Rita in 2005, 94 per cent of deaths were indirect and with Katrina, in the same year, 52 per cent of deaths were indirect. In this list, it is only Camille in 1969 and Harvey in 2017 that had fewer than 50 per cent deaths from indirect factors.

Figure 9.1 Hurricanes in the USA, 1969–2017



9.6.1 Planning, investment and action for a category 5 wind storm

The impact of Hurricane Maria in 2017 in Puerto Rico involved high levels of mortality, mass evacuation, extensive damage to housing and to key infrastructure, flooding and a breakdown of communications. A vast majority of people, their homes and businesses were without power for nine months after the initial impact.

The detailed follow-up epidemiological study showed that the full death toll of Hurricane Maria in Puerto Rico, of possibly more than 4,000, was well over 50 times higher than the initial estimate. The greatest number of the additional deaths was among the most vulnerable people, whose survival depended on continuous supply of medical and social care services the provision of which was critically affected by the disruption of facilities in the aftermath of the disaster (Pasch et al. 2018).

This raises a number of serious questions about whether small island states are well prepared for the impact of a category 5 hurricane on their most vulnerable people. Using the impact of the disaster in Puerto Rico as a model of the worst-case scenario, for other small islands, let us ask:

1. Have the emergency response teams and the relevant ministries of health and social care, identified the relevant classes of critically vulnerable people in advance, such as those on life support systems, on renal dialysis, those patients in intensive care, high-risk pregnant women and others, whose survival depends on certain medications and care regimes being continually available?
2. Do the relevant ministries and local operational bodies have effective plans for the support of these most vulnerable people in the face of disruption of the vital services on which their lives depend?

Further questions are raised about the procedures for the certification of cause of death and the use of International Classification of Diseases (ICD) 11 (WHO 2018) to ensure that both direct death from a storm and the cascading effect of indirect deaths are properly recorded. The follow-up study of Hurricane Maria found serious deficiencies in the mortality classification in use in Puerto Rico. This greatly understated the long tail of death in the aftermath of the storm. Moreover, it failed to draw attention to the issue of those vulnerable people whose untimely deaths were due not to the violence of the storm itself and the effectiveness of search and rescue teams, but were affected by the long-term impact of the disaster on the seamless provision of vital life-saving services to them. So, we must also ask:

1. Does the system of certification of death and the coding of the certificates in the mortality reports adequately capture the longer-term impact of external cause of death on the most vulnerable people in the longer-term aftermath of natural disasters?
2. Are the medical and statistics staff trained in the correct procedures and do they have access to appropriate manuals of guidance?
3. Is there an audit system in place to check the validity of cause of death certification and misuse of 'garbage' codes?

9.7 How well are the South-West Indian Ocean islands protected against the impact and aftermath of disasters?

It is timely therefore to review the existing provision for disaster risk reduction policies and plans in the South-West Indian Ocean islands, and to examine how far they take into account the range of impacts now apparent from the most recent evidence in island states, which are in general economically and environmentally vulnerable.

A series of exemplary expert studies on the South-West Indian Ocean islands, published in 2015 and carried out by the UN International Strategy for Disaster Reduction (UNISDR) with support from the European Union (Leste de Peridoe and Ishigaki 2015) as part of the extensive Islands Project of the Indian Ocean Commission, justify re-examination. The studies covered the local history of disasters, comparing the experience of Comoros, Madagascar, the two Commonwealth states of Mauritius and Seychelles, and the island of Zanzibar, examining their relative vulnerability, their populations at most risk, and their capacity for resilience within the context of their relative stages of economic and social development.

The assessments showed the relative intensity, frequency and impact of common hazards from tropical cyclones, sea-level rise and climate change. The studies showed evidence of investment in protective measures, including a heavy emphasis on protective infrastructure, early warning systems and training. We must now ask:

1. How far did these studies adequately look into the potential secondary and tertiary impacts of disasters, in the light of the cases now emerging from recent disaster events elsewhere?
2. How far are the IOC countries preparing for a greater emphasis on the continued provision of critical life-dependent special services for the most vulnerable people?

The detailed studies of the five islands of Madagascar, Comoros, Mauritius, Seychelles and Zanzibar were reported in 2015 as part of a joint exercise by UNISDR and the Indian Ocean Commission through the Islands Project. These studies provided a wide-ranging assessment of disaster risk, public investment planning and financing strategy. They showed that 96 per cent of the disaster loss in the period 1980–2013 was due to cyclones, amounting to a loss of US$17.2 billion at 2012 prices. There were 1,635 deaths in that 34-year period attributed to the disasters, principally to extensive events (that is, ones of high frequency but low impact), of which there were 1,204 in the period, and only one event classified as intensive (that is, low frequency and high impact). The hardest hit island in the period was Madagascar with a loss of 1,309 lives, but the fatality rate per million population in the period was higher in Mauritius and Seychelles than in Madagascar (see Table 9.1). The highest economic loss and loss per capita was in Madagascar, but Seychelles had the second highest economic loss per capita, principally due to flooding.

The assessment of the health impact was in terms of the immediate impact on mortality, without review of the longer-term effects on health. In the assessment of

Table 9.1 Loss due to disasters in the South-West Indian Ocean islands, 1980–2013

Islands	Population *(millions)*	Total economic loss from disasters *(million US$)*	Total economic loss per capita *(US$)*	Deaths from disasters	Deaths per million population
Madagascar	22.3	8,839	396	1,399	62.7
Mauritius	1.26	59.6	47	127	100.8
Seychelles	0.08	15	187	7	87.5
Comoros	0.73	10	14	34	46.6
Zanzibar	1.3	1	1	1	0.8
Total	25.7	8,924	347	1,568	122

Source: Leste de Peridoe and Ishigaki 2015.

economic loss and physical damage, the study considered the impact on assets in terms of loss of income, and destruction of property and infrastructure for up to five years after each event. The economic loss did not include any monetary value for loss of life.

The UNISDR studies of these islands found that at that time there was:

- no coherent disaster risk reduction policy, strategy or action plan for the region;
- no investment policy;
- critical infrastructure insufficiently protected;
- contingency planning underdeveloped;
- a lack of coherent planning and investment between ministries; and
- a need for more capacity building on risk assessment.

