Words into Action Guidelines:
National Disaster Risk Assessment
Hazard Specific Risk Assessment

8. Sea-level Rise

Key words:
Sea level change, glacial melting, land movement, flooding, storm surge, coastal adaptation

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Global climate change is expected to impact the entire globe by the end of this century. The release of carbon dioxide and other greenhouse gases is responsible for rapidly rising global mean surface temperatures, which could increase by as much as 4.8°C by 2100.1 This warming is causing ice to melt, along with an expansion of warming waters that is expected to increase global sea levels between 0.26 and 0.82 metres according to the 2013 report of the Intergovernmental Panel on Climate Change.

These rising sea levels pose an extreme risk to many global cities2, including Shanghai (China), Mumbai (India), Rio de Janeiro (Brazil), New York (United States) and London (United Kingdom). Many global regions, such as the South Pacific island of Tuvalu and low-lying coastal areas of Bangladesh, are already experiencing significant coastal flooding and inundation due to sea-level rise.3,4 But this is merely the beginning, as it is expected that, without adaptation, 0.2 to 4.6 per cent of the global population will be flooded annually by the end of this century, costing approximately 0.3 to 9.3 per cent of global gross domestic product.5

In undertaking hazard assessment, we need to keep in mind that because sea-level rise occurs gradually, it behaves very differently from many other hazards. Its impacts may not be immediately seen or coalesce around a single sea-level rise event. Permanent flooding on land is a direct hazard caused by sea-level rise; however, a number of indirect (secondary) hazards need to be incorporated into the assessments. These include extended damage caused by storm surges or saltwater contamination of fresh water sources.

Hazard assessment

Understanding disaster risk related to sea-level rise is essential to understanding the scale of impact this hazard could have for a particular locality. In the United States, the Mississippi River delta – including the city of New Orleans – is already experiencing severe flooding. Other regions, such as south-east Alaska, are not expected to experience rising sea levels until later in the century.

The table below lists some resources that are currently available to assess the risk of sea-level rise. It also provides links to sources on strengthening disaster risk reduction governance to manage sea-level rise, on enhancing

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1 Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. *Climate Change 2013: The Physical Science Basis.* Cambridge: Cambridge University Press.

2 Nicholls, R. J. and A. Cazenave (2010). Sea-level rise and its impact on coastal zones. Science, vol. 328, pp.1517-1520.

3 Church, J. A., N.J. White and J.R. Hunter (2006). Sea-level rise at tropical Pacific and Indian Ocean islands. *Global and Planetary Change,* vol. 53, issue 3, pp.155-168.

4 Hamlington, B. D. and others (2014). Uncovering an anthropogenic sea-level rise signal in the Pacific Ocean. *Nature Climate Change,* vol. 4, pp. 782-785.

5 Hinkel, J. and others (2014). Coastal flood damage and adaptation costs under 21st century sea-level rise. Proceedings of the National Academy of Sciences 111, pp. 3292-3297.

disaster preparedness for effective response and on guiding resilience investment.

The global costs of protecting the coast with dikes alone are estimated to range between US$ 12 billion and US$ 71 billion by 2100.5 While this investment in disaster risk resiliency may appear costly, it is still much less than the projected loss of gross domestic product – as forced migration of between 1.6 million and 5.3 million people caused by sea-level rise, without adaptation, is estimated to cost between US$ 300 billion and US$ 1,000 billion.[6]

Description of input data	National entities that most commonly have this data	Examples of open databases available from international sources
Rates of past sea-level change from tide gauges	National Oceanic and Atmospheric Administration, British Oceanographic Data Centre	www.gloss-sealevel.org/ www.psmsl.org/
Sea-level altimetry data	United States National Aeronautics and Space Administration	www.nodc.noaa.gov/SatelliteData/jason/
Future sea-level projections	United Nations Intergovernmental Panel on Climate Change	www.ipcc-data.org/
Sea-level adaptation strategies	United States National Park Service, United States Environmental Protection Agency, Australian Government Geoscience Australia OzCoasts programme	www.cakex.org/ https://coastadapt.com.au/
Examples of general adaptation projects	weADAPT, a collaborative platform supported by Sweden	www.weadapt.org/placemarks/maps https://toolkit.climate.gov/

Table 1- Sources of data for sea-level rise risk assessment

6 A global analysis of erosion of sandy beaches and sea-level rise: An application of DIVA. *Global and Planetary Change* (2013). vol. 111, pp. 150-158.

Table 1 includes input data required for understanding disaster risk. However, uncertainties exist that could influence the outcome of risk assessment. These uncertainties can be due to the following:

- Choice of sea-level rise scenario (also known as greenhouse gas concentration representative concentration pathways)7
- Accuracy of the models used (to be specified by the authors of the models)
- Secondary hazards (e.g. storm surge and groundwater intrusion) that could provide a "tipping point" for reconstruction, adaptation, or abandonment
- Willingness across all scales (intergovernmental, within the State, community, individual) to invest in planning to manage risk.

