

APPROACH TO THE FIRST PASS NATIONAL COASTAL RISK ASSESSMENT

Photo credit: AAM/Hatch

KEY FINDINGS

- This assessment is the first national assessment of the extent and magnitude of climate change risks to Australia's coastal zone.
- A significant investment in national capacity has underpinned the assessment – a consistent, detailed national coastal geomorphology map and a medium resolution digital elevation model covering the Australian coast are now available. Investment in high resolution elevation modelling is also occurring in many jurisdictions.
- A 'bucket fill' method was used to assess coastal inundation hazard. It combined sea-level rise of 1.1 metres, tidal range and storm surge (where available) with a medium resolution digital elevation model to identify locations likely to be flooded. Soft, erodible shorelines around the Australian coast were also identified.
- The number of existing residential buildings exposed to inundation risk was quantified using Geoscience Australia's National Exposure Information System (NEXIS) infrastructure database for each state, the Northern Territory and for key local government areas.
- Comparison with small areas where high resolution elevation data was available provided some verification of the method and indicated that the first pass outputs are generally robust. Further analysis using high resolution data will likely alter the estimated number of properties at risk.
- There are a number of limitations to the approach used which influenced the results. Storm tide modelling for a 1-in-100 year event was used where available (Victoria, Tasmania and New South Wales), a lack of modelled storm tide datasets for the other states has meant that modelled high water level was used (Queensland, Western Australia, South Australia, and Northern Territory). Similarly there is a current lack of national capacity to effectively assess climate change impacts on estuaries, where a large proportion of residential communities are clustered; and from the combined risk of catchment flooding and storm surge.
- Spatial and quantitative analysis of assets at risk has also been limited to residential buildings in this first pass assessment – further work is needed to assess the impacts on infrastructure and other assets.

3.1 Assessment objectives

While the coastal zone has been consistently identified as highly vulnerable to the impacts of climate change, assessments of risk to date have generally been at local or regional scales. With a growing focus on the need for adaptation action and a call for governments to provide further guidance to assist communities manage likely impacts, there is a need for a clearer picture of the nature and geographic spread of risks from climate change.

The National Climate Change Adaptation Framework endorsed by the Council of Australian Governments (COAG) in 2007 identified the need for a first pass national coastal vulnerability assessment.

The Framework notes that the absence of a national elevation model and nationally consistent mapping in the coastal zone has limited the analysis of coastal vulnerability to date. The need for a national assessment of risks from climate change to the coastal zone was reinforced by the COAG Working Group on Climate Change and Water in 2008.

The objectives of the National Coastal Risk Assessment are to:

- Provide an initial assessment of the climate change implications for Australia's coastal regions, with a particular focus on coastal settlements and ecosystems
- Identify areas of high risk to climate change impacts

- Identify key barriers or impediments to developing effective coastal adaptation responses
- Help identify national priorities for adaptation to reduce climate change risk in the coastal zone.

This assessment was initiated under the auspices of the Natural Resource Management Ministerial Council.

The focus of this chapter is largely on the approach used to identify the national risk to residential properties from sea-level rise as a result of climate change. The results of this analysis are described in Chapter 5. Risks to coastal ecosystems and industries are covered in this national assessment, but are based on a review of recent literature.

3.2 Building national capability

At the commencement of the assessment the available data and tools were not of sufficient resolution to underpin the national identification of areas at risk around the coastline. The Australian Government undertook a review of the methods and knowledge available for a national coastal risk assessment including identification of key gaps.¹ Consideration was also given to whether international studies or projects in other countries could inform an Australian risk assessment.²

Two key requirements emerged from this review and were supported by expert advice – the need for higher resolution national coastal elevation data and for more consistent geomorphology data. In response to this review the Australian Government has invested in building national datasets and capability, and the capacity to undertake a national risk assessment has also been enhanced. The following parts of this section describe these capabilities.

3.2.1 Digital elevation data and modelling

An accurate picture of coastal elevation is critical to assessing risk from inundation as water will obviously move to lower lying areas first where accessible.

The creation of a national digital elevation model (DEM) was the highest priority task identified by the Australian Government for the national risk assessment. DEMs have become widely used in the last 20 years for catchment and natural resource management and risk analysis. They provide a three dimensional model of the ground surface topography and can be constructed using a range of remote sensing technologies such as photogrammetry, airborne radar and satellite imagery (Figure 3.1).

