School of International Development
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Climate change and drowning risk in Bangladesh and Tanzania and the implications for RNLI programmes

Author(s):
Roger Few, Judith Omasete, Jo-Anne Geere, Nibedita S. Ray-Bennett

January 2023

DEV Reports and Policy Papers 24

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Authors: Roger Few[1], Judith Omasete[1], Jo-Anne Geere[1], Nibedita S. Ray-Bennett[2]

1 Water Security Research Centre, University of East Anglia, Norwich, NR4 7TJ, U.K.
2 Avoidable Deaths Network (ADN), School of Business, University of Leicester, Leicester, LE1 7RH, U.K.

This report was an output of the project ‘Understanding the impact of climate change on drowning risk in Bangladesh and Tanzania’, funded by the Royal National Lifeboat Institution (RNLI) under its international programmes.

First published by the School of International Development in January 2023.
The paper should be cited with due acknowledgment.

This Publication may be cited as:

Few, R., Omasete, J., Geere, J., and Ray-Bennett, N. (2023) Climate change and drowning risk in Bangladesh and Tanzania and the implications for RNLI programmes. DEV Reports and Policy Papers Series 24, The School of International Development, University of East Anglia, UK.

CONTACT

Roger Few
r.few@uea.ac.uk

School of International Development
University of East Anglia
Norwich, NR4 7TJ
United Kingdom

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Contents

1. Introduction 2

2. Current drowning risks: a summary of trends, factors, prevention 3

2.1 Drowning incidence 3

2.2 Key risk factors 5

Proximal factors 5
Intermediate factors 7
Contextual factors 9

2.3 Existing prevention initiatives 12

3. Climate change and other dynamics 16

3.1 Climate change projections 16

3.2 Climate change impacts 19

Bangladesh 19
Tanzania 21

3.3 Demographic projections and interaction with climate change risks 23

3.4 Connecting climate change impacts with key drowning risk factors 25

4. Implications for future drowning risk and RNLI programming 29

4.1 How might drowning risk change in the near future in Bangladesh & Tanzania? 29

A. Drowning prevention as a priority intervention 29
B. Interpretation of likely climatic changes by 2040 29
C. Demographic and economic trends and projections 30
D. Conclusions on the significance of climate change for drowning risk factors - at a national scale 30

4.2 Implications for interventions 31

Bangladesh 31
Tanzania 32

4.3 Key themes for further exploration 33

Interconnecting dynamics of environmental change and social risk factors at Lake Victoria 33
Drowning risk in urban informal settlements 34
The relative importance of extreme weather events for drowning risk 34

4.4 Headline recommendations 35

References 37

1. Introduction

This report provides findings from primarily desk-based investigation by the consultancy project team into the impact of climate change on drowning risks at the national scale and specifically in relation to current and potential target populations for RNLI intervention. We take a near to mid-term view on this, essentially comparing the present situation to how risks may alter within the period to mid-century, but especially within the next two decades to 2040 (though recognising that such a temporal framing can only be illustrative, rather than precise). Our focus is particularly on two RNLI countries of operation, Bangladesh and Tanzania.

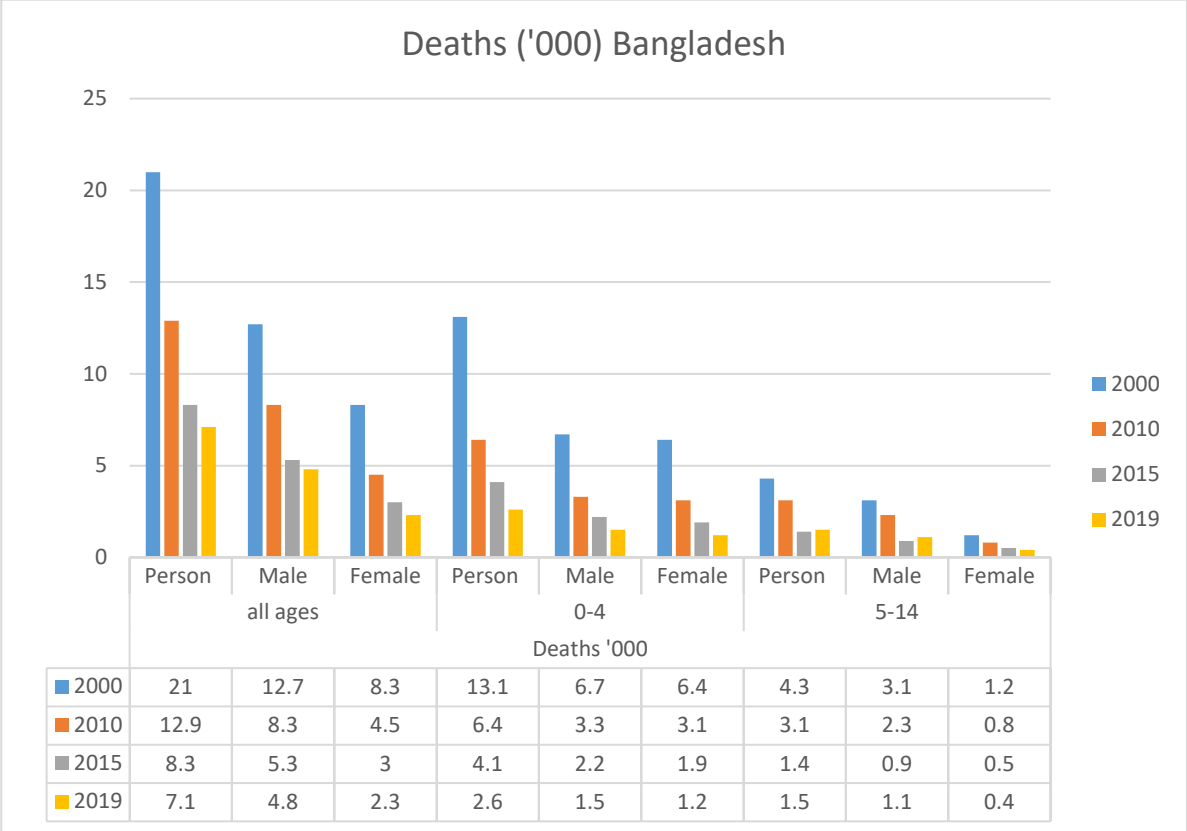
This report combines qualitative and quantitative information, triangulating across different sources of data, including in-country expert discussions, to provide a profile of current drowning incidence, trends, risk factors and the intervention environment in the study countries, and then examine the projected implications of climate change and the interaction with other risk dynamics. In the final section we qualitatively assess the significance of these changes for drowning risk in these countries in the near-term future, and the implications of the study for RNLI programming.

2. Current drowning risks: a summary of trends, factors, prevention

2.1 Drowning incidence

The WHO provide a repository of freely available data in the Global Health Observatory, disaggregated according to cause of death or injury, country, age category and sex (WHO, 2020). This provides useful insight on trends, although, due to inherent data limitations for both Bangladesh and Tanzania, the statistics represented must be considered with caution.

In **Bangladesh**, the number of people drowning per 1,000 population represented in Global Health Estimates (GHE) data has reduced by two thirds between 2000 and 2019 (figure 1). Data for both males and females grouped for all ages, 0-4 and 5-14 show a reduction in deaths (‘000) over the reported years, except for males aged 5-14 between 2015 and 2019. The biggest reductions in mortality due to drowning occur for males and females under 5 between 2000 and 2010, with smaller reductions between 2010 and 2019.



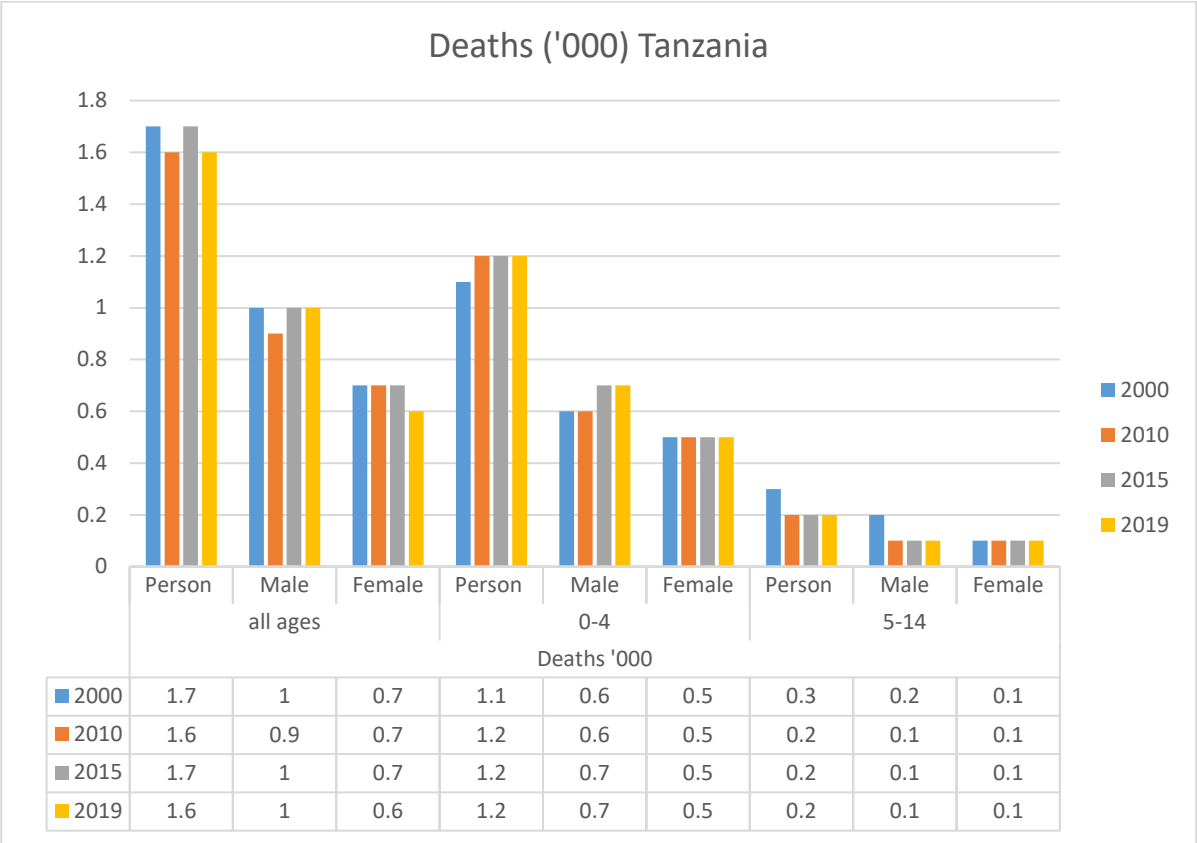
	Person	Male	Female	Person	Male	Female	Person	Male	Female
	all ages			0-4			5-14		
	Deaths '000								
2000	21	12.7	8.3	13.1	6.7	6.4	4.3	3.1	1.2
2010	12.9	8.3	4.5	6.4	3.3	3.1	3.1	2.3	0.8
2015	8.3	5.3	3	4.1	2.2	1.9	1.4	0.9	0.5
2019	7.1	4.8	2.3	2.6	1.5	1.2	1.5	1.1	0.4

Figure 1. Estimated Deaths (‘000) due to drowning in Bangladesh 2000-2019 (derived from WHO 2020 data).

