1 Linking the Impacts of Tropical Cyclones to the Sustainable Development Goals

David Chikodzi and Godwell Nhamo

Abstract

The socioeconomic and environmental costs of tropical cyclones (also known as hurricanes or typhoons) have drastically increased over the past 20 years. Countries in the global south are disproportionately bearing the burden of these increasing costs due to their vulnerability and limited ability to adapt and build resilience. This chapter provides a background to the book and introduces key issues that will be covered in the other chapters. The chapter also links the impacts of tropical cyclones to the sustainable development goals (SDGs) and details the material and methods used in the book. The debilitating impacts of cyclones are shown to challenge the successful implementation of the SDG targets. Methods used in the book include questionnaire surveys, in-depth interviews, document and critical discourse analysis, earth observation, geographic information systems, secondary data and field observations.

Keywords

Tropical cyclones · SDGs · Southern Africa · ThinkHazard · Climate resilience

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1.1 Introduction and Background

Tropical cyclones are extreme weather systems associated with an intense low-pressure centre, strong winds, thunderstorms and heavy rainfall, which usually have a debilitating impact on the affected communities (Sommen et al., 2018). Thomas et al. (2017) observe hazards associated with cyclones as coming not only from the strong winds but also from flooding (both coastal and freshwater) as a result of heavy rainfall associated with such. The same authors further argue that the attribution of hazards from cyclones must go beyond the meteorological event itself. To this end, the impacts of cyclones on communities are a function of their intensity, extent of vulnerability of socioeconomic and ecological systems and the capability of exposed societies to formulate efficient disaster risk reduction (DRR) strategies (Sommen et al., 2018).

Although there is still uncertainty over time and space in terms of the frequency of cyclone occurrence, there has been an observed tendency towards their intensification (Lee et al., 2020). Literature seems to suggest that tropical cyclone numbers will remain more or less the same in most ocean regions until the end of the twenty-first century (Koubi, 2019; Vink & Ahsan, 2018). However, it is anticipated that cyclones rated as categories 4 and 5 on the Saffir-Simpson scale were likely to increase in frequency worldwide

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(Lee et al., 2020). The Munich Re (2021) has for long classified cyclones as one of the costliest natural hazards in the world, with a total cost of US$225 billion in 2017. This saw hurricanes Harvey, Irma and Maria inflicting massive losses of over US$90 billion within a time lag of just 4 weeks. Koubi (2019) highlights that economic losses as a result of climate-related hazards rose by over 100% from 2015 (US$63.6 billion) to 2018 (US$122 billion). The socioeconomic consequences of tropical cyclones are not equally distributed the world over, with the global south countries having disproportionately carried the biggest burden due to their limited ability to build resilient infrastructure. From the year 1980 to 2015, the number of persons who lost their lives as a result of cyclones was almost 450,000, with the number of victims totalling an overage of 24 million annually (CRED, 2015). From these figures, people from developing countries in Asian and small island developing states have suffered the most as a result of the occurrence of cyclones (Ibid.). Vulnerability to cyclones is amplified by rapid population growth, and rapid urbanisation that is accompanied by increasing population density, especially in coastal communities at risk of cyclones (Djalante, 2019). Vulnerability is also aggravated by degraded ecosystems, old and failing infrastructure, as well as increasing socioeconomic disparities (Shultz et al., 2019).

The threat posed by tropical cyclones is adding more pressure points to communities, economies and ecological systems, which are already failing to deal with other threats that are not climatic in nature. Hence, cyclones can harm sustainable development efforts. For example, the 2017 Atlantic hurricane season left a trail of destruction over the Caribbean. On the island of Barbuda, over 90% of structures were completely destroyed. This led to the entire island being totally evacuated and uninhabited for the first time in over 300 years (NPR, 2017; Thomas et al., 2017). The increased threats of cyclones call for an increased understanding of the nexus between sustainable development and the occurrence of tropical cyclones. This increased understanding is more crucial to developing countries that are experiencing the most severe impacts of tropical cyclones due to their limited ability to adapt and build back better from the hazard (Djalante, 2019), as well as ineffective institution in DRR (McCaughey et al., 2018; Zscheischler et al., 2018). An in-depth study of linkages between the occurrence of cyclones and the achievement of sustainable development is invaluable in devising plans for acting on the risk and harnessing the opportunities that will enable the achievement of societal development priorities. This introductory chapter aims to link the impacts of cyclones to the SDGs (United Nations, 2015). Furthermore, the chapter details the methods used in the book, as well as highlighting its structure.