Exposure and vulnerability assessment

It is estimated that US$ 9.6 trillion to US$ 11 trillion in global assets and 290 million to 310 million people live within the present-day 100 year flood zone.5 This number does not include those working within the coastal zone who could be exposed to sea-level rise by 2100.

Neumann et al.8 offer four different scenarios under which demographic data are combined with sea-level rise data to identify the most vulnerable regions. People living in the coastal zone in China, India, Bangladesh, Indonesia and Viet Nam are estimated to be most vulnerable due to secondary storm surge hazards. Africa is also in a precarious position due to its rapid population growth and urbanization in the coastal zone, which will make Egypt and sub-Saharan countries in eastern and western Africa more vulnerable to sea-level rise and its associated hazards. Prevention measures and long term planning early on can help reduce vulnerabilities by retreating from any zones of potential exposure. Funds should be secured for any critical resources or infrastructure that cannot be moved but can be protected using engineered methods (e.g. elevate roads and buildings).

Risk assessment use in national DRR measures

A number of national-level DRR measures are important for management, after the risk of sea-level rise has been assessed.9 These measures include the following:

- Promoting the collection of appropriate data and encourage the use of

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7 Van Vuuren, D. P. and others (2011). The representative concentration pathways: an overview. *Climatic Change,* vol. 109, pp. 5-31.

8 Neumann, B. and others (2015). Future coastal population growth and exposure to sea-level rise and coastal flooding - a global assessment. PLOS ONE 10.

9 United Nations Office for Disaster Risk Reduction (2015). Sendai Framework for Disaster Risk Reduction 2015-2030, p. 37.

standardized baselines for the periodic assessment of sea-level risk and secondary hazards such as storm surge and groundwater intrusion.

- Adopting and implementing national sea-level rise plans that take into account changes in sea level across multiple timescales and climate change scenarios.
- Putting in place mechanisms to periodically assess and publicly report on progress in implementing resiliency measures to address sea-level rise. The reports should promote public scrutiny and be subject to institutional debates, including by parliamentarians, as well as scientists from the climate change arena.
- Promoting the mainstreaming of sea-level plans and assessments that include mapping and management strategies for rural development planning and management of wetlands, coastal floodplains areas, and any other areas prone to flooding.
- Encouraging the revision of existing building codes to include the impact of sea-level rise in designated flood and storm surge zones; and assessing buildings based on their adaptive capacity and ability to be relocated if necessary.
- Promoting cooperation among diverse institutions across multiple spatial scales.
- Promoting the inclusion of planning to adapt to sea-level rise into post-storm and other post-disaster documents. This includes rebuilding based on future shoreline positions.
- Considering the relocation of public facilities and infrastructure.

CASE STUDY

Box 1

A case of country good practice: Australia

The Government is actively planning for sea-level rise. In 2015 the Department of the Environment and Energy released its National Climate Resilience and Adaptation Strategy, which outlined the following four priorities for national engagement: (a) understand and communicate, (b) plan and act, (c) check and reassess and (d) collaborate and learn.

Managed retreat has been implemented in many parts of the country. Five guiding principles exist for those attempting this strategy. Managed retreat may not be an option for many less economically developed countries if they do not seek to establish and maintain protective coastal ecosystems. Sea-level rise will continue to be a hazard in regions that promote population growth along the coastline while ignoring the cumulative impacts of development and asserting political pressure for coastal development.

Liability laws that favour developers also put those at risk, since many are unaware of their potential future exposure to sea-level rise. The establishment of conditional occupancy rights (managed retreat via compensation for present-day landowners to abandon future at risk property) is one proposed technique to raise homebuyers' awareness of this issue, although stakeholder attitudes towards this approach vary.

Australia is an economically developed country, which makes adapting to sea-level rise easier because it can afford to pursue a number of strategies such as seawalls, beach sand replenishment and subsidized managed retreat to reduce the risk from sea-level rise and its associated secondary hazards.

But a number of less economically developed countries are also leading the way in creating strategies for reducing their sea-level rise risk. The Least Developed Countries Fund was established to help enhance and adapt infrastructure and develop community-based projects that build adaptive capacity across 51 least developed countries.

Resources for further information

Further information about understanding and preparing for sea-level risk:

- The Potsdam Institute for Climate Impact Research has information on the latest sea-level science, as well as links to ongoing global projects.
- The United Nations Environment Programme offers information on various adaptation and mitigation strategies related to climate change. Links to information regarding finance tools to fund projects can be found here: http://web.unep.org/climatechange/
- The Pacific Climate Change Portal was established as a resource for planners and managers so they could get information on projects, country profiles and sources of finance for climate change-related projects in the Pacific region.
- The EcoAdapt Climate Adaptation Knowledge Exchange (CAKE) manages a global database of climate change-related adaptation case studies, and as well as providing links to various tools : www.cakeex.org

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