Gupta et al (2021) reports that 43% of deaths of children aged 1-4 years old in Bangladesh are due to drowning. Saunders et al (2019) report that drowning of children aged 0-4 mostly occurs around the home and is linked to inadequate supervision, occurring on weekends or in the evenings when children are left alone or with elderly or inexperienced relatives. Older children and adults tend to drown further away from home, for example while collecting water, working or travelling on water (Meddings et al, 2021).

In **Tanzania**, according to GHE data (WHO, 2020), the number of people drowning per 1,000 population has hardly changed between 2000 and 2019 for both males and females when

data are grouped for all ages, 0-4 and 5-14 over the reported years (figure 2). Considering all ages in all years reported, more males die from drowning than females.



	Person	Male	Female	Person	Male	Female	Person	Male	Female
	all ages			0-4			5-14		
	Deaths '000								
2000	1.7	1	0.7	1.1	0.6	0.5	0.3	0.2	0.1
2010	1.6	0.9	0.7	1.2	0.6	0.5	0.2	0.1	0.1
2015	1.7	1	0.7	1.2	0.7	0.5	0.2	0.1	0.1
2019	1.6	1	0.6	1.2	0.7	0.5	0.2	0.1	0.1

Figure 2. Estimated Deaths (‘000) due to drowning in Tanzania 2000-2019 (derived from WHO 2020 data).

Sarrassat et al (2019) reported annual drowning deaths in Tanzania of 3,454 in 2015 and 2,486 in 2016 derived from WHO global health estimates, but again, indicated that these are likely to underestimate actual numbers because of limited reporting and data collection. Kobusingye et al (2017) reported unintentional drowning deaths as the leading or second leading cause of injury in two rural areas and in Dar es Salaam for children aged 0-5 and 5-14. Whitworth et al (2019) estimated that Tanzania as a whole has an average incidence of fatal drowning of 5.1/100,000 person-years, much lower than the estimates for the Geita region along Lake Victoria of 16.7/100,000 person-years, with fishermen identified as a group at high risk of drowning.

2.2 Key risk factors

Drowning risks are caused by multiple factors and hazards that influence each other and therefore requires the integrated involvement of multiple sectors in drowning prevention measures (Meddings et al, 2021). However, for analytical purposes, we provide a brief account in this section of the role specific key factors play across both **Bangladesh** and **Tanzania**. Note that climate change and related dynamics are discussed within section 3 of this report.

Here we divide the risk factors into three main groups – broadly-speaking, into proximal/direct, intermediate and contextual/indirect factors. These broad categorisations, though, are overlapping and by no means exclusive, and it should be recognised that elements of one theme may operate either directly or indirectly to increase drowning risk. Note that the identification of specific risk factors and the assessment approach using these (reported in section 4.1) is in part an adaptation of the approach used in Blackmore et. al. (2008).

Proximal factors
By 'proximal', we refer to causes and factors that are associated with drowning hazard in the most direct senses.

Geographic location: proportion of population living in proximity to water:
Communities residing close to coasts, rivers or other water bodies have increased drowning risks.

- In Bangladesh, there is 2.8 times higher odds of paediatric riverbank area drownings and 3.9 times higher odds of typhoon-related fatal drownings for people who live 50 meters from the sea (Cenderadewi et al, 2020).
- Populations concentrated around large water bodies, including Lake Victoria, are susceptible to drowning in part because of how they utilise the waters (Olaka et al, 2019). Most drownings in the lake occur when people are fishing, bathing, swimming and washing clothes (Chasimpha et al, 2015).
- However, proximity to small water bodies is also a significant risk factor in both countries. Cisterns and wells around homes in Tanzania can cause drowning deaths if uncovered (Sarrassat et al, 2019).
- Water transport also exposes passengers to drowning risks, especially as the sector is poorly regulated in both countries, with common overcrowding and unsafe vessels. This is evident in Barishal, a riverine division in Bangladesh, with fatal drowning rates nearly three times higher than the rest of the country. These deaths are not reported as drowning deaths, but as transport accidents (Jagnoor el al, 2019).

Extreme weather events:
Extreme weather events – especially tropical storms, heavy rainfall, river floods, riverbank erosion and coastal floods - increase drowning risks and vulnerabilities. They pose direct drowning hazards, as well as undermining livelihoods and access to essential services (Ahmed et al, 2021, UNICEF 2021).

- Bangladesh is widely described as one of the world's most disaster-affected countries, and observations suggest that the frequency of hazards such as tropical cyclones is already increasing (Uzzaman, 2014).
- But Tanzania is also exposed to major hydro-meteorological hazards. In 2020, for example, heavy cumulative rainfall raised water levels in Lake Victoria, causing widespread flooding for communities living close to the shoreline, and flash floods in

south-eastern Tanzania affected more than 18,000 people (C40 Cities Finance Facility, 2020).
- Damaged roads and disrupted transport systems can further put people at drowning risk as they try to move through floodwaters (Biswas et al, 2010; Hayward and Ayeb-Karlsson, 2021).
- The number of disasters reported by the World Meteorological Organization (WMO) for Bangladesh for the period of 1970–2019 were 277 and for Tanzania 64 (WMO, 2021).

Lack of supervision:
Reduced parental capacity to supervise young children and protect them from drowning risks is a key factor in child drowning (Saunders et al, 2019).

- Drowning deaths in an aquatic environment in rural Bangladesh were three times higher among children younger than 5 years old who were not in close proximity to an adult caregiver (Khatlani et al, 2017).
- Playing and swimming in Lake Victoria by unsupervised children is common (Whitworth et al, 2019), but young unsupervised children are also at risk in small water bodies close to home (Tyler et al, 2017).
- Families with low incomes unable to afford day care, leave their children alone at home or with inexperienced adults or elderly relatives (Saunders et al, 2019).
- Gupta et al (2021) found poor crèche attendance was associated with children aged 1-2 years who are the most at risk of drowning, who were the least likely to be enrolled due to safety concerns and who were taken away early for breast feeding or separation anxiety.
- Conversely, strong social networks at individual and community levels provide greater options for daycare and supervision of children.

Behaviours (risk taking):
Behaviours such as risk taking, substance abuse and lack of acceptance of drowning prevention measures increase drowning risks.

- In Bangladesh, Jagnoor et al (2019) reported passengers in water transport and the staff providing the service seldom practising water safety behaviour.
- Personal risk-taking behaviours may increase because of social and economic pressures, reduced food, water and income security and depletion of natural resources.
- But, in a study of drowning risk, Saunders et al (2019) argued that alcohol use, engaging in risky behaviour and not taking health and safety precautions is also seen among some men as a way of proving their masculinity.
- Many young male fishers, for example, are significant risk takers: they may underestimate risks to self, eschew safety measures, overestimate their capacity to swim, and use alcohol or drugs if they are in situations where they do not have to adhere to social norms (Miller et al, 2019; Cenderadewi et al, 2020; Kwena et al, 2012). However, Kobusingye et al (2017) reported a finding that wearing safety jackets did not seem to be influenced by gender.

Fishing occupation:
Fishermen are a particularly high-risk group, particularly in lower-income countries that lack effective boating and safety standards (Whitworth et al, 2019).

- In Tanzania the incidence of fatal drowning for fishing communities in Lake Victoria is estimated at 217 people per 100,000 person-years, far exceeding the estimated national average incidence (Plummer et al, 2021).

- As well as the risk-taking lifestyle/behavioural traits often associated with fishing and economic and regulatory weaknesses in the sector, the increasing effects of climatic hazards, environmental degradation and resource depletion also can exacerbate risks. Reduction of fish stocks puts pressures on fisherfolk to fish further afield and or for longer times on the water in vessels that might not be suited to the conditions (Meddings et al, 2021).
- Statistically, fishing families are also more at risk. Chasimpha et al (2015) reported that children from fishing families were three times more likely to experience drowning deaths compared to those from farming families.

Risk protection mechanisms:
Closely connected with governance constraints (see below) is the low level of drowning prevention infrastructure, equipment and services in both countries.

- Both Bangladesh and Tanzania have low levels of built infrastructure designed to reduce drowning risk at open water sources, such as fencing, signs warning against swimming or flotation devices. Barriers such as covering water sources, fencing, play pens and door barriers are vital for protecting communities, especially children (Hyder et al, 2014).
- At Lake Victoria, until recently there has been little provision of swimming lessons for people, and life jackets are generally seen as unaffordable (Whitworth et al, 2019). Issues of poor quality life jackets in the market have been worsened by a loss of confidence in wearing jackets after people wearing them drowned (Kobusingye et al, 2017).
- Poor weather forecasting, delayed emergency response by marine police and other overloaded boats attempting to provide support to a capsizing boat have also been reported as failings in risk protection for Lake Victoria (Kobusingye et al, 2017).
- Research elsewhere has also demonstrated the drowning risks posed by people failing to evacuate during severe hazards (Ching et al, 2015). A study following a severe typhoon in the Philippines found that drowning death victims were 21 times more likely to not have evacuated their residence before the cyclone hit and 10 times more likely to not have evacuated to the designated centres (Cenderadewi et al, 2020).

Intermediate factors
'Intermediate' factors by implication are slightly less direct in their influence, but refer to variable characteristics of people and their lives which in certain forms generate increased vulnerability to drowning.

Age:
In both countries, children under five make up a substantial proportion of drowning deaths (see section 2.1).

- Children in this age group are usually unable to or have limited ability to swim, and drowning is linked to the challenges of providing adequate supervision of children.
- In Tanzania, Kobusingye et al (2017) found that drowning was the leading or second leading cause of unintentional injury in two rural areas and in Dar es Salaam for children aged 0-5 and 5-14 years.

However, infirmity associated with old age is, of course, also a key risk factor for susceptibility (Jagnoor et al, 2019).

Gender:
In both countries overall more males die from drowning than females (see section 2.1).

- In Bangladesh, considering the WHO data for all ages in all years reported, more males die from drowning than females, which seems to reflect a greater risk of death in males older than four.
- In Tanzania considering all ages in all years reported, more males die from drowning than females. In settings such as Lake Victoria, the greater number of males drowning overall may reflect fishers being older youth and adult men.
- The expectation of men's gender role as bread winners, loan pressures and other livelihood activity disruptions may force them to work in unsafe environments such as fishing in rough seas (Hayward and Ayeb-Karlsson, 2021).
- Boys are given more freedom outside of the home in many cultures, including bathing and playing in streams and ponds, while girls are often more restricted to bathing inside (Tyler et al, 2017).

However, aggregate statistics hide different sets of vulnerabilities.

- Gender dimensions of drowning risk are complex and multi-faceted, and risk to an individual includes gendered norms and societal factors such as differential access to swimming ability, risk-related roles such as water-fetching, and low willingness to take refuge in cyclone shelters because of issues of security and personal privacy for women (Hayward and Ayeb-Karlsson, 2021).
- Social norms on women's dress code may also hinder women's ability to escape danger during floods and other drowning-related extreme events.
- Moreover, it should be noted that widowhood as a result of a male's drowning death can bring severe economic, social, cultural and health consequences for women (Kwena, et. al., 2012; Camlin et. al., 2013). This, in turn, potentially contributes to drowning risk: for example, as single mothers with low social capital, their children may be at higher risk to drowning due to lack of effective supervision.

Education:
Education is broadly associated with greater livelihood assets and resources that people can use to reduce their vulnerability to risk (see below). But there are more direct facets to the role of education via training and schooling.