The recommendations from the UNISDR studies in the South-West Indian Ocean (Leste de Peridoge and Ishigaki 2015) included:

- further investment in DRR through national budgets, especially in Madagascar and Comoros which were behind the other islands studied in their financial commitments in this field;
- improvement in the capture of the real value of economic losses;
- increase in training in risk management, with capacity building in the analysis of DRR, increasing technical support for probabilistic risk assessment;
- rise in the regional awareness of the need for DRR;
- filling the data gaps in risk assessment;
- provision for further assessment of the indirect effects of disasters; and
- integration of climate change into risk assessment process.

9.7.1 *World Risk Report* 2018 – high disaster risk in island states

More recently, in 2018, the *World Risk Report* presented an assessment of the relative risk of disasters in 172 countries and their capacity for resilience (Heintze et al. 2018) This report found that 13 of the 15 countries with the highest risk were in Africa and that 9 of these 15 were island states. Table 9.2 shows the position of each of the South-West Indian Ocean countries covered in the review, indicating that Mauritius was the most at risk and Seychelles the least at risk. The review was based upon a composite assessment using existing internationally published indicators.

The report calculated the risk index from a composite of available indicators rather than by a specific detailed review of the nature of the hazards and the action taken for resilience. So, for example, the measure of susceptibility was a composite of indicators of safe water and sanitation, slum housing, undernourished people, poverty, age dependency, gross domestic product (GDP) per capita and the Gini Index. Coping capacity was a composite of the corruption perception index, good governance, disaster preparedness and availability of medical services. The measure of lack of adaptive capacity was derived from the extent of education, of research, gender equity, forest management, expenditure on health services and life expectancy.

These *World Risk Report* assessments mirror those made by the UNISDR studies of 2015, showing the relatively high risk of disasters in Mauritius and Madagascar, the high level of resilience in Mauritius and the high lack of adaptive capacity in Seychelles, which is not prone to cyclones but has a high level of risk from flooding seriously affecting its coastal development areas. These measures of risk are illuminating, but provide a rather broad brush approach to risk assessment and they do not focus on what is promoted in the Sendai Framework as the crucial tests of resilience, which are the capacity for effective response and 'building back better', reducing mortality of affected people, and reducing economic loss, damage to infrastructure and disruption of basic services. The *World Risk Report* shows that both Madagascar and Comoros are highly vulnerable and susceptible to disasters and seriously lacking in coping and adaptive capacities.

9.8 Follow up of the 2015 UNISDR and IOC studies

Since 2015 when the joint UNISDR and IOC studies were undertaken, action has been taken in all the islands.

9.8.1 Action in the South-West India Ocean islands since 2015

Set out below for each of the South-West Indian Ocean countries, is a summary based upon recent reports and key person contacts, of the latest position.

The IOC Islands Project 2011–2017 (Bonne 2017) included a major section on DRR. This resulted in all the countries involved in the project[5] setting up disaster risk management units or centres, which continue to be operational, working on DRR policy development, DRR strategy and action plans. These are being linked to preparedness for climate change and adaptation.

Table 9.2 World Risk Index 2018

Country	Ranking 1=most at risk	WB Index	Exposure	Vulnerability	Susceptibility	Lacking coping capacity	Lacking adaptive capacity
Mauritius	16	14.27 Very high risk	37.22 Very high	38.35 Low	17.69 Low	59.26 Low	38.09 Medium
Madagascar	32	10.89 Very high risk	15.63 High	69.68 Very high	66.53 Very high	84.72 Very high	57.80 Very high
Comoros	51	8.36 Very high risk	13.13 High	63.67 Very high	47.48 Very high	84.06 High	59.46 High
Seychelles	115	4.59 Low risk	11.64 Low	39.44 Low	18.22 Low	60.88 Low	39.22 high

Source: Heintze H-Jet al. 2018.

9.8.2 Disaster insurance

One component of the Islands Project was to explore, through collaboration with the UNISDR and the World Bank, the case for disaster risk insurance, through a probabilistic assessment based on the record of the last 30 years or more of disaster experience across the participating countries.

The Islands Financial Protection Programme (IFPP) against 'catastrophic risk' was undertaken with UNISDR and the World Bank, starting in 2013. It aimed to strengthen capacities for unified climate change adaptation (CCA) and disaster risk reduction (DRR).

The design allowed the IOC to undertake a detailed implementation programme, for the introduction of risk financing activities in the IOC region, covering: (a) disaster response; (b) post-disaster reconstruction; (c) disaster reduction investments; (d) climate change adaptation; and (e) insurance and reinsurance schemes.

The overall initiative was designed to identify the proportion of development investments in schools, health facilities, infrastructure and roads etc., which included disaster risk considerations.

The review used tools such as the World Bank Disaster Aid Tracking instrument to identify flows of overseas development assistance (ODA) towards disaster risk reduction. A second step assessed current mechanisms that include DRR in public investment, examining whether there are existing mechanisms in national, sector and public investment planning or project formulation to ensure that DRR and CCA considerations are factored into public investment.

The scheme was ambitious, but advice from the World Bank, which considered the overall insurance scheme, was that it was not appropriate for the islands concerned. So, the idea of the insurance approach was not pursued in the IOC Islands Project countries. This is rather at odds with the development of disaster insurance for Pacific islands and for Caribbean islands (UNDP 2017).

Catastrophic insurance can be entered into by individuals and corporate bodies to cover loss due to disasters such as storms, flooding and earthquakes, with premiums related to risks and potential loss to be covered. The cover can exclude certain types or amount of loss, and may include conditions to be met in terms of precautions taken against loss. It may also include certain conditions that limit the minimum and maximum compensation.

Loss of life and injury may be excluded, or compensation limited to set lump sums and the specific registered details in the certification of cause of death.

While the uneven pattern and level of risk across the IOC islands may not be favourable to collective disaster insurance, there could be a case for exploring partial cover insurance for the emerging issue of the increasing recognition of the long tail of indirect impact, with lower premiums linked to specific criteria for adjudicating on the long tail of the aftermath in loss.

9.8.3 Enhanced preparedness

In the IOC countries, instead of insurance, emphasis has been placed on enhanced disaster preparedness and response, not least in the development of more resilient infrastructure and immediate action concerning the practical aspects of integration of disaster risk reduction and adaptation to climate change.