Prior to commencing this assessment the best DEM available with national coverage was that derived from the 3 second arc resolution Shuttle Radar Topography Mission (SRTM), which had a horizontal resolution of approximately 90 metres. The SRTM DEM was used by the insurance industry in an assessment of addresses at risk from climate change which was briefly reported in the IPCC's Fourth Assessment Report.³

Elevation data and modelling options were assessed by the Spatial Information Council and the Cooperative Research Centre for Spatial Information (CRCSI). The Australian Government made a decision to invest in a mid resolution DEM covering the entire coast and derived from *High Resolution Stereoscopic Reference3D* (SPOT) satellite imagery. The decision was based on the better resolution available through SPOT data (with a one second arc, 9 SPOT grid cells fit within one SRTM cell), and the fact that the data had been tried and tested and was available for the whole continent (except Cape York).

The SPOT DEM has a horizontal resolution of approximately 30 metres and a vertical height resolution of 1 metre (that is, the elevation of the surface is in steps of 1 metre intervals). It has absolute elevation accuracy (90 per cent confidence) of around 10 metres and a standard deviation value of approximately 6 metres. However, it should be noted that errors in the SPOT DEM are generally not geographically distributed on a random basis (i.e. single points in the data layer) but rather, errors will be distributed over an area in the DEM. This means that

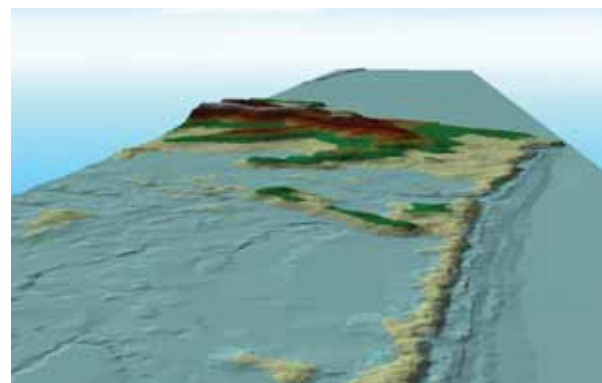


Figure 3.1 Image examples of digital elevation models for the Burrup Peninsula, Western Australia (left); and a coral reef and island of the Queensland coast (right).
Source: Fugro Spatial (left) and AAMHatch (right).

the general shape of the land tends to be adequately represented, even if the heights are not exactly correct, and relative patterns of inundation are able to be obtained. For a whole of continent first pass national analysis the SPOT data was assessed as fit-for-purpose.

The Australian Government is also interested in ensuring that access arrangements are put in place for the DEM data that maximise its public good use. The majority of DEMs built in Australia over the past 15 years have been built by the private sector, often with government funding, but using contractor models. This has resulted in a fragmented and uncoordinated network of DEMs with varying accuracies and specifications. To help constrain this problem the Spatial Information Council is coordinating a National Elevation Data Framework to:

- improve the quality of elevation data and derived products, such as DEMs
- optimise investment in existing and future data collections
- provide access to a wide range of digital elevation data and derived products to those who need them.

The Spatial Information Council organised a national workshop at the Australian Academy of Science in March 2008 to facilitate the development of the science case, business plan and governance approach for the National Elevation Data Framework. The workshop was preceded by nation-wide consultation with the geospatial community and a data audit and user-needs analysis.

State governments and the Australian Government have also invested in high resolution elevation data for key urban centres. The acquisition of high resolution elevation data (around 10–15 centimetres vertical accuracy) will pilot the quality assurance process of the National Elevation Data Framework. Existing, high resolution data will be accessed in the first instance, with new LiDAR (Light Detection and Ranging) data expected to be acquired in a few small areas to fill gaps. The Australian Government has committed to providing access to the generated DEMs for public good purposes and work is progressing on developing the required infrastructure to deliver online access to the DEMs.

3.2.2 Coastal geomorphology

One of the expected impacts from climate change is accelerated coastal erosion due to rising sea levels, although rates and location of erosion are highly dependent on several factors including:

- the inherent susceptibility of differing coastal landform types
- regional variations in the processes driving erosion or instability (for example, sea-level rise and wave climate)
- local factors such as topography and sediment budgets.