- Access to lessons in swimming skills and water safety obviously has a direct benefit in reducing drowning risk (Ching et al, 2015). There are global ethnicity, race and socioeconomic status inequalities in uptake of basic swimming skills and water safety training programmes may be rejected if not culturally appropriate and cost effective (WHO, 2021; Chen et al, 2020).
- It has also been estimated that effective education for parents/guardians on risks of drowning could help reduce drowning by 40 percent (Tyler et al, 2017).
- Also, school attendance itself has a protective function for school-age children in high-risk environments (Chasimpha et al, 2015), undermined by inequalities in access to schooling as well as the disruptive effects on the sector of extreme events (Jagnoor et al, 2019).

Physical Health:
Health, like education, is another general component of wellbeing that promotes resilience in the face of different risks. But it also has more direct links.

- Physical health problems may reduce capacity of individuals to rescue themselves or each other from drowning (due to fatigue, low stamina, low strength or disability). With poor physical health, ability to effectively supervise or react quickly to rescue someone is limited.

- On Lake Victoria, for example, poor physical health due to living with a long-term condition such as HIV may mean that individuals are less able to swim and survive in the event of a capsized boat or fall into the water (Kwena et al, 2012).
- With poor access to medical services, the fishing communities have a high prevalence of HIV/AIDs, malaria, bilharzia, tuberculosis, typhoid and cholera (Whitworth et al, 2019). Drowning deaths have also been associated with epilepsy (Chasimpha et al, 2015).

Mental Health:
Mental health services and numbers of mental health staff are very low in both countries, and mental health issues are often stigmatised. In an environment where water bodies are present, such traits could heighten drowning risk.

- Mental health problems link to increased risk of suicide, lack of self-care, risk-taking behaviour, accidental injury, domestic violence, neglect of children and reduced capacity to care for children with quality supervision (Biswas et al, 2010; Hayward and Ayeb-Karlsson, 2021).

Water and sanitation access:
In both countries many people lack access to basic water, sanitation and hygiene (WASH) services.

- People without basic WASH access are often reliant on collecting water from surface water sources and/or using water bodies for bathing and washing which may increase risk of drowning (Chasimpha et al, 2015; Hayward and Ayeb-Karlsson, 2021; Eckstein et al, 2021).
- The numbers of people without basic WASH access are likely to increase during and after extreme weather events (WaterAid, 2012; Omasete et al, 2021).
- In Bangladesh, women have refused to seek safety in cyclone shelters, in part because of lack of adequate sanitation facilities (Hayward and Ayeb-Karlsson, 2021; Ray-Bennet et al, 2019).

Livelihood instability:
Insecure economic livelihoods both create the conditions whereby people are more likely to put themselves at risk via their occupations in order to secure income and reduce the motivation to invest in occupational safety measures.

- Livelihood insecurity associated with environmental degradation may force farmers to switch to alternative livelihoods that put them more at risk.
- Notably, income dependency means that fishing activities on Lake Victoria tend to continue even in bad weather (Whitworth et al, 2019).

Contextual factors
'Contextual' or root causes of risk are more indirect in their effect but nevertheless can play a major role in shaping how likely people are to experience the proximal causes of drowning.

Degradation of resources:
Degradation of environmental resources (forests, soil, water) and ecosystem services tends to have detrimental impacts on wellbeing of the most vulnerable communities and families, especially those living in poverty or with natural resource dependent livelihoods (Uzzaman, 2014).

- The knock-on effect of a diminishing resource base may be to reduce their capacity to afford and/or maintain safety measures intended to reduce drowning risk.
- But it can also push people to undertake activities that place them at greater risk, in order to access resources, such as collecting water in unsafe environments or extending fishing activities beyond the normal range (see below).

Culture & ethnicity:
Cultural factors play a highly complex role, intersecting with many other risk factors such as gender roles and behavioural norms. However, one key aspect to highlight is the effect of ethnicity on water safety skills, and the effects of discrimination based on ethnicity and other traits.

- Chen et al (2020) suggest that swimming and life-saving competence varies among ethnic groups.
- Discrimination against specific groups may affect the groups' safe access to resources (such as drinking water sources, fishing sites, education services or occupational and safety equipment).
- Discrimination may mean some families or groups of people do not want to go to rescue centres during extreme weather events or may be forced to live and work in more precarious or dangerous places.

Poverty:
The existence of poverty is a fundamental risk factor, both in a general sense in its systemic effects on resilience, and in a specific sense vis-à-vis drowning risk (Saunders et al, 2019).

- People with low incomes and few assets and are more likely to live in hazardous settings and are therefore more likely to be exposed to drowning risks.
- Poverty forces people to take more occupational risks and makes people less likely to invest in prevention, including swimming skills and safety equipment, because their limited funds and resources tend to be directed toward meeting basic needs.

However, poverty is widely recognised to be multi-faceted, not reducible simply to economic measures – it has social, cultural, political, environmental and economic dimensions, all of which interlink to shape people's life chances and living conditions (see Box 1).

Box 1 Multi-dimensional poverty trends in Bangladesh and Tanzania
The Human Development Index (HDI) is a composite national-scale measure that combines data on life expectancy at birth, education in terms of average years of schooling, and economic indicators (gross national income per capita).
For **Bangladesh**, the latest available data results in an HDI of 0.632, a score that means the country is ranked 133 globally (out of 189 countries, with Norway highest at 0.957, and Niger lowest at 0.394). Its index is slightly lower than that of India, and there has been a steady increase of more than 0.2 in the index from 1990-2020. These data conform to the picture of a country that still has high levels of poverty, but a dynamic socio-economic profile. http://hdr.undp.org/en/countries/profiles/BGD
For **Tanzania**, the most recent HDI calculation is 0.529, making the country ranked 163 globally. Its index is roughly midway in the ranking of those for other countries of Sub-Saharan Africa, lower than its neighbours Kenya and Uganda, but higher than the bordering DRC and Mozambique. HDI has shown an overall increase since 1990, smaller than that of Bangladesh, with the most change happening in 2000-2010, and a slower increase over the last decade. These data suggest that Tanzania remains a country with high and persistent levels of poverty.
http://hdr.undp.org/en/countries/profiles/TZA

Population growth:
Population growth has an indirect effect only but is an important factor to register in this list.

- It increases the overall burden of human exposure to drowning risks (in the absence of widespread countermeasures), can intensify environmental degradation and leads to greater density of people in certain high-risk environments, especially if associated with migration.
- The annual percentage population growth rate for Bangladesh has generally declined since the 1980s and was reported by the world bank to be 1.003% in 2020 (The World Bank, 2021a).
- Despite a fall in the annual percentage population growth rate for Tanzania in the 1990s, the annual population growth has stayed close to 3% over time and was at this level in 2020 (The World Bank, 2021a).

Migration and displacement:
Migration is a complex process, triggered by many different causes, taking many different forms and influenced by both push and pull factors (Ocello et al, 2015). A form of migration that is of key interest when discussing future climate-related risks is forced displacement (see Box 2).

- In certain circumstances migration not only increases pressure on natural resources and existing livelihoods (Neumann et al, 2015; Morales-Muñoz et al, 2020) but concentrates people in locations where the threats of drowning are already high, such as coastal, lakeside and urban floodplain sites.
- Often it is the poorest, marginalised and most vulnerable who migrate and end up in informal settlements with minimal service and safety provision (Jagnoor et al, 2019; Schofield and Gubbels, 2019). Movement of people to new areas and occupations (such as fishing) also exposes them to new forms of risk to which they may not be accustomed, including the risks of drowning.
- Bangladesh is already experiencing high levels of rural-urban, rural-rural and forced migration. The Rohingya refugees who have fled from Myanmar add to the thousands displaced by natural hazards (Castellano et al, 2021).
- Tanzania's vulnerability to droughts and floods is said to be leading to high internal migration from farming settlements towards commercial, industrial, mining or tourism employment areas such as Arisha, Karega, Dar es Salaam and Zanzibar (Morales-Muñoz et al, 2020), while Atuoye et al (2021) also point to the displacement of farming households generated by large-scale land acquisitions.

Box 2 Forced displacement in Bangladesh and Tanzania
Potentially at least, any alteration to patterns of forced displacement could bring new, vulnerable populations into exposure to other geographically concentrated risks, including the risk of drowning. For the purposes of our study, it is the long-term displaced (those who are unlikely to return quickly, or ever, to their former areas) who are most relevant because they have the potential to create long-lasting shifts in the demographic profile of receiver areas.
Within-country displacement data is provided by the Internal Displacement Monitoring Centre (IDMC) https://www.internal-displacement.org/. Their website currently shows data up to end 2020. Use of the data is not straightforward for our purposes, because some details of the counting method complicate interpretation. The data provided refers both to *numbers of internally displaced people* (IDPs) existing at a point in time (which can include people forcibly displaced many years ago), and *numbers of new displacements* per year (which refers to incidences, not people, as it can include people who have been displaced more than once).

At end December 2020, **Bangladesh** had 772,000 IDPs, of which 345,000 had been displaced by disaster and 427,00 by protracted conflict and violence. However, many of the latter had been originally displaced decades before by historical conflicts. During 2020 approximately 4.4 million new displacements occurred, almost all by disasters and the majority (2.5 million) caused by Cyclone Amphan in May 2020. Most of these were pre-emptive evacuations and did not lead to long-term displacement, although 100,000 evacuees from Amphan were still displaced by the end of 2020. However, both 2019 (4.1 million) and 2020 were exceptional years for disaster-induced displacement. In the preceding years 2010-2018, a total of around 5.5 million displacements occurred, an average of 610,000 per year.
For **Tanzania**, the information on the website is less rich, and the numbers of long-term displaced people much lower – although only disaster-related displacement is shown. At end December 2020, Tanzania had 38,000 IDPs that had been displaced by disaster. During 2020 there were 57,000 new displacements associated with disasters, which appears to have been the highest figure since 2008. Successive annual counts of new displacements are available on the website for the previous years 2014-2019, which respectively were 14,000, 3500, 36,000, 1900, 29,000 and 11,000. The average for the 2014-2019 period was around 16,000 displacements per year, and the average for 2014-2020 around 22,000 displacements.

Policies and governance:
In both countries, fiscal and other resource constraints on government capacities are major contextual challenges for the management of different forms of risk, and the policy and intervention environment for drowning prevention epitomizes these limitations. Where regulations and policy measures exist, they are often poorly enforced or promoted, making governance constraints a major factor in the risk equation.

- (**See section 2.3** for more on this topic).

2.3 Existing prevention initiatives

In **Bangladesh**, progress on the overall governance of drowning risk is limited, despite some initiatives being undertaken by the Government of Bangladesh. In 1996, the Bangladesh Health Injury Survey led by the Directorate General of Health Services brought official recognition of drowning as one of the leading causes of child death in Bangladesh (Mazumder, 2020). Since then, the Government adopted the 'Multi-Sectoral Action Plan for Prevention and Control 2015-2018' (recently updated 2018-2025). The Plan stipulated that under the section 'Promote Healthy Setting' the Ministry of Health and Family Welfare should develop community day care centres in partnership with the Ministry of Women and Child Development, the Ministry of Local Government, Rural Development and Cooperatives, and NGOs and private organizations (Mazumder, 2020). The 'Operation Plan 1917-1922 of Non-Communicable Diseases Control' under the Directorate General of Health Services includes drowning under the 'Injury, Occupational Health and Climate Change' section. Drowning prevention has also been included in the Integrated Management of Child Illness (Mazumder, 2020).