The DRR management process has progressed in the region, in the face of the disaster risk profiles for the countries, (UNISDR Prevention Web, 2018a) especially in Mauritius through its National DRR Management Centre. Similar management and security centres have been set up in the other countries involved. In the Comores the French-based Platforme d'Intervention Regional de l'Océan Indien (PIROI) is working closely with the disaster response activities of the Red Cross and Red Crescent. PIROI is developing plans and technical capacities to respond in the region through accords agreed with the countries themselves.

A Regional Disaster Risk Reduction and Climate Change Adaptation Plan was tabled at the Council of Ministers of the IOC in 2018.

DRR is now being tackled in tandem with fresh perspectives on adaptation to climate change across the IOC countries, including la Réunion (France) in partnership with Tanzania, Mozambique and South Africa (IOC 2018). This is now being taken forward by the IOC, with the Agence Francaise de Developpement (AFD) as an accredited partner.

This planning, investment and action is important, necessary and all very well, yet, more careful further thought needs to be given to support for the most vulnerable people whose lives are at risk in the aftermath of storms for lack of services. For them, the first task in enhanced preparedness is to identify these people in advance. Most will already be known to the health and other support services, and could be targets for special surveillance and relief following the disruptive effects on the very services on which they rely. As all supply chains are increasingly on short or immediate delivery cycles, so it is with such people. There is a growing practice in the USA for centres of renal dialysis to have disaster preparedness plans to avoid disruption of services to their highly vulnerable patents, which can include advanced evacuation, training, and back-up supply and delivery systems (Kleinpeter 2011).

9.8.4 Planning for more preparedness for the aftermath of disasters

It was found, after Hurricane Maria in Puerto Rico, that households on average were without electricity for 84 days; without water for 68 days; and without cellular phone connections for 41 days, while 9 per cent were unable to reach emergency services by telephone. The resulting interruption of medical care was found to be the principal cause of sustained high mortality rates in the aftermath of Hurricane Maria (Kishore et al. 2018).

This presents a potential risk of preventable death for all island states in the aftermath of disasters. More planning and investment is needed to reduce the risks inherent in

the aftermath of a storm. It is those vulnerable people who may be hidden from view and unable to communicate their needs, who need help, before they are in crisis and die from want of simple, vital support.

9.8.5 Drone technology to the rescue?

Hope, however, could be coming from recent innovations in the peaceful use of drone technology (UN Peacekeeping 2018). Such aerial technology has potentially large post-disaster advantages. It is now being used for:

- leapfrogging over broken infrastructure for detailed surveillance of isolated people;
- locating missing people in need;
- extending Wifi connectivity where links have been cut; and
- targeting the delivery of vital medical and other supplies.

Such innovative services need to be reviewed as a standard part of enhanced preparedness, especially in island states whose normal logistical systems have been dislocated by a disaster and may take weeks or months to restore to normality. The first step, however, is to identify those who are currently dependent on vital continuing medical care/support and to devise plans with them for their emergency support in case of disasters.

9.9 The indirect impact of disasters

Different countries are prone to different types of disaster; but all are at risk from both the direct and indirect effects. In the IOC countries, Mauritius and Madagascar are at risk from cyclones, though these are more frequent and severe in Madagascar than Mauritius, with the latter having built greater resilience. Seychelles and the Comores are not subject to cyclones, but respectively are affected by flooding and desertification. Seychelles was hit by the 2004/5 Indian Ocean Tsunami, while La Réunion experiences regular impacts from its active volcano, from which the population is well protected. All the IOC countries are starting to experience the effects of climate change, including changes in rainfall, sea-level rise and variations in the seasonal weather patterns affecting agriculture, fisheries and livelihoods.

Previous research has tended to focus on the indirect impact of disasters in terms of their economic and, particularly, the commercial impact. While data are scarce and strong calls have been made to improve data collection and models of assessment, the field is perhaps richer in theory than concrete measurement (Jacobs 1999; Benson 2012).

In the UK, through the Government Office of Science, Benson (2012) has reviewed the issue of the indirect economic impact from disasters and examined the twin hypotheses that disasters are an economic disaster for countries, but contrasted with the Schrumpeter notion of the 'gale of creative destruction' giving rise to regeneration, higher productivity and greater competitiveness. Her conclusions call for more

research, but tend to support the view that in poor countries, disasters can overwhelm an economy which has little resilience for renewal and 'building back better' (ibid).

Hurricane Maria, however, has opened the door to the need for more study of the indirect impacts of disasters on vulnerable people and the management of risk reduction for them.

This issue is of general significance for all disasters whose indirect fatal impacts are as poorly documented as the medium- to long-term indirect impacts of disasters on the economy in general and their distributional effects.

9.10 SDGs and the Sendai Indicators: a heavy burden for small states

In light of this review, the present authors have revisited the development of international systems of goals, targets and indicators incorporated in the UN Sustainable Development Goals (SDGs) and in the Sendai Framework, to re-examine how far these data systems are worthwhile as tools for policy-making. They are clearly becoming a burden for small states where missing data is a growing problem (Roberts 2018).

9.10.1 Reported position of IOC countries

Despite the wide-scale problems of lack of reporting on the Millennium Development Goals (MDGs) and SDGs (Roberts and Ibitoye 2012; Roberts 2018), the latest versions of UN SDG database,[6] shows that all the IOC Islands Project countries, except Tanzania, have reported values for SDG 1.5.1 and 1.5.2 showing the human and economic impact of cyclones in the period 2005 to 2014.[7] All these, including Tanzania, have reported under SDG 1.5.3 that they have DRR strategies, except Comoros, which has set up a National Platform for DRR. However, none has reported to the SDG database that they have local strategies under SDG 1.5.4, although Seychelles has had local strategic plans since 2008.