1.1.1 Disaster Risk Reduction and SDG Achievement

Tropical cyclone occurrence is unfortunately unavoidable in certain regions of the world. Human communities should therefore device ways of reducing the consequences of tropical cyclones and increase resilience to their impacts (Hay & Mimura, 2010; Helgason, 2020). This calls for the building of capacity in individuals, communities, institutions and the different levels of governments in effective DRR and management in order to minimise the impacts of cyclones on the quality of life and livelihoods, health, property, cultural heritage and the environment (Petrović et al., 2017), all perspectives addressed in the 2030 Agenda for Sustainable Development and its 17 SDGs (United Nations, 2015). The Organisation for Economic Co-operation and Development (OECD) observe that low-income nations utilise about 9.3% of their gross domestic product (GDP) (an equivalent of US$30 billion annually) on social welfare (Haile & Nino-Zarazúa, 2018). This percentage is envisaged to increase significantly should the impacts of tropical cyclones continue to increase, especially when they create internally displaced persons (IDPs). Helgason (2020) observe that an estimated US$2.4 billion was spent in 2017 by 17 low-income countries to care for IDPs alone.

The 2030 Agenda for Sustainable Development recognises the pressing need for DRR (United Nations, 2015). The 17 SDGs recognise the robust linkages between societal well-being, the environment and delivery of ecological goods and services. Extreme climatic events like tropical cyclones threaten many livelihoods and are dragging many communities into ultra-poverty (Raza et al., 2020). All 17 SDGs are interwoven and inseparable. However, in this book, the SDGs that are emphasised and their targets related to DRR and management are depicted in Table 1.1. When disasters like tropical cyclones occur, they take the affected communities several years back in the development trajectory by reversing the gains that will have been made towards the achievement of the SDGs (Nerini et al., 2019). Cyclones will continue to inflict socioeconomic as well as environmental dilemmas that can potentially hold back the effective implementation of SDGs. Helgason (2020) highlights that the SDG Summit held in New York in September 2019 noted with concern that most countries were off track in attaining the majority of the 169 targets, in particular the 21 targets earmarked for implementation by 2020.

Table 1.1 Selected SDGs and targets related to DRR and management emphasised in the book

Goal	Target
SDG 1: End poverty	Target 1.5: By 2030, build resilience of the poor and those exposed to intense weather events as well as other disasters.
SDG 2: End hunger, achieve food security and promote sustainable agriculture	Target 2.4: By 2030, build smart and sustainable food production structures that raise productivity as well as production in ways that support ecosystem integrity and strengthen adaptative capacity to climate change and extreme weather.
SDG 3: Ensure healthy lives and promote wellbeing for all	Target 3.d: Enhance the capability of all nations, in especially developing countries, for disaster early warnings, DRR of national and global health risks.
SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Target 4.7: By 2030, make sure that all learners obtain the knowledge and skills required for the promotion of SD, for example, education for SD and sustainable lifestyles, appreciation of cultural diversity and its contribution to SD. Target 4.a: Build and upgrade safe and all-inclusive educational infrastructure which is child, disability and gender sensitive.
SDG 6: Ensure availability and sustainable management of water and sanitation for all	Target 6.6: By 2020, protect and restore water-related ecological systems, including mountains, forests, wetlands, rivers, aquifers and lakes.
SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Target 9.1: Develop quality, reliable, sustainable and resilient infrastructure to support economic development and societal well-being. Target 9.a: Facilitate sustainable and resilient infrastructure development in developing nations through enhanced financial, technological and technical support.
SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable	Target 11.4: Strengthen efforts to protect and safeguard the world's cultural and natural heritage. Target 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations. Target 11.b: By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030.

(continued)

Table 1.1 (continued)

Goal	Target
SDG 13: Take urgent action to combat climate change and its impacts	Target 13.1: Strengthen resilience and community adaptive capacity to climate-related hazards and natural disasters in all countries. Target 13.2: Make climate change strategies an integral component of national policies. Target 13.3: Improve education, awareness raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning. Target 13.b: Promote mechanisms for raising capacity for effective climate change-related planning and management in the least developed countries, including focusing on women, youth and local and marginalised communities.
SDG 14: Conserve and sustainably use the oceans, seas and marine resources for SD	Target 14.2: By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, by consolidating their resilience, and take action for their restoration in order to realise healthy and productive oceans.
SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests	Target 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services. Target 15.2: By 2020, encourage the sustainable management of all forms of forests, stop deforestation and rehabilitate degraded forests. Target 15.9: By 2020, make ecological system and biological diversity an integral component of national and local development planning, as well as integrating them into poverty reduction strategies.