Drowning prevention under these initiatives cross cuts sectors and ministries, but this creates a coordination problem at the operational level and in designing the delivery portfolio in Bangladesh (Mazumder, 2020). For example, developing the day care centres, teaching swimming skills, and conducting water safety sessions at schools do not fall under the jurisdiction of the Ministry of Health and Family Welfare. Currently, it can be argued that there is a lack of leadership, and, as such, the adoption of a National Strategy on Drowning

Prevention (Mazumder, 2020), the promotion of National Guidelines on Drowning Prevention, or Standing Orders on drowning interventions are ways forward to promote inter-sectoral and inter-ministerial coordination, cooperation, communication and leadership for effective governmental management and enforcement of preventive measures in Bangladesh.

Apart from the 'Project Bhasa' initiative that RNLI is currently supporting (see Box 3), we are aware of two other externally-funded interventions in Bangladesh - the UNICEF-funded 'Prevention of Child Injuries through Social-intervention and Education' (PRECISE) project; and the Bloomberg Philanthropies-funded 'Saving of Lives from Drowning' (SoLiD) project. PRECISE was a community based quasi-experimental study, which started in 2005 and ended in 2009. The project developed two effective interventions: Anchal (a community day care centre or 'creche'); and SwimSafe – a survival swimming programme for children 4-10 years, to prevent drowning and other injuries. PRECISE was discontinued in 2009, but the first component was taken forward as a large-scale community-based intervention in 2013 under the SoLiD project (JHIRIU, 2014).

SoLiD was led by John Hopkins International Research Injury Unit in collaboration with two in-country partners, International Centre for Diarrhoeal Disease Research, Bangladesh and The Centre for Injury Prevention and Research. The aims were to further test the provision of Anchals, and also the provision of protective playpens, over a two-year period (2014-2016) in seven purposively selected rural sub-districts of Bangladesh (JHIRIU, 2013; JHIRIU 2014; Alonge et al, 2020). The assumption was that the attendance in Anchals during the period when drowning injury is most likely to occur can reduce the risk of drowning by both supervising the child and removing the child from the hazard. Similarly, playpens, which are being locally manufactured, can restrict child mobility thus creating a barrier between the child and the hazard. They can also act as an aid to adult supervision, which in turn can minimize exposure to the risk of drowning. The interventions were being implemented along with family education and community awareness on drowning prevention (JHIRIU, 2014).

A pre-and-post evaluation of SoLiD revealed that more than 3,200 new Anchals in seven rural sub-districts of Bangladesh were established, with over 64,000 children 9 to 47 months old enrolled in Anchals (Alonge et al., 2020). The authors compared baseline drowning deaths in these areas through a retrospective analysis covering July 2012 to November 2013, to drowning deaths that occurred after Anchals had been established from October 2013 to February 2016. The results highlighted that drowning deaths reduced by 88 percent among Anchals-enrolled children aged one to four years old, leading the authors to recommend this intervention be scaled up.

The authors could not establish the effectiveness (or lack thereof) of the playpen alone (or in combination with the creche) due to a limited sample size, but did observe higher drowning rates for those children under the playpen-only package (aged 9 to 24 months), similar to rates reported in the literature for children aged 0 to 11 months in rural Bangladesh (Rahman et al, 2019). While the playpen intervention appears straightforward, it requires proactive use on the part of the caregiver for it to be effective (Alonge et al, 2020).

Drowning prevention governance in **Tanzania** is notably under-developed. Apart from the RNLI project focussing on Lake Victoria (see Box 3), we found no concrete drowning prevention initiatives on which to report. In work estimating the national drowning burden, Sarrassat et al (2019) underlined the need for better understanding of population groups at high risk in order to inform drowning prevention strategies in the country. Where relevant measures are in place, for example in regulations on adequate boat maintenance standards

and safe boating practices, sources suggest that these are not being enforced (Whitworth et al, 2019; Kobusingye et al, 2017).

Box 3 Current RNLI programmes

RNLI's current international programming in Bangladesh and Tanzania focuses primarily on the following projects.

Project Bhasa (which means 'float' in Bengali) led by the Centre for Injury Prevention and Research, Bangladesh (CIPRB) is a ground-breaking initiative to reduce child injury drowning in the Barishal division of **Bangladesh**. The Project began in 2016 and focuses on three communities of Barishal Division. Barishal division is highly exposed to natural hazards and climate-related disasters because several large rivers converge there. The Bangladesh Health and Injury Survey, 2016 reports a drowning mortality rate of 11.7/100,000, corresponding to a total of 19,247 deaths per year and 53 deaths per day. In Barishal, fatal drowning rates of 37.9 per 100,000 population, and non-fatal drowning rates of 697.6 per 100,000 population were found in 2016. Among the non-fatal drowning cases, approximately 18% of individuals had more than one drowning event. To reduce child drowning, Project Bhasa introduced four interventions, which are: 400 anchals (community day care centres) have been formed to increase supervision for children aged 1-5 years; 30,000 children aged 6-10 years have been trained to improve water safety survival skills (Swim Safe); 3000 community volunteers have been trained for rescue and first response in the event of drowning; and education, awareness and advocacy including interactive popular theatre, water safety awareness through schools, social autopsy, courtyard meetings and the formation of union and village injury prevention committees (Rahman, 2019).

In **Tanzania**, a major focus of recent attention has been Lake Victoria, and especially the fishing communities that surround and directly draw their livelihoods from the lake. Recent research has shown that drowning incidence is not only much higher in the Lake region than the national rate in Tanzania, but that it is exceptionally high among the fishers – in Whitworth et al's (2019) analysis of 86 drowning cases 81% of deaths were of fishers. As well as deaths associated with fishing, risks were linked to boat transport, recreational activities, and other forms of water use (Kobusingye et al, 2017). In 2020, the RNLI commenced a programme of work aimed at coordinating key stakeholders around Lake Victoria to work together to reduce drowning in artisanal fishing communities. This has included: meeting organisations and individuals committed to drowning prevention and supporting a drowning prevention network; researching data gaps; and scoping an intervention 'project' at the lakeside, recommending drowning surveillance and human-centred design training as potential interventions.

RNLI work in Tanzania has also included actions with coastal communities, including the establishment of six drowning prevention committees in Unguja and Pemba, and development of educational/training materials for seaweed farmers to address downing risks and wider resilience measures.

A meta-review of peer-reviewed articles by Miller et al (2019), did not find any study that evaluated prevention strategies on reducing drowning death risk in Africa. As such, research is needed to investigate the risk factors and to evaluate prevention strategies (Lin et al, 2015; Miller et al, 2019). This finding is confirmed by Whitworth et al (2019) who studied the incidence of unintentional drowning and perceived impact (social, financial, and other) among families and colleagues of persons who drowned in Lake Victoria in Tanzania. These authors emphasised that intervention strategies are required to reduce the drowning burden among neglected at-risk populations.

For populations living in proximity to Lake Victoria, a number of measures were recommended by Kobusingye et al (2017) that may have wider relevance in Tanzania, including: personal flotation devices (PFD) and use of high-quality life jackets; information on lifesaving responses during an emergency on the water; and the use of weather forecasts to reduce risk.

3. Climate change and other dynamics

This section explores the key impacts of future climate change in the study countries, primarily at a national scale. We present both information from statistical/modelled data on projected climate characteristics and a summary discussion of the actual and potential impacts of those changes, drawn largely from qualitative sources. This is then linked to demographic projections and developmental outlooks for the two countries, as they relate to drowning risk.

3.1 Climate change projections

Our primary scientific reference for information on climate trends and projections is Working Group 1's contributions to the IPCC 6th Assessment Report, including a full report and atlas material now available for access at AR6 Climate Change 2021: The Physical Science Basis — IPCC. This represents a collation of the most up-to-date synthesized information on climate observations and projections that we can access. A key chapter in this is the regional assessment Chapter 12 which provides aggregated information on a regional basis. However, this is backed up with more detailed country specific information on means and extremes where available, as indicated below.

In all these data it is important to be aware of substantial uncertainties. For East Africa, for example Gebrechorkos et al (2019) emphasize the deficiencies of local and regional climate data on which to help build climate models, and that models for the region have often been coarse in their resolution, and not reliable at finer scale – although continual improvements are gradually changing this situation. For climate change projections, therefore, it should be understood that these operate under envelopes of uncertainty within the modelling outputs and also that specific projections relate to specific emissions scenarios (of which there is a range). Statements about projections also use variable dates, for example by 2050 or end of the 21st century – hence further judgement has to be made to establish how these statements relate to the currently preferred projection period for this study, which is up to 2040.

Bangladesh

Bangladesh lies within the IPCC's South Asia (SAS) region, where the following regional-scale changes have been identified with high confidence:

- Increase in mean air temperature (change already observed)
- Increase in extreme heat events (change already observed)
- Increase in mean precipitation
- Increases in heavy precipitation events and pluvial floods
- Increase in relative sea level
- Increases in coastal flooding and coastal erosion.

And the following changes have been identified with medium confidence:

- Increase in river floods
- Increase in landslides
- Increase in fire weather.

An associated AR6 factsheet for Asia highlights key climatic changes for the SAS region during the 21st century as including:

- heatwaves and humid heat stress becoming more intense and frequent
- both annual and summer monsoon precipitation increasing, with enhanced interannual variability.

Focussing more finely on Bangladesh alone, an excellent synthesis source is the World Bank's Climate Risk Country Profile for Bangladesh (The World Bank, 2021b). Their analysis refers to the range of projections based alternatively on the low (RCP2.6) and high (RCP8.5) emissions pathways, as used by the IPCC.

For changes in mean conditions, this source provides the following illustrative estimates:

Temperature	Average daily temperature for 2040-2059 (compared to reference period 1980-2005)	+ 1.2 to + 1.9 °C
Precipitation	Annual average rainfall for 2040-2059 (compared to reference period 1980-2005)	slight increase
Sea level	Number of people permanently displaced by sea level rise by 2050	up to 900,000

A key statement within this document is: "In Bangladesh, models show a trend of consistent warming that varies by emissions scenario. Projections in rainfall provide a higher degree of uncertainty but a slight increase in average annual rainfall is indicated, with a likelihood of an increase in intensity for extreme rainfall events" (The World Bank, 2021b, p8).

For extreme events, i.e. natural hazards risk, the document yields the following estimates:

Heatwaves	Number of days when the Heat Index surpasses 35°C in 2030-2040 (compared to reference period 1980-2005)	+ 25 days (*approx. based on imprecise diagram*)
Drought	Annual drought probability up to 2090s	Possible increase but evidence unclear (low confidence)
River flood	Additional number of people affected by severe flooding due to climate change component by 2030s (compared with 2010)	+ 5.3 million
Coastal flood	Average number of people experiencing coastal flooding per year by 2070-2100 (assuming no adaptation)	2.6 to 7.2 million
Tropical storms/cyclones	Intensity and frequency of extreme cyclone events	Expected to increase, as observed data suggests, but evidence unclear

As the report notes, modelling future climate-related hazards is made difficult by uncertainties in the dynamics of climate systems (e.g. for tropical cyclones, monsoon effects) and also by the interaction between climatic changes (e.g. sea level rise will increase the area of land inundated by cyclonic storm surges).

Tanzania

Tanzania lies within the IPCC's South-eastern Africa (SEAF) region but also extends into the very northern limit of their Eastern Southern Africa (ESAF) region. For the SEAF region, the following regional-scale changes have been identified with high confidence:

- Increase in mean air temperature (change already observed)
- Increase in extreme heat events (change already observed)

- Increases in heavy precipitation events and pluvial floods
- Increase in relative sea level
- Increases in coastal flooding and coastal erosion.