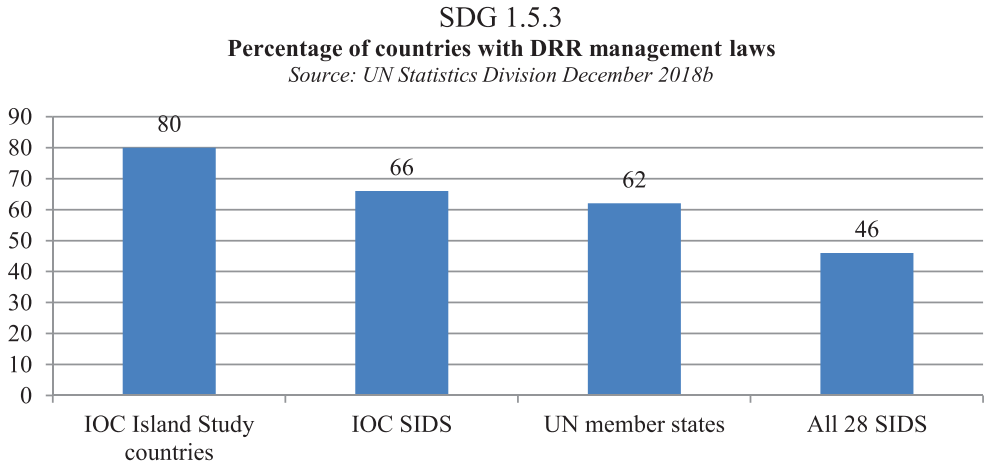
Yet as the cyclone season approaches in Mauritius, the District Council of Pamplemouses, in the north of the main island, has set up a local DRR management committee, with emergency services, local business interests and civil society represented.

The response of the countries included in the UNISDR and IOC Islands Project, to establish at least national legislation or regulations for DRR management arrangements, compares well with the response among SIDS in general and with that of UN member states overall (see Figure 9.2). This in itself is a significant benefit of the investment in the studies themselves.

Comoros

Comoros is at great risk from cyclones, sea surges, tsunamis and the active volcano, Karthala. It has established a National Platform for DRR, with a financial contingency plan to respond to such hazards.

Figure 9.2 Percentage of countries with DRR management laws, SDG 1.5.3



Mauritius

In Mauritius, a strategy is being developed to respond to the risks of natural disasters, particularly cyclones. There has been in place for many years a well-developed and effective cyclone warning system (Roberts 2004). In 2015, the government set up a National Disaster Risk Reduction Management Centre in the Ministry of Environment and announced in 2016 that a DRR policy, a strategic framework and an action plan were being developed. This is expected to cover flooding, landslides and natural risk profiling. The plan is expected to include a multi-hazard early warning system, training for community-based response teams, a website and communications system. A national emergency operations command has been set up, with the disaster response command under the national police force, equipped with a mobile command vehicle. Mauritius has been affected by a series of category 5 cyclones since 1960.[8]

In 2016, Mauritius made a commitment to the Sendai Framework and its implementation (UNISDR 2016b). The 2015 UNISDR IOC study had found that in Mauritius, the central infrastructure was not sufficiently protected against disaster risk and contingency financing methods were also underdeveloped.

With certain of its parastatal bodies, Mauritius has compensation funds covering loss and damage to assets in disasters. For example, the Central Electricity Board and the Central Water Authority have funds, as well as Mauritius Ports and Airport Mauritius. The sugar planters have a Sugar Insurance Fund to protect the harvests of planters and estates and to guarantee against loss.

Madagascar

In Madagascar, there is a strong commitment and programme for DRR, which has been strengthened following Cyclone Enawo in 2017 (UNISDR 2017b). This category 4 cyclone had the following impacts:

- 81 recorded deaths;
- 250 people injured;
- 500,000 people affected;
- 200,000 people displaced;
- 40,000 houses destroyed;
- 3,900 school classrooms damaged;
- 1,300 waterpoints polluted; and
- 100 health centres damaged.

In addition, many roads and electricity supplies were destroyed, there was extensive flooding and the port of Antalaha was left inaccessible (UNISDR 2017b).

Madagascar's Disaster and Risk Management Act was amended in February 2016 to include an updated strategy on disasters and risk management; this was validated by the government in September 2016. The two documents are based on the Sendai Framework for Disaster Risk Reduction, a global agreement adopted in 2015, and on good practices documented over time.

Co-ordination of disasters and disaster risk management in Madagascar is handled by a National Committee for Disaster and Risk Management, which includes the government and relevant stakeholders. Through this committee, members share experiences and are able to advise the Bureau National de Gestion des Risquese et des Catastrophes (BNGRC) to help improve the implementation plan of the national strategy on disaster and risk management.

A key step taken by the Government of Madagascar is to include disaster risk reduction in its national development policy and consideration of disaster risk reduction in all national poverty reduction programmes. One of the strategic areas of the country's 2015–2019 National Development Plan is the valuation of natural capital and the strengthening of resilience to risks of disasters.

To inform this process, UNISDR provides technical support to the government, including through risk profiling and has published a report on disaster risk reduction to facilitate planning and implementation of risk-informed development (UNISDR 2017b).

Seychelles

Since 2008, Seychelles, under the Disaster Risk Management Act (updated in 2104), has had a national disaster response plan and complementary plans in every district. While Seychelles does not suffer from cyclones, except in its southern-most islands,[9] it does have heavy flooding along the coastal areas where most of the people live and businesses are located. The small island of la Digue is, for example, receiving US$1.5 million from the Global Climate Adaptation Alliance for restoration work on land drains following continual flooding of coastal areas from heavy rainfall (Seychelles

New Agency 2016). Seychelles was badly affected by the Indian Ocean Tsunami of 2004/5, which cut off its main airport for some days, disrupting domestic and international travel.

Tanzania

Tanzania has a website dedicated to the SDGs (Tanzania, 2018). Its strategy on DRR is integrated within the national Vision 2025 and mainstreamed with the national development planning and implementation framework, with a parliamentary group established for the implementation of the SDGs (UNA 2018).

9.10.2 Flaws in the SDGs and the Sendai Framework data set for small states

The SDGs (UN Statistics Division 2018b) were intended as a more refined extension of the former Millennium Development Goals (MDGs) (UN Statistics Division 2018a). The MDG system had 8 goals, 17 targets and some 48 indicators. The system proved too elaborate for many small countries to collect and report the data required, with a resulting heavy level of missing data. One study on progress with the MDGs found 44 per cent missing data for small island developing states (SIDS) and other small states and 27 per cent missing for benchmark states (Roberts and Ibitoye 2012).