Source: Authors, data from UN (2015)

The Sendai Framework for Disaster Risk Reduction (Sendai Framework) 2015–2030 is aimed at significantly reducing the effects of disasters in terms of death, financial losses and damages, as well as interruption of basic services (UNDRR, 2015; WMO, 2016). As tropical cyclones continue to occur and increase in intensity around the world, the Sendai Framework, if implemented effectively, will help to reduce and prevent their impacts through clear targets and priorities for action, as articulated in the 2030 Agenda for Sustainable Development. Target (e) of the Sendai Framework set 2020 as the year countries would have enacted national and local DRR plans. By April 2020, of the 85 countries reporting under the Sendai Framework, only six countries had their DRR strategies fully aligned to the framework, while 34 countries had their strategies aligned from 75% to 99% (UNStats, 2020). A sizeable number of countries (18 of them) still had their DRR strategies less than 50% aligned to the requirements of the SFDRR (Fig. 1.1). This limited alignment will constrain these countries in implementing efficient DRR plans in the case of tropical cyclones and other disasters.

A tropical cyclone event produces a domino effect on the impacted area. This will be in the form of primary, secondary and territory hazards. Primary hazards are directly caused by the tropical cyclone and are difficult, if not impossible, to mitigate to any significant extent. Secondary hazards also occur as a result of the impact of the primary hazards, and it is partly possible to mitigate them (Rogers et al., 2020). Tertiary hazards of tropical cyclones result from the impact of both the primary and secondary hazards or may be a manifestation of human failure and usually have considerable societal impacts (Ibid.). Usually, these hazards are related and sometimes interconnected, with each hazard leading to further impacts and can be both short and long terms. Table 1.2 illustrates some of the primary,

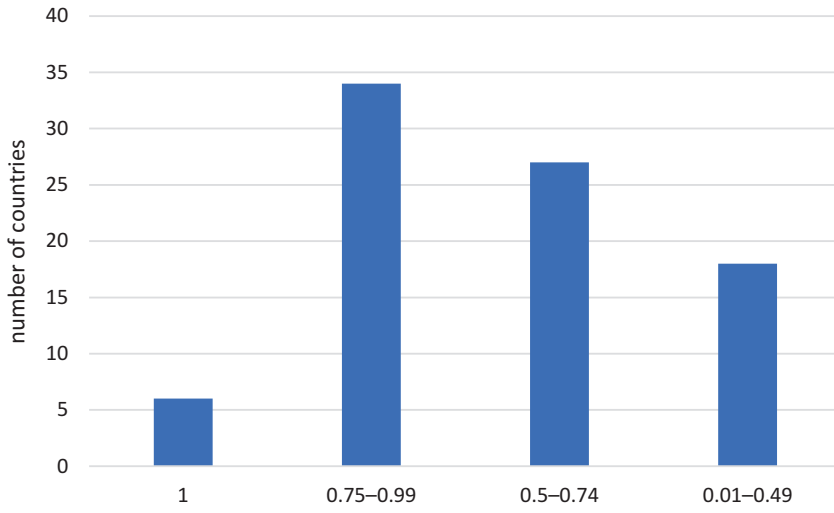

Fig. 1.1 Degree of alignment of national and local DRR strategies to the SFDRR
Source: Authors, data from UNStats (2020)

secondary and tertiary hazards associated with tropical cyclones.

The next section discusses the impacts of tropical cyclones on agriculture (SDG 2) and health infrastructure and systems (SDG 3).

1.2 Impact of Cyclones on Agriculture and Public Health

The impacts of tropical cyclones on agriculture direcftly link with the achievement or lack thereof of the second SDG, which aims to end hunger, achieve food security and promote agriculture that is sustainable (United Nations, 2015). As observed, many parts of the world that are vulnerable to tropical cyclones also depend heavily on agriculture for livelihoods, income and supporting downstream industries (Mohan, 2017). The impacts of cyclones on agriculture are noted to depend on several factors such as the status of the crops, level of crop development, type of crops and whether the crops are in the direct path of the cyclone. Research done globally shows that agricultural production is very sensitive to cyclones and in most vulnerable tropical countries, small-scale farmers in particular are extremely susceptible to their effects and experience massive losses in crop production, leading to food and livelihood insecurity (Mohan, 2017; Rakotobe et al., 2016).