And the following changes have been identified with medium confidence:

- Increase in intensity of cyclones (but decrease in frequency).

NB Mean precipitation and aridity show contrasting signals across the region, because models project a drying trend in the west and a wettening trend in the east of the region.

An associated AR6 factsheet for Africa highlights key climatic changes during the 21st century for the SEAF region as including:

- projected increases in frequency and/or the intensity of heavy precipitation and pluvial flooding
- projected increase of tropical cyclone wind speeds and associated heavy precipitation.

For the ESAF region (noting that Tanzania only touches on the north of this region), it also indicates:

- projected increase in aridity and droughts
- projected increases in fire weather conditions.

To date, a World Bank country profile has not been published for Tanzania, but some summary information, drawing on AR6, is at https://climateknowledgeportal.worldbank.org/country/tanzania. For some changes, this source provides the following illustrative estimates:

Temperature	Mean temperature increase for 2031-2040 (monthly) (compared to reference period 1995-2014)	+ 0.67 to + 0.81°C (monthly variation)
	Additional days with Heat Index above 35°C per year for 2031-2040	+ 0.5
Precipitation	Annual precipitation change for 2031-2040 (compared to reference period 1995-2014)	minimal change
	Monthly precipitation change for 2031-2040 (compared to reference period 1995-2014)	+ 7.2mm to – 8.9mm

This source indicates variation within the country in both temperature and rainfall projections:

- Greater warming over the west and north of the country (figures provided for 2050, contrast a warming in excess of 1.77°C over the Lake Victoria zone with a warming in excess of 1.39°C in Central Tanzania zone)
- A complex pattern of rainfall projections by 2040, with decreases of more than 100mm per year in the southern coastal regions and increases of more than 30mm in several interior zones.

Additional detail for Tanzania is provided in a series of briefing documents produced in 2017 by Future Climate for Africa (FCFA) (available at https://futureclimateafrica.org/summary-of-fcfas-research-on-climate-change-in-tanzania/). The data used a baseline of 1950-2005, and only presents projections using the high emissions scenario RCP8.5. This source generally corroborates the points made above, including the patterns of spatial variation in rainfall projections, but adds some additional points:

- Differences between models, with some showing decreased rainfall across the country and others showing possibility of higher rainfall, result in lower confidence in projections of future rainfall changes
- Seasonal differences appear to emerge by 2040 with overall slight drying of up to 9% for the late spring/early summer period of October-November-December (a critical time for agriculture), and slight increase of up to 9% for March-April-May (autumn)
- There is higher likelihood of dry spells and the potential for drying in the south of the country could be damaging for crops
- Intense rainfall events are likely to increase, possibly associated with flooding
- By the 2040s increases in the mean number of days with temperatures of more than 30°C (a threshold sometimes used to examine the sensitivity of maize to heat stress) from 10 days to 80 days
- Future warming throughout Tanzania in the range of 0.8 to 1.8°C by the 2040s (compared to the 1950-2005 baseline).

Evidence for significant future threat from tropical cyclones is unclear. Incidence of severe cyclones is currently rare in Tanzania and seems unlikely to change rapidly by 2040, although some sources have suggested that the passage of Cyclone Kenneth, which made landfall in Tanzania in 2019, is reason to maintain close investigation on patterns of cyclone generation in the southwestern Indian Ocean (Msemo et al, 2021).

3.2 Climate change impacts

The literature on climate impacts in Bangladesh and Tanzania both translates data on projected means and extremes to impacts on the ground and provides wider discussions around climate change implications. Here we summarize insights from this material, ordered around the key aspects of climatic change.

Bangladesh

Temperature changes

The most direct effect of temperature rises in Bangladesh will be increased frequency of very hot weather periods, which threaten human health, especially in urban areas and for those working outside. This is especially likely to affect poorer residents of cities, in crowded dwelling spaces with little chance to afford air conditioning. Dhaka is regarded as particularly at-risk from future heat-related morbidity. As temperatures climb toward 35°C, they affect the human body's ability to regulate temperature, and, without adaptation, annual heat-related deaths in the South Asian region could increase by 276% by the 2050s (The World Bank, 2021b).

Sea level rise

The inexorable effects of sea level rise are to steadily alter the geography of coastal zones, bringing more and more low-lying land into ever greater influence of the tides. This effect is particularly damaging for inhabitants of the vast Ganges–Brahmaputra–Meghna (GBM) delta, where sea level rise alone could lead to saline intrusion into farmland, increased flooding, threats to livelihoods and ultimately the abandonment of large areas (Uzzaman, 2014; Kay et al, 2015; The World Bank 2021b). About two-thirds of Bangladesh lies within 5m above sea level with a high population density whereby a 100cm increase in sea level will immerse 18% of the total land area, affecting 11% of the total population (Ahmed et al, 2021).

These impacts are likely to hit the poorest the hardest, not just because of their low asset base but because of where they live. According to The World Bank (2021b, p18), “the impacts of sea-level rise along Bangladesh’s coastal zone are mitigated by the extensive network of polders which encircle the land. Vulnerability to sea-level rise is highest in the areas outside of these polders, which are often inhabited and farmed by the poorest groups in society”.

Some settlements will no longer be habitable in inundated areas, but, unless there is a wholesale retreat of towns, infrastructure and populations from low-lying coastal areas, sea level rise will also exacerbate the human impact of storm surges and high tide events because higher sea levels will increase the frequency of extreme sea level events. Kay et al (2015) created a shelf-sea model of the Bay of Bengal to investigate this, and found a marked increase, with levels that under present conditions would occur every decade starting to occur in most years by 2050. Such events will create direct threats to life, infrastructure and livelihoods.

Floods and Cyclones

Bangladesh already faces some of the highest levels of exposure to flood and storm hazards in the world. “Bangladesh has extremely high exposure to flooding (ranked 1st in the world), including, riverine, flash, and coastal, as well as high exposure to tropical cyclones and their associated hazards (ranked 19th)” (The World Bank, 2021b, p12). Future intensification of tropical cyclones will bring increased threats from high winds, heavy rainfall, and coastal floods – caused both by high river flows and storm surges exacerbated by sea level rise, as noted above. All these hazards – but, in Bangladesh, especially the last – are a major threat to populations and the infrastructure, economy and services on which they depend (The World Bank, 2021b).

Intensified extreme rainfall also raises the risk of river floods – both flash floods and slower-onset river flood events – as well as landslides in upland areas. Future change in riverine flood hazards is difficult to predict in terms of exposure and vulnerability because of other dynamics such as land use changes, river flow changes including creation of upstream dams, and improvement of flood protection structures. Nevertheless, The World Bank (2021b, p16) states that: “increases in extreme river flows are likely to place pressure on Bangladesh’s flood defense system that without adaptation action are expected to increase the risk of disaster-level fluvial flood events”.

Flood risk is also something that is likely to worsen through the process of rural-urban migration, as poorer migrants become concentrated in informal settlements that often tend to be in the areas of Bangladesh’s major cities that are most exposed to flood hazards (The World Bank, 2021b).

Systemic impacts: livelihoods and wellbeing

The combination of salinization, increased rainfall variability, flooding and temperature rises affecting heat-sensitive crops is likely to impact on food production and yields in the agricultural sector (The World Bank, 2021b), although the pattern of this is difficult to project.

Both vector-borne and water-borne diseases could potentially be impacted by higher temperatures, extreme rains, floods and dry periods (The World Bank, 2021b). The viable transmission range of malaria is likely to spread, and incidence of the disease is projected to rise by 2041-2070 in Bangladesh under all emissions pathways. Other studies suggest that dengue may also increase in incidence. Flood events may increase transmission of water-borne diseases. UNICEF (2021) notes that children are more vulnerable than adults

physically and physiologically, and are at higher risk of toxic substances and contracting diseases exacerbated by climate change. Hayward and Ayeb-Karlsson (2021) emphasize the mental health impacts of the multiple hazards associated with climate change in Bangladesh.

Systemic impacts: migration

Analysis of the impacts of climate change on migration in Bangladesh is a topic that has attracted considerable attention and critique. The World Bank (2021b) suggests that slow-onset climatic changes could result in 6-12 million internal climate migrants in Bangladesh by 2050, but with a greater acceleration in the latter half of the 21st century. Most of these will be the poorest and most climate-vulnerable communities. It is expected that in-migration 'hotspots' are likely to develop, and one study suggests this would be to the northern and eastern regions of Bangladesh, as well as to metropolitan Dhaka. Rana and Ilina (2021) report that some projections suggest that more than 35 million people in the coastal areas of Bangladesh may experience climatic 'push' factors for migration by 2050, especially those within 19 coastal districts and living along major riverbanks (of the Padma, Meghna and Jamuna rivers). However, the authors argue that Bangladesh's urban authorities have insufficient capacity to support rural-urban migrants who want to settle in cities as a form of adaptation to climate change.

Morales-Muñoz et al (2020) also view migration as a potential coping strategy in Southern Asia for people to manage the implications of sea-level rise, flooding, coastal erosion and groundwater depletion. However, they and other authors point out that the connections between climate change and migration are complex, that climate-related impoverishment can actually discourage internal migration, that patterns of migration are often structured by non-climatic factors, and that separating environmental drivers of migration from non-environmental drivers is inherently difficult.

Tanzania

Temperature changes

Slowly rising temperatures have the potential to create significant changes in Tanzania by mid-century, involving not only increasing heat stress, especially in urban areas, but also impacts on water shortages for people, livestock, crops and the energy sector through increased evapotranspiration rates. The increase in warm days and cold nights impact crop yields, water supply and transformation, and a significant increase in temperature affects the susceptibility of livestock to diseases, reduces fertility and affects milk production (Gebrechorkos et al, 2019).

Rainfall changes

Discussion of the impacts of future annual rainfall changes for Tanzania, and wider East Africa, is inherently difficult because of the variability in the model outputs. It is uncertain for example if the changing river discharges into Lake Victoria are likely to raise or lower the lake levels. Even if more of the current available models currently suggest a slight wettening trend, it is not possible to conclude that this will most likely be the case. And new climate models could become available that clarify trends better and completely change the main message. As a research briefing note produced by the Future Climate for Africa project summarizes:

> "We therefore have to be cautious with our interpretation and recognise that projections still include wetter and drier future climate conditions throughout

Tanzania. A major consequence of this situation is that planning should consider a range of future climate conditions." (FCFA, 2017).

The consequence of main concern for rural areas would almost certainly be any long-term drying trends, which some models do predict are likely to occur in localized zones (although it is not feasible for us to pinpoint easily where this might be, based on available information). This, and the greater likelihood of dry weather spells, would particularly affect rain-fed agriculture and livestock-keeping areas, leading to decreased production and potentially food insecurity (Gbegbelegbe et al, 2018).

Floods

The general expectation for Tanzania that there will be an increase in extreme events will almost certainly increase disaster risk (in the absence of compensatory adaptation and disaster risk reduction advances). River and coastal flooding can affect both rural and urban areas, and climate change potentially increases the frequency, spatial extent and depth of floods. Where flood hazards occur, the consequences in East Africa can include not only damage to livelihood assets and infrastructure but also increased disease risk (from e.g. mosquito-borne disease and fecal contamination when drainage systems are overwhelmed).