Figure 3.2 Illustration of the coastal attributes captured in the National Coastal Geomorphology Mapping tool.
Source: Sharples et al. 2009⁴

The inherent susceptibility of landform types is of first-order importance in assessing coastal vulnerability. The creation of a detailed map of coastal landform types – the coastal geomorphology, was essential to provide an understanding of the potential extent of risk from erosion or other types of instability, for example, cliff slumping. Further work on understanding regional variations and local factors would provide significantly improved estimates of the magnitude of risk of unstable shorelines.

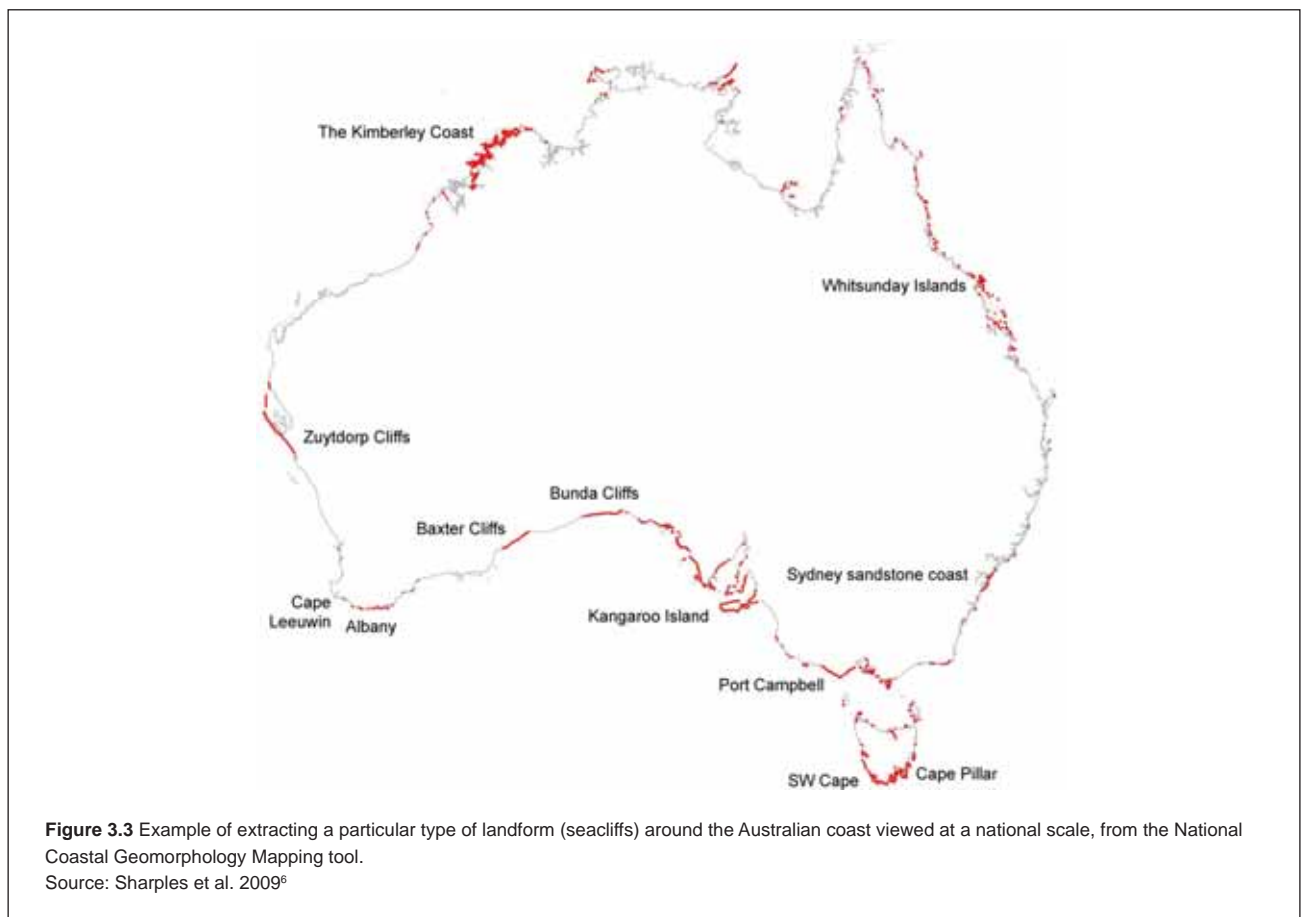
Prior to this national assessment the most detailed nationally consistent map available was an early geographic information system (GIS) map produced by CSIRO in the 1980s. This map was constructed by dividing the coast into 10 kilometre segments, sampling the landform types within each segment and recording the proportion of various types in each segment. While useful for broad national purposes, the resolution of this earlier mapping was not considered adequate for a national coastal risk assessment.