Notwithstanding, while attempting to fill certain gaps on the scope of the MDGs, the SDG system increased the size of the burden of data by more than doubling the number of goals, making a nearly tenfold increase in targets and a fivefold increase in indicators. Missing data remains a major issue, and the latest 2018 UN report on the SDG system revealed that 80 per cent of the data was missing (UNDESA 2018). The increasing burden is felt heavily by small states and has been cited as a curse rather than a cure for the monitoring of sustainable development (Roberts 2018). William Easterly in *Foreign Policy* magazine has suggested that 'SDG' should stand for 'senseless, dreamy and garbled'.[10]

To add to the already overburdened lot of the statistics bureaux in small states, the UNISDR is calling for implementation of a further elaboration of data for monitoring disasters, linked to the Sendai Framework, involving another set of 38 indicators covering 7 targets and 4 priorities. While some of these indicators duplicate what is already defined in the SDG system, the overall burden for small states is increasing, with little apparent gain for policy-making.

An official report (UNISDR 2017) on recent disasters in 87 countries, including 11 SIDS, determined to try to implement the Sendai Framework data system, provides sorry reading. Many countries provided only partial data across the 38 indicators. The reports were especially weak on the assessment of economic loss, loss of livelihoods, and impact on agriculture and forestry assets. Asked if they needed help in gathering data for the system, less than half the countries in the survey responded. Of those that did, the majority wanted financial assistance, capacity building and technical transfer to comply with the requirements of the Sendai Framework data system.

A minority of countries responded to questions on damaged and destroyed health systems, disruption to education, the status of implementation of a DRR strategy, clear timeframes for action and the existence of a follow-up procedure. Less than a quarter of the countries surveyed had data on the extent of the population exposed to disaster risk that were covered by an early warning system and pre-emptive evacuation process. The report concluded that considerable work would need to be done to enable countries to provide the agreed indicators in the Sendai Framework data system.

The Sendai Framework data system has been painstakingly documented, with an 80-page manual on data definitions and collection methods (UNISDR 2016a, 2017b, 2017c). This, however, is unlikely to engage the fullest support of many SIDS and other small states, whose capacities for the collection and reporting of obligatory data are already overwhelmed, with many calling for help(UNISDR Prevention Web, 2018b) .

For monitoring macroeconomic development, international analysts commonly confine themselves to the economic fundamentals, embraced by less than ten indicators: it is an extravagance to call for data on 242 SDG indicators and 38 on disaster management alone, devoid of evidence of the practicality of the exercise, nor showing concern for the cost effectiveness of the elements for illuminating differences in performance and aiding policy- and decision-making. The need to cut the data requirements down to size, at least for SIDS and other small states, needs further consideration (Roberts 2018). To some extent, this will emerge automatically, as small states, for lack of resources, restrict their reporting to key indicators. Yet some attention needs to be given to the practice of the UN Statistics Division? The insertion of estimated values to substitute for gaps in reporting by the countries themselves, which can be misleading.

It has been found, not surprisingly, that countries with higher levels of income invest more in greater levels of risk reduction and security and those with lower levels of income suffer more. Wealthier countries develop better protection and may have more transparent systems for accounting for national expenditure and great clarity in attributing disbursement to specific ends (Kelenberg and Mobarak 2011). But what is more critical is how far the expenditure on risk reduction actually reduces risk and what are the 'best buys' for a given level of investment in the face of the strength and frequency of known hazards. For this, a clear evidence base is required and the 2015 UNISDR and IOC studies of the South-West Indian Ocean islands lay out clear priorities for future strategy and action. Some progress has been made, but consolidation of this broad policy is now required. This is all the more necessary in the light of the findings of the review of Hurricane Maria (Andrade et al. 2018).

The UN *Post Disaster Needs Assessment* (PDNA) report on lessons learned from a decade of experiences (Jeggle and Boggero 2018), was compiled before the full results of Hurricane Maria appeared. As a result, it did not have the benefit of the findings of post-Maria epidemiological study, which brought into such sharp focus the massive impact on people with special needs and the probability that other such disasters had failed to spot this crucial issue for the future of DRR management. However, that

otherwise model PDNA report did draw oblique attention to the issue by noting that disaster needs assessment as a method should ensure greater inclusion of the most vulnerable socially marginalised groups with special needs (ibid, pages VII and 37). The study included Marshall Islands, Vanuatu, Fiji, Haiti and Seychelles in its review.

Nor is there much cause for greater hope that the Sendai Framework indicators will capture the true impact on the most vulnerable, whose unheroic long tail of deaths in the aftermath can contribute massively to the overall long-term mortality of disasters. For the guidance manual on the Sendai Framework data system addresses the issue rather obliquely, without providing a technical methodology that has emerged from the meticulous post-Hurricane Maria study (UNISDR 2017c).

The guidance manual gives greater emphasis to the direct, immediate deaths in a disaster, i.e. the 'direct causes of death that are more feasible to attribute'. Maybe this guidance will now be changed in the light of figures emerging of the overwhelming impact on the mortality from a category 5 wind storm – where the most vulnerable people linger for a while, but die in its aftermath. Maria also demands not just that methods of attributing death to the disaster are refined[11] and use is made of the correct ICD classification of death,[12] but that the strategy for saving life is reoriented accordingly.

Despite the enhanced performance of the IOC countries in responding to a key part of the Sendai Framework, which is duplicated in the SDGs, there must be serious doubts both of the capacity of small states to complete these data sets and of the usefulness of these indicators to them for policy-making. Moreover, these official international data systems have yet to take into account the lessons learned from Hurricane Maria in terms of data collection and disaster preparedness.

The Sendai Framework priorities begin with the understanding of disaster risks and end with 'building back better' (Wahlistrom 2015). After Hurricane Maria, the interpretation of these priorities needs to be re-evaluated.

9.11 Essential DRR issues for small island states

As a checklist for policy-makers in small island states, the six key questions to ask are:

1. What action has been taken to establish a policy, strategy and action plan on DRR?
2. How far have the conclusions and recommendations of previous post-disaster reviews been followed through?
3. Has the core of the Sendai Framework been implemented, and the key data required for monitoring progress towards the Sendai targets been collected and reported?
4. Is the island protected against the risk of a category 5 cyclone or other severe disasters (early warning systems, critical infrastructure, housing, power, water and sanitation, evacuation measures and emergency shelter, emergency food, medical supplies, communication systems)?