In Bangladesh, for example, seasons of multiple tropical cyclones have led to the cumulative loss of over 1.6 million acres of cropland and, in most cases, they strike when many of the crops are nearing harvest time (Hossain et al., 2008). Furthermore, movement to agricultural commodity markets is usually disrupted in the hardest hit areas. In Dominica, agriculture and its value chains contribute about 13% of the GDP and employ about 21% of the labour force with the main export crop being bananas. In 1989 when tropical cyclone Hugo hit the country, agricultural GDP declined by 14.6%, while non-agricultural GDP rose by 4.4%, leading to the overall decline of the GDP reduction by 1.1% (Benson & Clay, 2001). Hurricane Dean's devastation of the Caribbean led to the abrupt cessation of banana exports to Europe, negatively affecting the livelihoods of over 4000 farmers and other downstream value chains (Mohan, 2017). Banana and pawpaw plants have been identified as the most sensitive to tropical cyclone damage, while tannia, ginger and pineapples have been noted to be more resistant (Ahmed, 2001). Tropical cyclones can also have a negative impact on crop production for more than one season. This is due

Table 1.2 Primary, secondary and tertiary hazards related to cyclones

Cyclone primary hazards	Cyclone secondary hazards	Cyclone tertiary hazards
Lightning Strong winds Heavy rainfall Intensive tropical heat	Flooding Landslides/mass movement Storm surges Rise in water levels in reservoirs Riverbank widening and erosion Soil erosion	Damage to embankments, irrigation and drainage infrastructure, pumping facilities Loss of agricultural land IDPs Loss of infrastructure, e.g. transportation, schools, hospitals, energy and communication Waterborne diseases Environmental degradation Siltation of water resources
High impacts Damage to property and destruction of livelihoods Excess deaths and injuries IDPs	Degradation of arable land Loss of freshwater resources Severe disruption to transportation and supply chain networks	Extensive shortages of food and water Increase in insecurity Civil unrest

Source: Authors, adopted from Rogers et al. (2020)

to erosion of the top and productive soil, soil salination due to storm surges, outbreak of diseases in the aftermath, damage to production equipment, and destruction of irrigation and related infrastructure (Mohan, 2017).

On the other end, Shultz et al. (2019) foresee the impacts of tropical cyclones on public health increasing in communities located in vulnerable areas. After the 2017 hurricane season in the West Indies, the death tolls in the affected areas continued to grow for several months as victims faced extended power cuts, shortage of basic provisions and a weakened healthcare system. In Puerto Rico, for example, the official death toll after hurricane Maria was 58. However, 10 weeks after the disaster, preliminary studies of excess deaths showed that the death toll was about 20 times higher compared to previous years (Robles et al., 2017). This suggests that more deaths occurred in the aftermath of the disaster.

Tropical cyclones also propel the emergence of communicable diseases such as malaria and waterborne diseases like cholera. These are usually triggered by the failure of power grids, which in turn disable water and sewer treatment systems. Hence, cross-contamination of the water supply with wastewater usually takes place (McMichael, 2015). Psychological distress is also usually experienced by those who survive the tropical cyclone event. Direct and inevitable exposure to a possible deadly threat can trigger depression and/or post-traumatic stress disorder (Shultz et al., 2019). This is further heightened by pressures and hardships that occur in the aftermath of the hazard (Ibid.). Galea et al. (2007) argue that as much as a third of the survivors can be affected by mental disorders after a life-threatening hurricane. These risks of mental health problems are very high for special populations like children, the elderly, the disabled and persons with special needs. For those already diagnosed with recurring mental health problems, interruption of routines and hinderances to getting medical attention as replenishing medicines can lead some patients to decompensate (Goldman & Galea, 2014). Other SDG-related impacts from tropical cyclones and covered in this book include education (SDG 4) and water and sanitation (SDG 6).

1.3 Impact on Education, Water and Sanitation

Dobkin et al. (2010) view classroom attendance as being one of the crucial factors defining the academic performance of learners. Spencer et al. (2016) argue that natural disasters like tropical cyclones have negative impacts on the educational ecosystem of the affected place. This is because they cause school children to be absent from the classroom. Absenteeism occurs after tropical cyclones due to the roads leading to schools being damaged, transport constrained

and school infrastructure also being damaged (Baez et al., 2010). In the aftermath of tropical cyclones, schools sometimes remain closed until renovations or reconstructions are done or until authorities deem them safe to re-accommodate learners. It has also been observed that closures of schools during such disaster events disrupt teachers' productivity in the classroom, worsening the learning environment (Spencer et al., 2016). In a study conducted by Spencer et al. (2016) to determine the impact of hurricanes on student pass marks in the Caribbean, the authors concluded that hurricanes had a negative impact on the performance of students, especially in science subjects. Furthermore, the greatest negative impact occurred when hurricanes strike when schools are in session. Hurricanes occurring when learners are in session lead to the reduced number of school days and the number of classroom instruction hours. Hence, this results in poor performance from students. Jacoby and Skoufias (1997) observe that when disasters like cyclones occur, poor households often indulge in negative coping mechanisms. Such negative coping mechanisms include taking children out of school and using them as child labour to reduce the economic burden and increase income. In Fiji, for example, Monier (2016) observed that soon after cyclone Winston struck, as many as 120,000 students were temporarily left without schools to learn from. This was mainly because close to 240 schools were either damaged or ruined and most schools were used as temporary evacuation shelter for people who had lost their homes.