Systemic impacts: livelihoods and wellbeing

Grothmann et al (2017) underline how changes in climatic conditions can drive the distribution of land cover types, water resources and availability of products from natural and cultivated land. Whether those changes will be significant in the period to 2040s depends heavily on one's interpretation, but Atuoye et al (2021) discuss the sensitivity of food production, fishing and hunting to climate change. They claim that a one degree rise in temperature can lead to 6-8% decline in crop yield per hectare on average, and that a 10mm/month change in precipitation results in 7-8% average change in crop yield per hectare (8% in rainfall dependent farms and 3% in irrigated farms). Overall, they argue that small-scale farmers who produce 80% of food in sub-Saharan Africa are among the most vulnerable to climate change (Atuoye et al, 2021).

Guo et al (2019) underline that understanding how the quality and quantity of different types of water sources are affected by changing means and extremes is important in prioritising future investments and improvements to maximize health outcomes in Tanzania. Only 76% of the population in Tanzania has access to improved drinking water, and access to improved sanitation is poor. Cholera outbreaks in 2015 and 2017 were associated with El Nino weather patterns that brought heavy rainfall to the region.

Systemic impacts: migration

Several authors discuss the potential effect of climate change on human migration in the region. The coastal parts of Tanzania, for example, are argued to be highly vulnerable to climate stressors – climate change and an increase in large-scale land acquisitions is already seen as pushing small-scale farmers out (Atuoye et al, 2021). Ocello et al (2015) refer to the effects of droughts, storms and floods and gradual changes in sea levels, precipitation and temperatures leading to multiple issues, such as water shortages and crop diseases. They question whether migration is a strategic coping mechanism or a last resort, while also underlining that migration is not only influenced by environmental change but also strongly by cultural, political, and socio-economic conditions (Ocello et al, 2015).

The question of whether migration is a positive adaptation strategy or an indicator of inability to adapt is also taken up by Warner and Afifi (2014). They look at migration as a risk management strategy against climatic stressors such as rainfall changes, because migration, if successful, can reduce food insecurity through remittances. However, if unsuccessful in terms of remittances, it can lead to food insecurity via reduced labour supply to produce food for the household. Tanzania is dependent on rainfall for food security and income – and hence sensitive to changes in timings, quality, quantity and predictability of rainfall (e.g. delayed onset and shorter raining seasons, reduced number of rainy days per year, increased frequency of heavy rainfall events and more frequent prolonged dry spells during rainy seasons). The low skilled, poor and landless households reported migration was a last resort when they cannot access agriculture-based incomes and food. Those with one crop per year were more likely to migrate because they have no diversification options, not just from rural to urban areas but also between rural areas (Warner and Afifi, 2014).

Morales-Muñoz et al (2020), see climate change impacts in Tanzania as likely to manifest in food insecurity at regional, local and household levels. This may lead both to forced migration because of disasters, but also greater movement of the younger population to urban areas and via seasonal migration to work in agricultural production in areas of higher productivity and available markets. Lack of social protection, weak institutions and unsustainable development paths increase the vulnerability of rural populations. Migration tends to be perceived negatively with policies not supporting and accommodating migrants, and the authors also underline that it is important to understand the multiple drivers of migration including the role of structural socio-economic issues (Morales-Muñoz et al, 2020).

Focus on Lake Victoria: potential climate change implications

Olaka et al (2019) examine risks to the Lake Victoria Basin, noting that it supports a multitude of ecosystem services and the economies of the riparian countries (Kenya, Tanzania, Uganda and Burundi). Threats to fresh water that are exacerbated by climate change include increased river siltation from high erosion in the basin, recurrent destructive floods in the low-lying areas, riparian land encroachment, degradation of riverbanks, eutrophication and proliferation of the invasive water hyacinth. Increasing intensity and frequency of extreme climatic events poses additional threats to future ecological and community wellbeing. Lake Victoria levels are already influenced by regional and hemispheric phenomena, such as El Nino-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD), and climate changes are also expected to bring changes in the annual and seasonal rainfall. The authors claim that by the 2030s, the annual rainfall will increase by 5-10% over most of the basin, though the long rains will reduce by 5-10% over most of the lake area (Olaka et al, 2019). Extreme weather events are already an issue on the lake, posing dangers to fishing communities, and climate change may exacerbate these. Efforts to strengthen forecasting of extreme weather include the WISER project which appears to be developing a forecasting project in Kenya, targeting Lake fishers (*for more details see Watkiss et al, 2020*).

3.3 Demographic projections and interaction with climate change risks

Graphs illustrating projected total population growth between 2021 and 2050 for Bangladesh and Tanzania (figure 3) were derived from data downloaded from the World Bank database 'Population estimates and projections' (https://databank.worldbank.org/source/population-estimates-and-projections#). World Bank data is also available for Bangladesh and

Tanzania on rural population (% of total population); urban population (% of total population) and net migration.

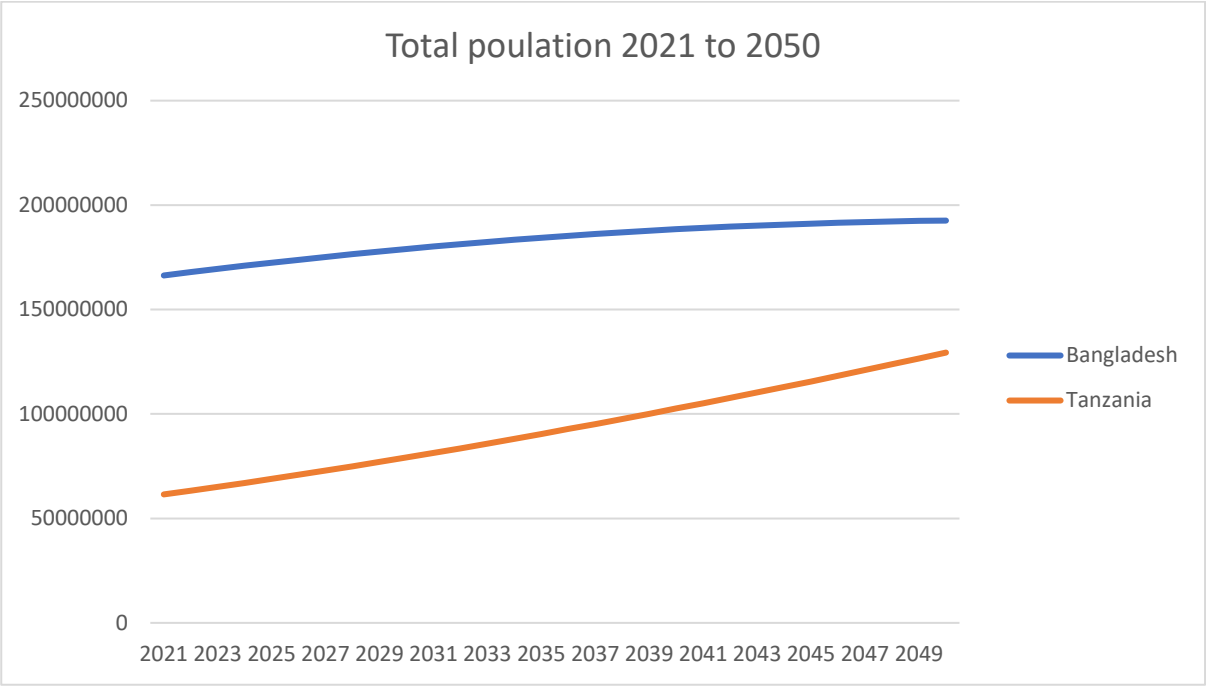


Figure 3. Total population for Bangladesh and Tanzania 2021 to 2050.

The projections indicate that in **Bangladesh** the total population is expected to level off at around 190 million in the early 2040s, and stay below 200 million people in 2050, an increase of about 22 million compared to the population in 2022. This slowing population rise should be accompanied by continuing reduction in poverty rates, based on current HDI trends – assuming there is no major disruption to development trends. However, this apparent stabilisation of population growth and progressive reduction of national poverty rates masks some important population dynamics that may be relevant to climate change adaptation strategies. Gradual, substantial rural to urban migration is predicted, such that urban dwellers will change from being approximately 40% of the population in 2021, to 50% of the population around the mid 2030s and 60% of the population by 2050. This rural to urban shift may represent movement of people away from coastal areas to larger inland urban centres such as Dhaka, and therefore reduce the population exposed to sea level rise or extreme coastal weather events such as cyclones. However, it is also likely that many migrants to urban centres will move into and expand informal urban settlements, whether in Dhaka, which is susceptible to flooding during the monsoon season (Howlader, 2021), or large coastal urban areas such as Chittagong, that will remain at risk of coastal change and extreme weather events.

With regard to forced displacement, the IDMC uses information about the probability of future hazard scenarios to model displacement risk based on probable housing destruction. The modelling for Bangladesh indicates an expectation of about 1,215,000 displacements per year (97% associated with hydrometeorological hazards – floods, cyclones and storm surges). Though fewer than the exceptional years 2019-2020, this still represents a projected twofold increase from the 2010-2018 period. (NB the explanation of the modelling does not indicate dates for these projections). This figure would currently equate to a little over 0.7% of the national population being displaced per year, some of which will also contribute to long-term shifts in population distribution.

Therefore, risk of drowning may be exacerbated by different types of weather events in a wider range of rural and urban locations in Bangladesh, but remain closely associated with poverty, poor rural or urban housing, lack of community cohesion, unsafe home environments and limited safeguarding of young children.

In **Tanzania**, the recent population growth rate of 3% is consistent with projections that the total population will steadily increase from around 63 million in 2022 to 129 million in 2050, roughly doubling in that time span (figure 3). That major increase in total population is likely to be accompanied by a continuing, but only slow, decline in the country's high levels of poverty – and that, again, assumes there is no major disruption to overall development trends. There is a similar trend for rural to urban migration as predicted for Bangladesh, with the percentage of the total population living in urban areas changing from 36% to 55% by 2050. Rural to urban migration may intensify the overall exposure of vulnerable urban groups to drowning risks in such environments, although this study has not revealed information on urban drowning incidence for Tanzania through which to gauge this likelihood.

IDMC modelling indicates an expectation of about 90,000 displacements per year for Tanzania (69% associated with hydrometeorological hazards – floods). This is considerably more than the data in any year prior to and including 2020, indicating modelled expectations of four to five times more hazard-induced displacements than currently. Nevertheless, it implies that, nationally, displacement would affect fewer than 0.15% of the population per year (taking into account possible repeated displacements and future population growth).

How the country's migration trends might affect populations of fishers on Lake Victoria is unclear. However, a growing urban population might plausibly increase demand for fish as a source of protein, to make fishing actually or apparently appear more lucrative, and expand and/or increase pressures on the fishing industry and fish stocks. Plausibly, this could also cause the Lakeside population to increase, as some migrants opt to move to the area rather than head to major cities. Poor regulation of the industry and resource pressures could lead to increased numbers of fishers, conflict between competing fishers, unsafe fishing practices and inadequate infrastructure for protection from extreme weather events. These factors may combine with climate related changes to local weather (such as increased frequency, severity, or unpredictability of storms), to perpetuate or exacerbate drowning risk among lake Victoria's fishers.

3.4 Connecting climate change impacts with key drowning risk factors

Having reviewed projected climate change and its impacts in the two countries and viewed these in relation to demographic projections, the next task of the study was to interpret the potential consequences of climate change impacts for the key generic drowning risk factors identified in section 2.2. In the previous report, the team undertook an illustrative exercise considering each risk factor and whether it is likely to increase in importance as a factor by 2040 because of the direct and indirect effects of climate change (climate change as a driver of increased risk), set against the severity of consequence for each risk factor (a qualitative estimation of the likely strength of its association with drowning). The qualitative exercise, using risk assessment matrices, was a useful device to aid discussion of the relative importance of climate change effects for drowning risk and programme activities prior to, during and after a workshop with RNLI staff and other experts. Through this process of independent research and expert elicitation, the team offers the set of summary

interpretations on plausible connections between climate change and drowning risk factors shown in Table 1. Those climate change connections that arose as potentially most significant as a risk dynamic are indicated with shading.