5. What steps have been taken to reduce the risk of flooding?
6. What steps have been taken to identify the most vulnerable groups of people dependent on vital medical and social care and to provide emergency support system for them in the aftermath of a disaster?

For a sharper focus on DRR, the international data systems in the SDGs and the Sendai Framework dataset need to be revisited, to reduce the burden of data collection on small states and to provide a plan to reduce the evident mortality from the aftermath of disasters.

9.12 Conclusions and recommendations

The recent history of natural disasters has shown the long-term human impact has an extended tail of deaths following on after initial disaster events. This furthermore contributes to the demise of a much larger number of the most vulnerable people than was hitherto suspected. In Hurricane Maria in the USA, such late indirect deaths were 98 per cent of the total deaths; in Rita they made up 94 per cent and in Katrina 52 per cent. The number of these deaths can thus, far outweigh those whose lives are lost by buildings falling on them or by drowning in subsequent floods and mudslides.

This long-run fatal aftermath, which is a probable feature of many types of disaster, must cause us seriously to revaluate the potential for preparedness. For quite different action is required to reduce the risk of this much larger death toll, which may be commonly understated in disaster reports. A correct assessment of this tail depends on the correct use of methods for the classification and coding of the cause of death and, above all, a different type of technical intervention.

Review of the preparedness for DRR in the South-West Indian Ocean Islands confirms this concern, even after exemplary studies had been conducted in the Islands Project, with support from UNISDR, the IOC and the EU. More needs to be done to address the post-disaster risks to survival of vulnerable people – for example, those on dialysis, those with asthma and chronic obstructive lung disease, and others whose lives depend on power, water and sanitation, and continual medical care services.

Registers of those at risk after a storm, and alternative support mechanisms for them, are being developed in other countries. The use of drone technology now operated by the UN for peaceful use, should be reviewed as a potential to provide urgent support to the most vulnerable people in the aftermath of disasters, whose lives are at risk from disruption of vital, timely services.

9.12.1 The lessons learned from the Island studies and action since 2015

This chapter gives rise to recommendations for action in preparedness and in further study, as follows.

DRR systems should:

1. consolidate the implementation of the recommendations of the 2015 UNISDR and IOC studies in all the countries covered;

2. provide a sharper focus on the risk factors affecting the long tail of indirect fatalities in the aftermath of disasters;
3. identify the most vulnerable people and ensure emergency back-up services are available for them;
4. provide education programmes to alert people and services to the risk factors which affect the survival prospects of the most vulnerable, especially those with chronic disease and who are dependent on life-saving medical services;
5. identify those life-support systems that are at risk from disruption of power and other technical support and provide alternative back-up for emergencies, such as the use of drone technology; and
6. improve reporting systems on cause of death certification and coding to capture the full extent of indirect fatalities and injury from disasters.

After Hurricane Maria, there is much to be done to re-orientate global and local DRR strategy to avert further loss of life from the aftermath of disasters, which may tragically continue to account for a large and neglected loss of human life, especially in small and island states where there is little room for evacuation to the hinterland.

Notes

1 'Deaths occurring as a direct result of the forces of the tropical cyclone are referred to as "direct" deaths. These would include those persons who drowned in storm surge, rough seas, rip currents, and freshwater floods. Direct deaths also include casualties resulting from lightning and wind-related events (e.g., collapsing structures). Deaths occurring from such factors as heart attacks, house fires, electrocutions from downed power lines, vehicle accidents on wet roads, etc., are considered "indirect deaths"." (Pasch et al. 2018)

2 Classification and certification of cause of death is the responsibility of qualified physicians and is governed by international convention for the completion of death certificates using the *International Classification of Diseases (ICD),* now into its 11th edition (WHO 2018). The appropriate cause of death resulting from natural hazards is found in Chapter 23 of the ICD: 'External Causes of Morbidity and Mortality', and the sub-section: 'Exposure to Extreme Forces of Nature'. There are special guidelines for completing the death certificates, which are then passed to official medical statistics offices for coding and compilation into national statistical returns, which are then annually reported to the WHO for international comparative purposes. Pasch and colleagues found that there was a clear raised mortality rate following Hurricane Maria in Puerto Rico; the causes of death specified in the statistical reports were replete with the use of what are termed 'garbage' codes, such as heart failure. These are resorted to by physicians who do not know which classification to use or who want to conceal the real cause of death or the underlying factors. Pasch found in a series of local key-person interviews that many physicians in Puerto Rico had not been trained in appropriate classification methods related to hurricanes, the special manuals for classification had not been distributed and there were certain disincentives arising for hazard insurance that dissuaded physicians from citing the hurricane as a factor in many late deaths (Pasch et al. 2018).

3 See: Anderson, JL (2018), 'Daily Comment', *New Yorker*:, available at: https://www.newyorker.com/news/daily-comment/what-donald-trump-fails-to-recognize-about-hurricanesand-leadership (accessed 20 November 2018).

4 Using US$85 billion as a mid-point of reported estimates of damage due to Hurricane Maria in Puerto Rico.

5 Comoros, La Réunion (France), Madagascar, Seychelles and Zanzibar (Tanzania).

6 Accessed 17 December 2018.
7 For Madagascar from 2005 to 2015.
8 Cyclone Carol (1960), with winds of up to 256km/h and barometric pressure of 943; Jenny (1962), with winds up to 235km/h and barometric pressure of 995; Gervaise (1975), with winds up to 280km/h and barometric pressure of 951; Hollanda (1994), with winds up to 216km/h and barometric pressure of 984; Dina, (2002) with winds up to 228km/h and barometric pressure of 988.
9 The islands of Farquar is receiving World Bank support to build back better following cyclone Fantala in 2016, with the loss of tourist infrastructure and where the recovery needs are estimated to be US$8 million (Seychelles News Agency 2016).
10 Easterly, W (2015), *Foreign Policy,* 28 September, available at: http://foreignpolicy.com/2015/09/28/the-sdgs-are-utopian-and-worthless-mdgs-development-rise-of-the-rest/
11 The guideline does draw attention to the need for more correct attribution of immediate disaster deaths, but does not go into detaild of the correct use of the International Classification of Diseases (WHO 2018). Nor does it identify the need for retraining of registration and coding staff certifying cause of death, using Chapter 23 of the classification for external causes and the sub-code for exposure to extreme forces of nature as an underlying cause of death, as recommended in the Maria report recommendations (Pasch et al. 2018).
12 The ICD 2018 reference guide (WHO 2018) prescribes the use of the following terms on death certificates and morbidity classification to allow the use of the external causes code to link a main cause of death to the external cause of extreme force of nature, by using terms such as 'due to'; 'caused by'; 'attributed to'; 'secondary'; and 'associated with'.