Ensuring the availability, efficient management of safe and adequate water, sanitation and hygiene (WASH) facilities is the aim of SDG 6. According to UN Water/WHO (2019), WASH facilities are key components of the public health and well-being of society. If a massive disturbance to WASH systems occur, this may result in huge public health challenges and possibly epidemics that may worsen a humanitarian crisis. Despite the absence of WASH facilities impacting on the quality of life and undermining basic human rights, in the year 2017, as many as 2.2 billion people globally did not have access to safely managed water, 4.2 billion did not have access to safely managed sanitation and 3 billion lacked access to basic handwashing facilities (Rafa et al., 2021). Large funding gaps in the global south hamper the achievement of SDG 6 targets despite notable improvements (UN-Water/WHO, 2019). WASH concerns are usually heightened during tropical cyclones as facilities can be damaged. Cyclones impose damage to WASH facilities due to strong winds, heavy rainfall, inland flooding and coastal storm surges (EPA, 2015). Damage to WASH facilities as a result of cyclones includes pipe breaks, sewage spills, loss of power and pumping equipment, loss of water quality testing capacity and damage to utility equipment such as storage reservoirs (Ibid.). Due to their importance to society, WASH facilities should be designed to withstand shocks imposed by tropical cyclones so that they may remain functional or at least provide the minimum level of required service (Rafa et al., 2021). This scenario is key for the timeous recovery of the impacted communities. Building cyclone smart WASH facilities is almost solely dependent on the willingness of governments to finance such facilities (Rafa et al., 2021). The next section is dedicated to briefly look at the impacts of tropical cyclones to infrastructure (SDG 9) and human settlements (SDG 11).

1.4 Impact on Infrastructure and Settlements

Global agendas such as the Paris Agreement, the 2030 Agenda for Sustainable Development, the New Urban Agenda and the Sendai Framework all endeavour to have investments that produce climate-smart (SDG 13) infrastructure, which supports sustainable development. In as much as it is SDG 9 that clearly spells out the need for constructing resilient infrastructure, the achievement of most of the SDGs is underpinned by the development of appropriate infrastructure (World Bank, 2015). Investments in infrastructural development create jobs and synergies in the economy and support the services that stimulate the capability of individuals to be economically

productive. Having resilient infrastructure that can survive the shocks exposed to it throughout its lifetime provides resilience and protects sustainable development. Infrastructure that can withstand shocks from, for example, tropical cyclones shields the economy by minimising disruptions to industry and guarantees the continuity of critical servitudes like power, hospitals and water during a disaster (World Bank, 2015). Smart infrastructure reduces disruption to community livelihoods and therefore brings stability for them.

For the world to stay true to the SDGs and achieve their targets, infrastructure investment between US$3.2 and US$3.7 trillion per year is required between 2015 and 2030 (World Bank, 2015). However, there have already been noted gaps in infrastructural investment in many countries of the global south that are over US$452 billion from 2014 to 2020. The average spending on infrastructure in these countries is estimated to be at around US$259 billion against a requirement of over US$711 billion (UNstats 2020; World Bank, 2015). Figure 1.2 depicts the gaps in funding infrastructural projects in different regions of the world. The most glaring gap in funding is in south Asian countries. These are also countries at the highest risk of tropical cyclone hazards, and with their anticipated intensification in future, this represents an increased threat to less resilient infrastructure (Pennisi & Malakoff, 2017). There is a need for urgent action to support the development of resilient infrastructure to cope with the increased risk in this region. Unless this is implemented, the region is unlikely to achieve the SDG targets by the year 2030 in the face of such threats (Lin et al., 2016). For sub-Saharan Africa, the gap in funding could be small when compared to other regions from the global south, but the close to two billion difference is enough to increase vulnerability to disasters for the affected communities.

To support decision-making on locating new projects and infrastructure, as well as improving their designs to cope with potential hazards, the World Bank produced a decision support system known as ThinkHazard. The web-based tool enables even non-specialists to robustly assess the impacts of hazards on new development projects. The hazards included in the ThinkHazard database are the risks of river floods, earthquakes, droughts, cyclones, coastal flooding, tsunamis, volcanoes and landslides. The ThinkHazard web tool user only needs to enter the location of their project, which can be the national, provincial or district name. The output shows the user whether they require high, medium or low awareness of specific hazards