Table 1 Underlying climate change link mechanism for each risk factor

Proximal risk factors	
Geographic location: proximity to water	Probable increase in exposure to floodplain and waterside environments in both countries, associated in part with population movements linked to climate change impacts.
Extreme weather events	Projected to increase in both countries, associated with direct threats (e.g. flooding, bank erosion) and indirect (e.g. cooling off in water during heatwaves).
Lack of supervision of young children	Climate change is very likely to increase stresses on low-income families in both countries by exacerbating livelihood insecurity and therefore increasing working hours, and increasing incidence of illness, injury or loss of life because of poor safety/work practices combined with extreme weather events. Any of these factors may reduce parental capacity to supervise young children and protect them from drowning risks.
Risk-taking behaviours	Climate change may increase agricultural food insecurity and livelihood pressures leading to greater occupational risk-taking behaviour. Increased populations of fishers associated with migration pressures may increase competition and conflict between fishers and add stress to the industry and fish stocks, which could reduce adherence to existing safety standards and regulations.
Fishing occupation	Increasing storm hazards will make fishing more dangerous. Reduction of farm productivity, migration patterns and demand for fish as a source of protein may lead to more people fishing and greater stresses on the whole industry. This may increase competition, conflict and risk taking (e.g. fishing during more frequent, extreme weather conditions).
Lack of risk protection mechanisms	People with precarious livelihoods dependent on weather and natural resources (e.g. small scale farmers, fishers, those living in flood prone areas) are likely to experience more income shocks (e.g. crop failure) and insecurity (volatile markets), so will be less able and likely to invest in protective measures or insurance.
Intermediate risk factors	
Age under 5	In both countries, climate change impacts on livelihoods and migration are likely to increase the number of families with children under five living near or regularly accessing surface waters (for WASH access or work). This age group are unable to or have limited ability to swim.
Gender disparities	In both countries more males drown than females. However, increased extreme events and economic and ecological pressures associated with climate change may alter patterns of differential

	exposure to risk of drowning for males and females among specific social groups.
Low education level	In both countries increased frequency of severe weather events may limit or interrupt education, reducing the protective effect of creches and educational supervision when they are most needed, limiting opportunities for children to learn swimming/safety skills and develop swimming competency. In adults, low literacy may contribute to limited awareness of extreme event early warning information.
Poor physical health	Climate change may increase stresses on health services infrastructure and generate increased injury, water related disease, malnutrition etc. Physical health problems may reduce capacity of individuals to rescue themselves or each other from drowning, as well as reducing capacity to work/maintain livelihoods and build resilience to climate related or other shocks.
Mental health	A wide range of social, economic and psychological stresses linked to climate change and its effects on family and community wellbeing and stability may increase risk of mental health problems. Mental health problems raise drowning risk in areas where there are surface waters.
Lack of basic WASH access	Increased strain on services related to extreme events and/or drying trends in some areas, leading to exposure to drowning risks from accessing alternative water sources.
Livelihood instability	Higher temperatures and more climate variability is likely to increase degradation of natural resources (e.g. water, soil, vegetation and fish stocks) making livelihoods of people who depend on these natural resources more unstable and insecure. This may push people toward occupations or living areas with higher risk of drowning.
Contextual risk factors	
Degradation of resources	Some ecological change highly likely as a result of climate change, creating indirect effect on rural livelihood assets, and increasing underlying vulnerability to hazards.
Cultural pressures and discrimination	Increased incidence of drowning due to increased frequency and severity of extreme weather events can be exacerbated by cultural factors and ethnic discrimination (e.g. access to protection mechanisms/evacuation shelters, livelihood pressures associated with marriage/death customs) – however, climate change is unlikely to be a driver of change in cultural factors.
Poverty	Economic stresses associated with climate change may push more people into poverty. People with low income and assets generally have greater underlying vulnerability to hazards, and must take more risks and invest in less safety equipment, because their limited funds and resources are directed toward basic needs.
Population growth	Projected population increases leading to numerical increase in people experiencing environmental, social and demographic drowning risk factors associated with climate change.

Migration and displacement	Rural to urban migration and internal displacement associated with climatic change may lead to new population groups being exposed to more diverse drowning risks.
Weak policies and governance	Economic and other stresses linked to climate change may place increasing demands on government capacities and potentially reduce government revenues, limiting resources available for drowning safety policy implementation and governance.

4. Implications for future drowning risk and RNLI programming

In this concluding section we draw on the different elements of the study to present overall interpretations of the likely implications of climate change for future drowning risk, identify key themes and knowledge gaps, and offer some recommendations regarding future intervention programmes in drowning prevention in Bangladesh and Tanzania.

4.1 How might drowning risk change in the near future in Bangladesh & Tanzania?

Here we present a series of interpretative statements summarizing key points from the different aspects of the study relating to future drowning risk over the next two decades.

A. Drowning prevention as a priority intervention

- Drowning has been showing signs of reducing in incidence, particularly in Bangladesh where its baseline rate is, however, much higher than in Tanzania.
- Reporting deficiencies and other data quality issues, combined with the high numbers involved and the concentrations for certain age-groups and livelihoods, mean that it remains a major public health concern in both countries.
- Drowning prevention action remains very weakly developed in Tanzania.
- Evidence from non-RNLI drowning prevention measures in Bangladesh suggest mixed success, lessons to be learned, but potential significant success for well-designed measures to reduce risk.

B. Interpretation of likely climatic changes by 2040

BANGLADESH	TANZANIA
Increase in average temperatures and frequency of heatwaves	Increase in average temperatures and in the frequency of heatwaves
	Likely increase in dry weather and possibly drought in some areas
Increase in high rainfall intensity events	Increase in high rainfall intensity events
Increase in human exposure to river floods	Some increase in human exposure to river and coastal floods
Displacement from low-lying areas in the south due to sea level rise	
Increase in human exposure to coastal floods	
Increase in exposure to intense cyclones	

C. Demographic and economic trends and projections

BANGLADESH	TANZANIA
Recently declining and low annual population growth rate, close to 1% in past 10 years	Population growth rates stays close to 3% over time and in 2020
Population stabilising at about 190 million by 2050	Population doubling between 2022 and 2050, from 63 million in 2022 to 129 million in 2050
Percentage of urban population increasing from 40% in 2021 to 60% in 2050	Percentage of urban population increasing from 36% in 2021 to 55% in 2050
High levels of multi-dimensional poverty currently	High levels of multi-dimensional poverty currently
Steady decline in poverty since 1990	Uneven overall decline in poverty since 1990
Poverty therefore likely to remain high until 2040 but the proportion of poor likely to steadily but slowly reduce	*Poverty therefore likely to remain high until 2040 but the proportion of poor may reduce slightly*
High but variable numbers of people displaced per year by disasters, sometimes exceptionally high but most not for long-term periods	Moderate, variable numbers of people displaced per year by disasters
Projected twofold increase in disaster-induced displacement (based on figures for 2010-2018)	Projected fivefold increase in disaster-induced displacement (based on figures for 2014-2019)

D. Conclusions on the significance of climate change for drowning risk factors - at a national scale

- Climate change is part of a complex set of dynamics affecting drowning risk (in different ways, some increasing, some reducing risk), and needs to be factored in among them when setting public health policies and designing drowning prevention interventions
- For Bangladesh, climate change impacts over the next two decades are both probable and of significant enough consequence to warrant consideration in future planning of risk management in different sectors.
- For Tanzania, the projections are perhaps not so clearly significant at a national scale, though the potential for increased extreme events is serious for those exposed and vulnerable.
- However, it seems that in all cases these changes in both countries **represent a slight to moderate increase from existing risks – rather than a true step-change** in the spatial pattern or the type of hazard that people face.
- **The rationale for RNLI drowning prevention projects as presently designed therefore continues.**
- Nevertheless, because of projected or predicted changes in environmental and other risk factors it would be wise to **monitor other priority groups/locations over the next 10 years**.

4.2 Implications for interventions

Bangladesh
In Bangladesh support to reduce drowning risk for children in areas where people have their homes near or above water bodies should continue to be a priority, especially for those living in multi-dimensional poverty and with limitations on adult supervision in the home. Poverty rates at an aggregate scale will be gradually reducing in the time period for this study, yet the slowing but continuing population growth means that the overall numbers of people in poverty is not likely to diminish significantly. Moreover, coastal areas will be affected by gradual sea level rise and rising tropical cyclone intensity, and many sources conclude that there is a strong likelihood that this will raise drowning risk in settlements in those zones, especially for those marginalised groups living outside coastal flood protection structures. **This strengthens the argument for retaining drowning prevention initiatives targeting children in those low-lying coastal districts.**

But displacement of people from such areas is likely to be exacerbated by those same factors, leading to greater shift of people inland, including to major urban centres. Many sources generally conclude that ongoing migration patterns, fuelled at least in part by climatic stresses, will result in an increasing proportion of people living in urban areas, with the poor concentrated largely in informal settlements – where there is less protection from, and in places more exposure to flooded environments. Meanwhile, riverine and pluvial flood risk is also likely to intensify across much of the country, leading to more flood hazard inland. A growing informal urban population will be exposed to this rising short-term drowning risk, especially children (and often, perhaps, without the extended family supervision that is more common in rural areas). Hence, **urban informal settlements in flood-prone sites are a possible additional geographical focus for child-focussed drowning prevention,** and further work to understand and monitor changes in drowning incidence in these locations could be advisable.

In light of this context, Project Bhasa warrants continuation in the Barishal division of Bangladesh, especially because coastal storms, seal level rise and extreme river flows are likely to put the people of the Barishal division at even higher risk of drowning. Therefore, lifesaving and life-enhancing interventions, such as anchal and swim safe are the need of the hour for children, and an argument can be made to expand the target group to include adolescents and adult men and women who need to learn lifesaving swimming skills in Barishal. Ideally, though, given the demographic shifts occurring in Bangladesh, it is recommended that initiatives based on Project Bhasa be scaled up amongst poor and vulnerable households elsewhere in Bangladesh, including those concentrated in the periphery of cities. Interventions such as, anchal, swim safe, and first responders training, must also take into account factors such as gender, age, access to aquatic locations and WASH to avert drowning risk in urban settings.

Furthermore, it is recommended that drowning prevention work can be expanded to reimagine RNLI's policy and practice under the ambit of the UN's Disaster Risk Reduction (DRR) framework and Avoidable Deaths Network's (ADN) Avoidable Deaths Framework. ADF is a sense-making operational tool. To reduce avoidable deaths such as drowning, avoidable deaths framework (ADF) has three components:

i) preventable measures, ii) amenable measures, and iii) governance measures (Cook, 2019; Ray-Bennett et al, 2021, Ray-Bennett, 2018; Mizutori, 2020). Preventable measures can be promoted through (active or passive) surveillance, outreach with primary health care (PHC) centres, health screening, health teaching, social marketing and policy development. Amenable and timely interventions can be promoted through CPR, first aid response, ambulance services, rapid referral services etc. Governance measures can be promoted through effective coordination, communication, and collaboration with relevant stakeholders and across sectors (e.g. PHC, Emergency Services, Ministry of Health and Family Welfare, Ministry of Disaster Management and Relief, Ministry of Environment and Forests, Ministry of Women and Children Affairs – among others).