References

Adhikari, R et al. (2018), *Disaster Risk Reduction in Action, What Works at Local level*, International Red Cross and Red Crescent Societies, Asia Pacific Office, available at: https://media.ifrc.org/wp-content/uploads/sites/5/2018/06/DRR-in-Action-Case-Studies-FULL-Final-v2-1.pdf. Accessed 01/08/19.

Andrade, E, N Barratt, U Cohn-Ramos et al. (2018), *Ascertainment of the estimated mortality from Hurricane Maria in Puerto Rico*, Milkin Institute School of Public Health, Washington University, USA, and the University of Puerto Rico Graduate School of Public Health, available at: https://publichealth.gwu.edu/sites/default/files/downloads/projects/PRstudy/Acertainment%20of%20the%20Estimated%20Excess%20Mortality%20from%20Hurricane%20Maria%20in%20Puerto%20Rico.pdf. Accessed 01/08/19.

Benson, C (2012), Indirect economic impact from disasters, Government Office of Science, UK, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/287473/12-1296-indirect-economic-impacts-from-disasters.pdf. Accessed 01/08/19.

Bonne, G (2017), *Shaping our future, IOC Islands Project External Report*, Indian Ocean Commission

Carroll, AE and A Frankt (2017) The Long Term Consequences of Hurricane Harvey, *The New York Times*, August 31. https://www.nytimes.com/2017/08/31/upshot/the-long-term-health-consequences-of-hurricane-harvey.html. Accessed 01/08/19.

Dudley, N, C Buyek et al. (2015), *Protected Areas as Tools for Disaster Risk Reduction*, International Union for the Conservation of Nature and the Ministry of Environment of Japan, Japan, available at: https://reliefweb.int/sites/reliefweb.int/files/resources/2015-001.pdf. Accessed 31/07/19.

Eckhardt, D, A Leiras and AMT Thome (2019), 'Systematic literature review of methodologies for assessing the costs of disasters', *International Journal of Disaster Risk Reduction*, Vol. 33, February 2019, 398–416.

Heintze, H-J et al. (2018), *World Risk Report*, imprint, Bundnis Entwicklung Hilft, Ruhr Universitat, Bochum, Germany. ISBN 978-3-946-785-06-4

Ho, JY et al. (2017), 'Adult mortality five years after a natural disaster', Working Paper 22317, National Bureau of Economic Research, Cambridge, MA, available at: https://onlinelibrary.wiley.com/doi/pdf/10.1111/padr.12075. Accessed 01/08/19.

Hugenbusch, D and T Neumann (2016), 'Cost-benefit analysis of Disaster Risk Reduction: a synthesis for informed decision making', UN International Strategy for Disaster Reduction (UNISDR) Prevention Web, available at: https://www.preventionweb.net/publications/view/50665. Accessed 01/08/19.

Indian Ocean Commission (IOC) (2018), 'Quid des perspectives climatiques?', 33rd Council of Ministers of the IOC, press review, 29.

Jacobs, J (1999), *Impacts of natural disasters*, Commission of Geosciences, Environment and Resources, National Research Council, National Academy Press, Washington, DC, available at: www.nap.edu/read/6425. Accessed 01/08/19.

Jeggle, T and M Boggero (2018), *Post Disaster Needs Assessment: lessons from a decade of experiences*, Global Facility for Disaster Reduction and Recovery, World Bank Group, UNDP and UN.

Keim, M (2018), 'How do people die in disasters?', available at: http://disasterdoc.org/how-do-people-die-in-disasters/. Accessed 01/08/19.

Kelenberg, D and AM Mobarak (2011), 'The Economics of Fatal Disasters', *Annual Review of Research Economics*, 3, 307–312.

Kishore, N, D Marques et al. (2018), 'Mortality in Puerto Rico after Hurricane Maria', *New England Journal of Medicine*, 397, 162–170, available at: https://www.nejm.org/doi/full/10.1056/NEJMsa1803972?query=featured_home&wpisrc=nl_health202&wpmm=1. (Funded by the Harvard TH Chan School of Public Health and others.) Accessed 01/08/19.

Kleinpeter, MA (2011), 'Disaster preparedness for dialysis patients', *Clinical Journal of American Society of Nephrology*, Vol. 6 No. 10, 2337–2339.

Leste de Peridoe, P and K Ishigaki (2015), 'Review of South West Indian Ocean Region', UNISDR Working Papers on Public Investment Planning and Financing Strategy for Disaster Risk Reduction, UNISDR, Geneva.

Mechler, R (2016), 'Reviewing estimates of the economic efficiency of disaster risk management: opportunities and limitations of using risk-based cost–benefit analysis', *Natural Hazards*, April, Vol. 81 Issue 3, 2121–2147.

Moran, M and C Monje (2016), 'Guidance on treatment of the economic value of a statistical life in the US', Department of Transport, USA, available at: https://www.transportation.gov/office-policy/transportation-policy/revised-departmental-guidance-on-valuation-of-a-statistical-life-in-economic-analysis. Accessed 01/08/19.

Pasch, RJ, AB Penny and R Berg (2018), *Hurricane Maria* (AL 152012), National Hurricane Centre Tropical Cyclone Report, available at: https://www.nhc.noaa.gov/data/tcr/AL152017_Maria.pdf. Accessed 01/08/19.