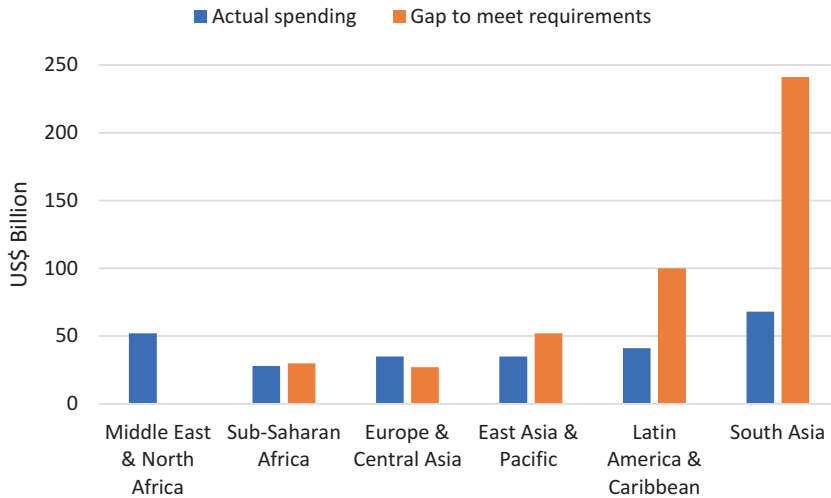

Fig. 1.2 Gaps in infrastructural funding across the globe
NB: Data exclude China, which is over-investing in infrastructure
Source: World Bank (2015)

when planning for their project (ThinkHazard, 2021). The aim of the ThinkHazard project is to assist planners to identify, prioritise and manage multiple hazards with the greatest chance of causing damage to their interests.

Taking cyclones as a case in point, when the risk is classified to be high, it implies that given the information currently available, there will be a more than 20% chance of potentially damaging wind speeds and heavy rainfall in the area in the next 10 years. It also means that to achieve sustainable projects, the impact of cyclones must be considered at all phases of project development, in particular during design and construction (ThinkHazard, 2021). Areas classified as being of medium risk to cyclones mean that there will be a 10% chance of potentially damaging wind speeds and heavy rainfall in the area in the next 10 years (Ibid). Figure 1.3 depicts the levels of tropical cyclone risk in Southern Africa as given by the ThinkHazard project. Its shows that the small island nations of Mauritius, Reunion, Seychelles, Comoros as well as Madagascar and Mozambique have the highest risk of tropical cyclone occurrence. The southern parts of Malawi, as well as eastern and south eastern Zimbabwe, have a high-to-medium risk of cyclone occurrence.

In terms of the impacts of tropical cyclones on communities and settlements, it has been observed that since 2008, over 20 million persons have been driven from their shelter as a result of this risk (Koubi, 2019). In addition, climatic hazards are posing threats to national security by aggravating existing conflict drivers like poverty, livelihood insecurity, poor leadership and food insecurity (Ibid.). Rigaud et al. (2018) observe that climate-related migration will continue to increase the IDPs, especially in countries of the global south. Climate-related hazards like tropical cyclones create hotspots of in- and out-migration, as people move to less vulnerable areas. This trend, as highlighted by Rigaud et al. (2018), will have more effects on the most vulnerable communities in the poorest countries, which will further enhance inequalities within and between countries. The occurrence of hurricanes is also observed by Baez et al. (2017) to increase the rate of migration in the Caribbean and South America. Waters and Adger (2017) argue that climate hazard-related

