

Hazard Specific Risk Assessment: Hydrological

4 - Sea Level Rise

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

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 warming global mean surface temperatures that could increase by as much as 4.8°C by the end of this century¹. 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 meters according to IPCC 2013 report.

These rising sea levels pose an extreme risk to many global cities², such as Shanghai (China), Mumbai (India), Rio de Janeiro (Brazil), New York (USA), and London (UK). Many global regions such as the island nation of Tuvalu and low-lying coastal areas of Bangladesh are already experiencing significant coastal flooding and inundation due to sea level rise³⁴, but this is merely the beginning as it is expected that without adaptation, 0.2–4.6% of the global population will be flooded annually by the end of this century costing approximately 0.3–9.3% of global gross domestic product⁵.

When undertaking hazard assessment it is important to keep in mind that sea level rise behaves very differently in comparison to many other hazards because sea level rise occurs gradually. The impacts of sea level rise 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, there are a number of indirect (secondary) hazards that need to be incorporated into sea level rise risk assessments, such as 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 your particular locality. Low-lying regions such as the South Pacific island nation of Tuvalu, the Bangladesh delta, and United States Mississippi River Delta including the city of New Orleans are already experiencing severe flooding while rapidly increasing water levels threaten to inundate other areas of the country that have historically never been flooded before. Meanwhile other regions, such as southeast 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 your risk to sea level rise. The table also provides links for stakeholders to sources on strengthening disaster risk reduction governance to manage sea level rise, enhancing disaster preparedness for effective response, and guiding resilience

investment. It is estimated that the global costs of protecting the coast with dikes alone range between US\$12 and US\$71 billion by 2100⁵. While this investment in disaster risk resiliency may appear costly, it is still smaller than the projected loss of gross domestic product as forced migration of 1.6–5.3 million people caused by sea level rise without adaptation is estimated to cost US\$300–1000⁶.

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

Description of Input Data	The national entities that most commonly have this data	Examples of existing 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	National Aeronautics and Space Administration-USA	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	U.S. National Park Service, U.S. Environmental Protection Agency, Australian Government OzCoasts Program	www.cakex.org/ https://coastadapt.com.au/
Examples of general adaptation projects	weADAPT	www.weadapt.org/placemarks/maps https://toolkit.climate.gov/

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:

- Choice of sea level rise scenario (also known as greenhouse gas concentration representative concentration pathways⁷).
- Accuracy of the models used (this should be specified by the model authors).
- Secondary hazards (such as 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-scale, individually) to invest in planning to manage risk.

Exposure and vulnerability assessment

It is estimated that US\$9.6–11 trillion in global assets and 290–310 million people live within the present-day 100 year flood zone⁵. This number does not include those working within the coastal zone that could be exposed to sea level rise by 2100. The vulnerability of those exposed depends on how adversely these people will be affected. Neumann et al.⁸ offer four different scenarios under which demographic data is combined with sea level rise data to identify the most vulnerable regions. Those operating in the coastal zone in China, India, Bangladesh, Indonesia, and Vietnam are estimated to be most vulnerable due to secondary storm surge hazards. Africa is also in a precarious position due to their rapid population growth and urbanization in the coastal zone that will make Egypt and sub-Saharan countries in Eastern and Western Africa more vulnerable to sea level rise and its associated hazards. Planning now can help reduce vulnerability as plans are made to retreat 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

There are a number of national level DRR measures that are important for management after assessing your risk to sea level rise⁹. These measures as they relate to sea level rise include:

- Promote the collection of appropriate data and encourage the use of standardized baselines for periodic assessment of sea level risk and secondary hazards such as storm surge and groundwater intrusion.
- Adopt and implement national sea level rise plans that take into account changes in sea level across multiple time scales and climate change scenarios.
- Put in place mechanisms to periodically assess and publically report on your progress to implement resiliency measures to address sea level rise. These reports should promote public scrutiny and be subject to institutional debates, including by parliamentarians, as well as appropriate scientists from the climate change arena.
- Promote 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.
- **Encourage the revision of existing building codes to include the impact of sea level rise on top of designated flood and storm surge zones.** Assess buildings based on their adaptive capacity and ability to be relocated if necessary.
- Promote cooperation among diverse institutions across multiple spatial scales.
- Promote 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.
- Consider the relocation of public facilities and infrastructure.

BOX 1 - A case of a country good practice

Australia - The Australian government is actively planning for sea level rise. In 2015 the Department of the Environment and Energy released their National Climate Resilience and Adaptation Strategy¹⁰ that outlined the following four priorities for national engagement: 1) understand and communicate, 2) plan and act, 3) check and reassess, and 4) collaborate and learn. Managed retreat has been implemented in many parts of Australia¹¹. 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 favor 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) in Australia is one proposed technique to raise homebuyers awareness of this issue, although stakeholder attitudes towards this approach vary¹².

Australia is an economically developed country, which makes adapting to sea level rise easier because they can afford to pursue a number of strategies such as seawalls, beach sand replenishment, and subsidized managed retreat to reduce their risk from sea level rise and its associated secondary hazards. However, there are a number of less economically developed countries who are also leading the way in creating strategies for reducing their sea level rise risk. The Least Developed Countries Fund (LDCF) was established to help enhance adapt infrastructure and develop community-based projects that build adaptive capacity across 51 least developed countries¹³. The LDCF funded US\$8.8 million for projects to promote management of marine resources and create an integrated coastal management program that included adding climate change planning to government documents in Vanuatu from 2010 to 2014. These projects also incorporate indigenous knowledge into their plans. In Lonamilo Village in Vanuatu, locals have relocated gardens for food inland, begun building their homes on stilts, and dug channels to redirect floodwaters¹⁴.

Resources for further information

Further information about understanding and preparing for sea level risk can also be found at:

- 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 Program lists more information on various adaptation and mitigation strategies related to climate change. Links to information regarding finance tools to fund projects can be found on their climate change homepage: <http://web.unep.org/climatechange/>
- The Pacific Climate Change Portal was established as a resource for planners and managers so they could get more 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 at: www.cakeex.org

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