Tanzania

With such a high incidence of drowning in the Lake Victoria area, the rationale to focus on lake-side fishing communities is not likely to be challenged as a result of near-term climate change. Indeed, greater exposure to extreme weather events, especially storms, is considered likely to increase drowning risk for fisherfolk and their families. Migration to the Lake Victoria region (possibly fuelled by economic demand for fish protein from growing urban populations) has the potential to expand the sector further, increasing competition and magnifying the tendency toward unsafe work practices in absence of better regulation. Climate change may also exacerbate other environmental/ecological pressures on the lake ecosystems, undermining the productivity of the sector. That could plausibly make the sector diminish in size (i.e. reduce drowning incidence), but equally plausibly its effect could be to reduce profit margins further so that the fishing sector is even less able to adopt regulation and safe practices. Hence, **very strong rationales remain for retaining and expanding the focus of intervention on the Lake Victoria communities.**

There seems to be potential too for RNLI's work in Lake Victoria to draw on the experience of life-saving interventions under Project Bhasa, some of which could be replicated in the RNLI's seven selective communities in three regions (Mara, Mwanza and Kagera). The components of intervention can be implemented based on the need assessment of each region since some of the selective areas are islands, others are mainland, and others are isolated with rural and peri-urban settings. They could include as appropriate: swim safe, which could target children, adolescents and adult fishermen who are in need of swimming skills; first responder training for community volunteers, health workers and emergency services; and education and advocacy for water safety awareness. Efforts should also continue to integrate drowning prevention work with renewed attempts to develop community-focused early warning systems to avert drowning deaths during floods, cyclones, and intense rainfall.

However, it is possible that the next two decades will also see the emergence of new drowning risk hotspots in Tanzania. The country's poverty rates are not likely to reduce greatly in this period, and the major increase projected for the national population means that the overall numbers of people in poverty will grow (even if the proportion reduces). As in Bangladesh, there will be a rapidly increasing proportion of people in urban areas, with the poor largely concentrated in informal settlements – where there is less protection from, and potentially more exposure to hazards. Drying trends in coastal areas combined with land acquisition issues may possibly lead to displacement of more people inland and to urban areas. Though climate change

effects on average rainfall are unclear and possibly not significant nationally, there is good evidence that extremes – intense rains, intense dry periods – are more likely to occur, affecting areas in a more localised way. There is likely to be increasing flood risk generally, but especially in areas that are already flood-prone, and this is likely to have drowning risk implications, especially for children. This indicates that it might be useful to **monitor for changes in drowning incidence in rural, urban and coastal sites that are already prone to floods and other hazards** (i.e. localized across Tanzania).

4.3 Key themes for further exploration

The discussions above draw on an openly interpretive and subjective process. So much remains unknown about how climate change and other dynamics will play out in the study countries and re-shape drowning risks. However we have identified three key topics that stand out from our discussions as themes that would strongly benefit from a deeper understanding, gained either through new data collection (primary research) or possibly, in some cases, by accessing existing datasets and undertaking a more disaggregated analysis.

Interconnecting dynamics of environmental change and social risk factors at Lake Victoria

Evidence from literature and from the team's discussions with water sector and environmental management experts in Tanzania paints a complex picture of environmental and social change in and around Lake Victoria. These dynamics, of which climate change is and will be a key part, intersect in ways that are likely to impact on drowning risks for communities dependent on the lake for their livelihoods and wellbeing. Already one of the most densely populated regions of Tanzania, the population around Lake Victoria is likely to increase further through migration and displacement associated with land use change, drought and other pressures elsewhere, together with the attraction of urban development in lakeside towns such as Mwanza (Olaka et al, 2019; Atuoye et al, 2021; Warner and Afifi 2014; Ocello et al, 2015). The environment in and around the lake is already affected by land degradation, beach erosion, siltation from rivers, fluctuating lake water levels, lack of waste management and poor sanitation in informal settlements, water quality pollution, eutrophication and proliferation of invasive blue green algae and water hyacinth (Yunana et al, 2017; Morales-Muñoz et al, 2020; Onyango et al, 2020). It has been indicated that this is forcing family members who commonly participate in landing fish and fetching clean water to wade out deeper into the lake. The ecological damage together with increasing demand for fish protein may have resulted in declining fish stocks (Yongo and Outa, 2016; Mgale and Nikusekela, 2017). With declining catches and livelihood pressures, including the need to repay micro-finance loans, it has then been argued that this is leading fishers to travel for further and longer into the lake – potentially exposing them to greater drowning hazards associated with the increasing frequency of extreme weather events (Onyango and Jentoft, 2010; Thiery et al, 2016; Nunan, 2021; Plummer et al, 2021).

<u>Clear understanding is needed of how these climatic, environmental and economic interconnections are taking shape at Lake Victoria, set within a context already noted earlier in the report of weak regulation, poor safety measures and social norms of risk-taking.</u>

Drowning risk in urban informal settlements

Projections indicate that the number of people living in informal or precarious urban settlements is likely to increase in both Tanzania and Bangladesh, due to combined effects of rural to urban migration and population growth. In this report, we have highlighted a plausible connection between increased urban migration (driven in part by climatic and environmental changes) and exposure to drowning risk, especially for children in low-income families occupying informal settlements (Chowdhury and Gulshan, 2016). The logic for this suggestion is that informal settlements often emerge on marginal lands within urban areas, which in many cases means that people occupy precarious dwellings along riverbanks, on floodplains, near watercourses prone to flash floods and sometimes on stilts over water bodies (Doberstein and Stager, 2013; Abunyewah et al, 2018). However, the team has found very little detail on urban drowning hazards in the literature we have surveyed, and minimal hard evidence on the relative drowning risks faced by lower-income groups in urban settings. Drowning, for example, is listed among health risks faced by households in informal settlements in Corburn and Sverdlik (2019) and Okaka and Odhiambo (2019), but in both sources no further elaboration or data is provided. Mathur et al (2018) found that urban sites accounted for 22 of 25 (88%) near drowning injuries reported in their study comparing urban informal settlements and rural villages in Ujjain, India. However, this difference was explained because their rural study sites did not have water bodies nearby, while the urban sites were close to water bodies passing through the city. Even comparisons of urban and rural rates of drowning between rural areas and in urban areas in general are relatively few and limited in scope within developing countries. Focusing on fatal injuries Burrows et al., (2010) reported that drowning ranked among the top five causes of childhood death in six South African cities and was the most common cause in two of these. However, Kobusingye et al., (2001) found drowning to be the leading cause of death in a rural setting on the shores of lakes Kyoga and Victoria, compared to road traffic accidents being the leading cause of death in the Kawempe division of Kampala, which includes areas of dense urban slums.

<u>It is difficult to be conclusive about the relative risks of drowning in urban informal settlements, especially for young children in such environments, without further research, including more extensive, disaggregated analysis of data between types of urban and rural settings.</u>

The relative importance of extreme weather events for drowning risk

In this report we focus quite strongly on weather extremes and associated hazards – on the risks posed by changes in the frequency and/or intensity of hazardous events such as floods, tropical cyclones and coastal storm surges. As some of the most tangible effects of a changing climate, such events are inherently of importance when considering future drowning risk. However, when the team undertook a rapid search of the academic literature on extreme weather and drowning we found what we consider to be a significant evidence gap. This is arguably the case even at the basic level of analyzing causes of death occurring during extreme events, for which drowning is usually stated as clearly the leading cause (e.g. Meddings et al, 2021) or at least the one most 'readily-identified' as leading to direct deaths (Ahern et al, 2005). However, the global evidence base remains heavily weighted toward empirical data from a few countries, and especially the USA (see e.g. the systematic reviews on floods and cyclones by Doocy et al, 2013a and 2013b, which conclude that drowning

accounts for the majority of direct deaths). Also, we did not yet find any sources reporting robust empirical work to compare the drowning risks associated with different types of flood hazards – although the likelihood that this will differ according to speed of onset, velocity, depth and spatial extent has been underlined (Malilay, 1997; Ahern et al, 2005). Even harder to find is a range of evidence comparing the incidence of drowning in extreme events relative to other circumstances of drowning. A noteworthy exception could be the statement by WHO (2014), which in pointing out the data-reporting problem that disaster-drowning and some other types such as intentional drowning and water transport incidents are not included in their drowning statistics, suggests that a great many drownings may be unrecorded for this reason. The report suggests that this could raise drowning numbers possibly by 4-5 times in lower-income countries. Though the precise proportion of that estimate that can be related to extreme events is unclear, nevertheless, if it were broadly correct, it would potentially make extreme events associated with a high proportion of deaths in hazard-prone countries such as Bangladesh - and perhaps much higher in highly hazardous environments such as Lake Victoria.

Understanding how disaster-drowning compares to 'background' levels of drowning (i.e. that would occur under normal conditions) requires analysis across data sets that is beyond the reach of this study, and probably requires new empirical case study-based research using multiple evidence sources to provide more robust data.

4.4 Headline recommendations

Risk of drowning may be exacerbated by changes in mean climatic conditions and weather extremes in a growing range of rural and urban locations in Tanzania and Bangladesh, and there may be some spatial modification of drowning incidence associated with increased migration. Overall, however, our conclusion is that this is unlikely to significantly alter the relative importance of drowning risk factors and the distribution of drowning hotspots over the next two decades.

In most cases, these changes are likely to intensify existing risks in sites where drowning incidence is inherently associated with proximity to and utilization of water bodies, compounded by unsafe working, transport and home environments that combine to result in unsafe working practices for adults or limited capacity for safeguarding of young children.

- Therefore, the current focus of RNLI programmes in Bangladesh and Tanzania remains justified in planning ongoing intervention.

Should capacity and finance be available, however, there are some potential avenues for expanded and/or additional intervention in both countries, or at least for active monitoring of changes:

- Consider expanding the scope of Project Bhasa in Bangladesh to consider urban sites if evidence indicates that a combination of climatic hazards and migration is intensifying drowning risk – this may especially be the case for young children in urban informal settlements.

- Monitor and investigate changes in drowning incidence in rural, urban and coastal sites in Tanzania that are already prone to floods and other hazards, with a view to potential expansion of interventions if drowning risk is seen to intensify there in future.
- Establish ‘knowledge exchange networks’ that bring together active individuals from affected communities, including first-responders, to share vernacular knowledge on drowning prevention
- Such groups could also constitute the basis for citizen science projects through which network members could be active participants in knowledge generation about drowning risk and monitoring of changes.

Specialist Research/evidence recommendations:

- Further work targeted to understanding the complex interconnection of climatic, environmental, economic, social and cultural dynamics at Lake Victoria could prove crucial in framing, and seeking funding for, further drowning prevention initiatives.
- Robust studies that compare drowning incidence in informal urban settlements to other urban or rural areas, to provide the evidence base to justify (or not) intervention in growing informal settlements located close to water bodies or flood-risk areas in both countries.
- Research on the risk posed by extreme weather events compared with drowning risk in other circumstances, together with studies that compare different types of hazard as casual factors (responding to an evidence gap that is not always explicitly recognised in generalised statements about drowning and climatic hazards).

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School of International Development
University of East Anglia,
Norwich NR4 7TJ, United Kingdom

Email: dev.general@uea.ac.uk
Web: www.uea.ac.uk/dev | www.devresearch.uea.ac.uk

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