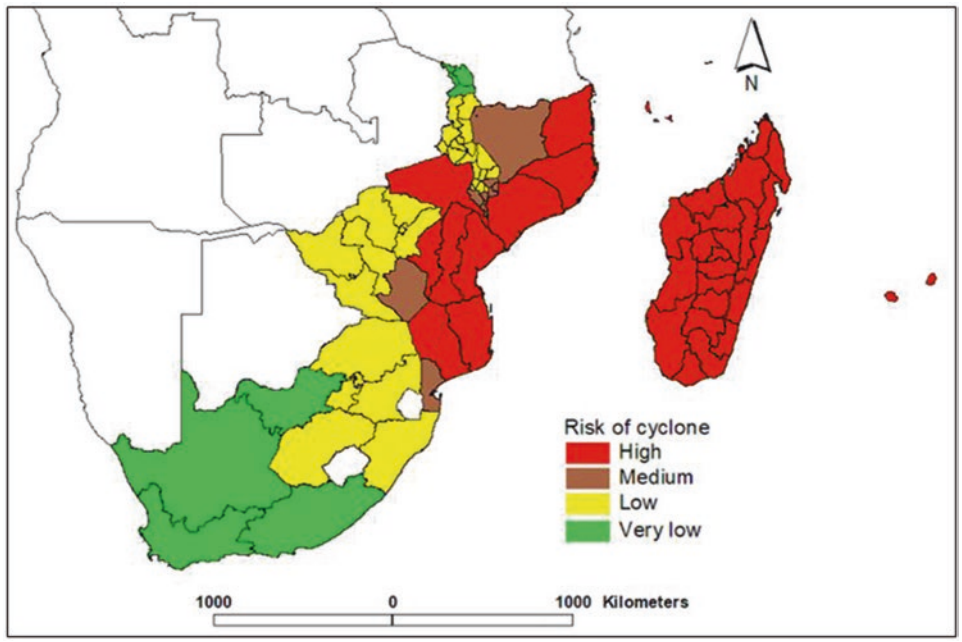

Fig. 1.3 Risk of tropical cyclones in Southern Africa
Source: Authors, data from ThinkHazard (2021)

migration will make the realisation of SDGs difficult. This is because most migrants move from rural to urban environments that are already lacking in services and social support, which makes them even more vulnerable to other urban hazards like flooding. Those left behind in areas of out-migration are usually the vulnerable groups like women and children who are less able to manage the impacts of climatic hazards (Waters & Adger, 2017). This is usually the case in many countries of the global south. Tropical cyclones also have some impacts on the oceans (SDG 14), biodiversity (SDG 15) and tourism (covered across several SDGs).

1.5 Impact on Natural Resources, Oceans and Tourism

Tropical cyclones have accelerated the pace of degradation of natural ecosystems in the areas that are impacted. Storm surges from tropical cyclones dump huge volumes of saltwater that pollute coastal freshwater resources and disturb close-by terrestrial ecosystems (Smith et al., 2008). This tends to disrupt benthic and coastal terrestrial habitats and inflict damage to fisheries, thereby affecting SDG 14 that focuses on the ocean (blue) economy (Sainsbury et al., 2018). Storm surges during cyclones can induce massive changes in coastal geomorphology over a short period of time. This is due to erosion and deposition processes that, in turn, influence coastal hydrology, ecosystem productivity and other biogeochemical processes (Steneck et al., 2019). Tropical cyclones can also increase the mortality or displacement of coastal fauna and flora, directly linking into SDG 15 (Radabaugh et al., 2019). The structural damage caused by strong winds that occur during cyclones has been shown to increase the rate of tropical forest fragmentation in tropical forests. Furthermore, areas that are frequently hit hard by tropical cyclones tend to have dichotomies in forest structure and canopy attributed to the phenomena (Simard et al., 2019). Hogan et al. (2020) view the impacts of tropical cyclones on ecological systems as interacting with other stressors to create complex responses at landscape levels. Damage as a result of cyclones has been noted to have fast-tracked the long-term degradation of Caribbean coral reef cover from 2% to 6% (Gardner et al., 2005).

The occurrence of tropical cyclones also affects the tourism industry both directly and indirectly, thereby impacting three SDGs that makes explicit reference to tourism including SDG 8, SDG 12 and SDG 14 (United Nations, 2015). The World Travel and Tourism Council (WTTC) details three main reasons tourism activities decline in the aftermath of disasters such as tropical cyclones (WTTC, 2018). The main reason is that the damage to infrastructure and facilities induced by the cyclones prevent the impacted area from engaging in tourism; the decline can be due to the perceived risk, hence the avoidance of areas deemed to be vulnerable to disasters. In other instances, potential tourists may feel uncomfortable or have ethical concerns about visiting a region in crisis (Rossello et al., 2020).

Literature also provides several real-life examples of dips in tourist arrivals following tropical cyclones (Bhati et al., 2016; WTTC, 2018). The West Indies, for example, is the most tourism-dependent region in the world. The industry is the major contributor to livelihoods and often serves as the primary industry or at least as a major earner of foreign exchange (Rossello et al., 2020). In Antigua and Barbuda, as well as Anguilla, the tourism industry constitutes over 70% of the GDP (WTTC, 2018). Granvorka and Strobl (2013) observes that on average, hurricane occurrence leads to about a 2% loss in tourist arrivals for the average destruction in the West Indies, while the most destructive ones can lead to over 20% reduction. In 2004, Hurricane Ivan led to damages worth US$1.1 billion in Grenada and resulted in significant reductions in tourist arrivals (Rossello et al., 2020). The next section briefly touches on the methods used in generating and analysing data by over 60 authors that contributed to the book.

1.6 Methodologies Utilised

The research for this book was mainly carried out in three Southern African countries, namely Malawi, Mozambique and Zimbabwe. These countries were the hardest hit by tropical cyclone Idai, which occurred in March 2019. Given the aim of the book, which was to document the impacts of tropical cyclones and their implications for the attainment of SDGs in Southern Africa, the mixed methods approach was preferred in the collection, analysis and presentation of data. The mixed methods approach was preferred because the nature of the subject the book sought to address was transdisciplinary. Aramo-Immonen (2013) opines that the mixed methods approach involves the collection and analysis of both quantitative and qualitative data and provides researchers, across research disciplines, with a robust approach to answering research questions especially if they are complex in nature. All 20 chapters in the book used a different mixture of methods in an endeavour to answer the research questions being asked.