Rappaport, EN and BW Blanchard (2016), 'Fatalities in the United States Indirectly Associated with Atlantic Tropical Cyclones', American Meteorological Society, July Bulletin, 1139–1148, available at: https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-15-00042.1. Accessed 01/08/19.

Roberts, JL (2004), 'Cyclone early warning systems in the Western Indian Ocean', in Nightingale, D (ed.), *Case Studies, Human Vulnerability to Environmental Change, Africa Environment Outlook*, UN Environment Programme (UNEP), 151–159.

Roberts, JL (2010), 'Disaster risk reduction: practical adaptive options', in Nath, S, JL Roberts and N Madhoo (eds.), *Saving Small Island Developing States, Environmental and Natural Resources Challenges*, Commonwealth Secretariat, London, 156–171.

Roberts, JL (2018), 'Small island developing states and Sustainable Development Goals: curse or cure?' in Briguglio, L (ed.), *Handbook of Small States*, Routledge, London and New York, 517–529.

Roberts, JL and I Ibitoye (2012), *The Big Divide, a ten year report of small island developing states and the Millennium Development Goals*, Commonwealth Secretariat, London.

Santos-Burgo, C et al. (2018) Ascertaining the Estimated Excess Mortality from Hurricane Maria, Puerto Rico, Milken Intitute, George Washington School of Public Health and University of Puerto Rico School of Public Health, https://prstudy.publichealth.gwu.edu/sites/prstudy.publichealth.gwu.edu/files/reports/PR%20PROJECAccessed01/08/19T%20REPORT%20FINAL%20Aug%2031%202018%20AGM%200933hrs.pdf. Accessed 01/08/19.

Saulnier, DD, KB Ribacke and J Von Shrub (2017) No Calm After the Storm, Prehospital and Disaster Medicine, 32, 5, October, 568–579

Seychelles News Agency (2016), '$4.5 million in damages from cyclone that hit remote Seychellois island, World Bank says', available at: http://www.seychellesnewsagency.com/articles/5175/.+million+in+damages+from+cyclone+that+hit+remote+Seychellois+island,+World+Bank+says. Accessed 01/18/19.

Shultz, J, J Russell and Z Espinal (2005), 'Epidemiology of Tropical Cyclones: the dynamics of disaster, disease and development', *Epidemiological Reviews*, Vol. 27 No. 1, 21–35, OUP, available at: https://academic.oup.com/epirev/article/27/1/21/520830. Accessed 01/08/19.

Tanzania, (2018), Sustainable development Goals, Data Portal, available at: http://tanzania.opendataforafrica.org/TZSDG2016/sustainable-development-goals-of-tanzania. Accessed 01/08/19.

UN Association (UNA) (2018), 'How are the Sustainable development Goals implemented in Tanzania?', available at: http://una.or.tz/how-are-the-sustainable-development-goals-implemented-in-tanzania/. Accessed 01/08/19.

UN Department of Economic and Social Affairs (UNDESA) (2018), *The Sustainable Development Goals Report*, UN, New York.

UN Development Programme (UNDP) (2017), 'Financing Systems for Sustainable Development', available at: http://www.undp.org/content/sdfinance/en/home/solutions/disaster-risk-insurance.html. Accessed 01/08/19.

UN International Strategy for Disaster Reduction (UNISDR) (2016a), *The Sendai Seven Campaign, 7 targets in 7 years (2016–2022)*, UN, available at: https://reliefweb.int/sites/reliefweb.int/files/resources/49524_iddr2016conceptnotefinal.pdf. Accessed 01/08/19.

UN International Strategy for Disaster Reduction (UNISDR) (2016b), *Mauritius declaration of commitment to the Sendai Framework*, available at: https://www.preventionweb.net/files/49455_mauritiusdeclarationenfinal.pdf. Accessed 01/08/19.

UN International Strategy for Disaster Reduction (UNISDR) (2017a), *Technical Guidance for monitoring and reporting progress in achieving the global targets of the Sendai Framework for disaster risk reduction*, UNISDR, available at https://www.unisdr.org/files/54970_techguidancefdigitalhr.pdf. Accessed 01/08/19.

UN International Strategy for Disaster Reduction (UNISDR) (2017b), 'Madagascar sees early warning and preparedness as key to disaster risk', available at: https://www.unisdr.org/archive/53627. Accessed 01/08/19.

UN International Strategy for Disaster Reduction (UNISDR) (2017c), *Sendai framework data readiness review*, available at: https://www.preventionweb.net/files/53080_entrybgpaperglobalsummaryreportdisa.pdf. Accessed 01/08/19.

UN International Strategy for Disaster Reduction (UNISDR) (2018), *Report on Puerto Rico Hurricane Maria 2017*, available at: https://www.unisdr.org/archive/60270. Accessed 01/08/19.

UNISDR Prevention Web (2018a), Country Disaster Risk Profiles data, available at: https://www.preventionweb.net/countries/com/data/. Accessed 01/08/19.

UNISDR Prevention Web (2018b), Sendai framework Monitor of indicators, available at: https://www.preventionweb.net/drr-framework/sendai-framework-monitor. Accessed 01/08/19.

UN Peacekeeping (2018), 'Does drone technology hold promise for UN?', available at: https://peacekeeping.un.org/en/feature-does-drone-technology-hold-promise-un. Accessed 01/08/19.

UN Statistics Division (2018a), Millennium Development Goals and Beyond 2015, available at: http://www.un.org/millenniumgoals/. Accessed 01/08/19, under maintenance.

UN Statistics Division (2018b), Sustainable Development Goals database, available at: https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%20refinement_Eng.pdf. Accessed 01/08/19.

Wahlistrom, M (2015), *Sendai Framework for Disaster Risk Management*, UNISDR.

Wallemacq, P and R House (2018), *Economic Losses Poverty and Disasters, 1998–2017*, CRED, UNISDR, available at: https://www.unisdr.org/2016/iddr/IDDR2018_Economic%20Losses.pdf. Accessed 01/08/19.

West, C et al. 2008, Mental health Outcomes in Police Personnel after Hurricane Katrina, JOEM, 50, 6, June, 689–695

World Health Organisation (WHO) (2018), *International Classification of Diseases for mortality and morbidity statistics* (Eleventh Revision), Reference Guide, use of terminology, WHO, UN. Geneva]