The case study approach was used in most of the chapters in the book. A case study approach was preferred because it can generate an in-depth, multi-dimensional understanding of a complex issue in its real-life setting (Crowe et al., 2011). The case study approach is applicable to several disciplines though it has been widely used in the social sciences. Yin (2009) observes case studies to have utility in *explaining and exploring* events in the ordinary contexts that they occur, hence helping to understand causal links and pathways of cause-and-effect relationships.

The data-gathering techniques included household questionnaire surveys, in-depth interviews, document and critical discourse analysis, earth observation, geographic information systems, secondary data analysis and field observations.

Questionnaire surveys were used as one of the main data-collection techniques. These involved going directly to the affected communities and asking them to complete the survey detailing their personal as well as household experiences. Questionnaires used produced reliable data since it was the victims who directly responded to questions that directly answered the research questions. Surveys were administered in selected impacted communities in Zimbabwe, Malawi and Mozambique. The questionnaire surveys produced mainly quantitative data, which in most cases were analysed using descriptive statistics and cross tabulations. In Zimbabwe, for example, questionnaire data capturing was done using the QuestionPro software. This made data analysis much easier to perform as patterns and relationships merged in near-real time.

In-depth interviews were done in all the showcased countries. These were done with purposefully selected key stakeholders who were deemed to have in-depth knowledge about the occurrence of cyclones in the areas of study. Participants of in-depth interviews differed from country to country, but included local government officials, traditional leaders, political leaders, scientists, government officials, prominent survivors, intervening institutions, NGOs involved and local community leaders. These produced mainly qualitative data which was analysed using thematic content.

Since tropical cyclones hit specific geographic areas and impacts are felt at specific locations, GIS and earth observation techniques were used to help visualise the impacted areas and the relationships that exist among the affected places. Maps of the impacted places and impacted infrastructure were produced to help explain why these were hit hard and also to aid in the recovery process. Satellite imagery were also utilised to show the impact of tropical cyclones before and after the event and to show recovery in some areas. The extent of damage in some hard-to-reach places, such as forests, agricultural land and areas affected by landslides, was assessed using different earth observation techniques. Different vegetation indices generated from different sensors were also utilised to determine the extent of damage to key vegetation biomes and rangelands in general. Field observations were also carried out during fieldwork operations. Some of the pictures taken during field visits and observations were used to aid descriptions in terms of the extent of the damage. The pictures

help the reader to vividly conceptualise and understand the extent of the damage due to the tropical cyclones.

Secondary data used were compiled from reputable sources such as the United Nations agencies, the World Bank, African Development Bank, disaster management agencies in the studied countries, non-governmental organisations with interests in DRR, different government ministries with an interest in DRR, as well as hydrological and meteorological service departments in the profiled countries. The organisation either produced reports detailing the impacts of cyclones as they occurred at different phases of the disaster management cycle or regularly monitor or collect records on meteorological and hydrological parameters, which are key in understanding the intensity and impacts of tropical cyclones. Data from secondary sources were in most cases used to triangulate data collected from primary sources such as questionnaires and field observations. Given that some sources of data needed validation since there was too much data being generated from various sources over short periods of time, secondary data became handy in this process. The next and final section in this chapter presents the book and chapter outlines.

1.7 Layout of the Book

This book is divided into five parts. Part one gives the introduction and background to the book. It has one chapter that links the impacts of cyclones to the SDGs. Part two focuses on the impacts of cyclones on agriculture and public health. This part contains five chapters with case studies from Malawi, Mozambique and Zimbabwe. Part three of the book concentrates on the impacts of tropical cyclones on education, water and sanitation and livelihoods. It has four case studies detailing victims from the tropical cyclone Idai in Zimbabwe and Mozambique. Part four of the book has got three chapters focused on the impacts on infrastructure and settlements. Part five of the book looks at the impacts of cyclones on natural resources, oceans, tourism and other losses. It has six chapters with case studies from mainly Zimbabwe, Malawi and Mozambique. The final chapter focuses on the policy implications of the findings from the book.

The book comes as part of a series with three volumes. The other volumes include 'Cyclones in Southern Africa Vol. 1: Interfacing the Catastrophic Impacts of Cyclone Idai with SDGs in Zimbabwe' and 'Cyclones in Southern Africa Vol 2: Foundational and Fundamental Topics'.

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