Following an expert meeting in early 2007 it was decided that the coastal geomorphic and vulnerability mapping approach that had been undertaken for Tasmania would be used as the basis for compiling a map for the entire Australian coastline. This approach uses a line map format to rapidly compile geomorphic data and then through analysis, identify potentially

unstable shores.⁵ Such an approach was considered to be the only method capable of being prepared for the whole country in the timeframe.

The development of a national geomorphology map of continental Australia and most adjacent islands (excluding the Great Barrier Reef) was a major step forward in building national capability. The mapping captures the enormous geodiversity of Australian coastal landforms within a simple, nationally-consistent geomorphic classification (see Figure 3.2). As a ‘geomorphic’ map, the topography of the coast (the platform, elevation and shape of the coastal landforms) is captured as simple categories, and it also indicates what the differing coastal landforms are made of – varying rock types, coral, sand, mud, laterite, boulders, and beachrock.

The data for the geomorphology mapping was derived from over 200 pre-existing maps and datasets, many compiled at different times, at different scales for different purposes, across different jurisdictions and using different classification systems. Landform data was obtained from many sources and reclassified into a single nationally-consistent format. The geomorphology mapping represents the first dataset to provide coastal landform information in a consistent format for the entire national coast, and at a level of detail that allows features down to 50 metres or less in size (such as small pocket beaches or short cliff-lines) to be individually distinguished (Figure 3.3).



The mapping captures the geomorphology information in a single GIS polyline representing the shore (usually a nominal mean high water mark line). The line is split into segments wherever the coastal landform types change and each distinctive segment is assigned with multiple attribute fields (data records) that describe the landform types of that segment of the coast. Landform attributes of the coastal zone are captured both inland and offshore up to 500 metres from the high water level.

The example in Figure 3.5 shows simplified examples of four of the ‘basic’ geomorphic attribute fields, each displayed as individual line maps. The fifth line map in the series shows how coastal types, having specified combinations of these multiple attributes, can be represented in a single line. In this example coastal landform stability classes are displayed.

The National Coastal Geomorphology mapping has been peer reviewed in a national workshop at the University of Tasmania and is available on the OzCoasts website (www.ozcoasts.org.au) where it can be queried and interrogated through the web browser.

While the mapping was prepared from data sources with differing scales and resolutions, it is possible to extract information on the lengths of coastline in each state and territory which are potentially unstable (refer to Box 3.2).

Box 3.1 Why use a line map approach?

The dataset of coastal geomorphology was compiled in a line format because of the ease with which each of the different landform attribute fields can be displayed or analysed, individually or as specific combinations of attributes. A line map is able to segment the coast at every point where any of the landform attributes change, as illustrated in Figure 3.4.

Because of the essentially linear nature of coasts a line map is a useful and efficient map format for many coast-related purposes, but there are some applications for which polygon or topographic mapping is required. For example, while the coastal geomorphology mapping could indicate potentially flood-prone coastal segments (using the Backshore profile attribute), a contour map or DEM is necessary to map the actual areas likely to be inundated.

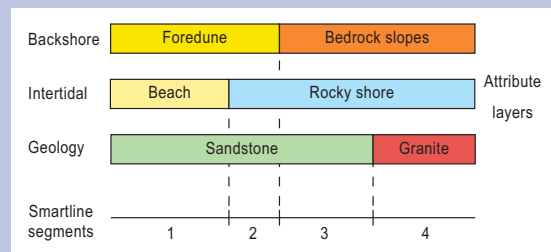


Figure 3.4 The ‘line mapping’ representing the coastline, is segmented wherever any one or more coastal attributes change, allowing the full alongshore extent of all attributes to be recorded. Source: Sharples et al. 2009⁷

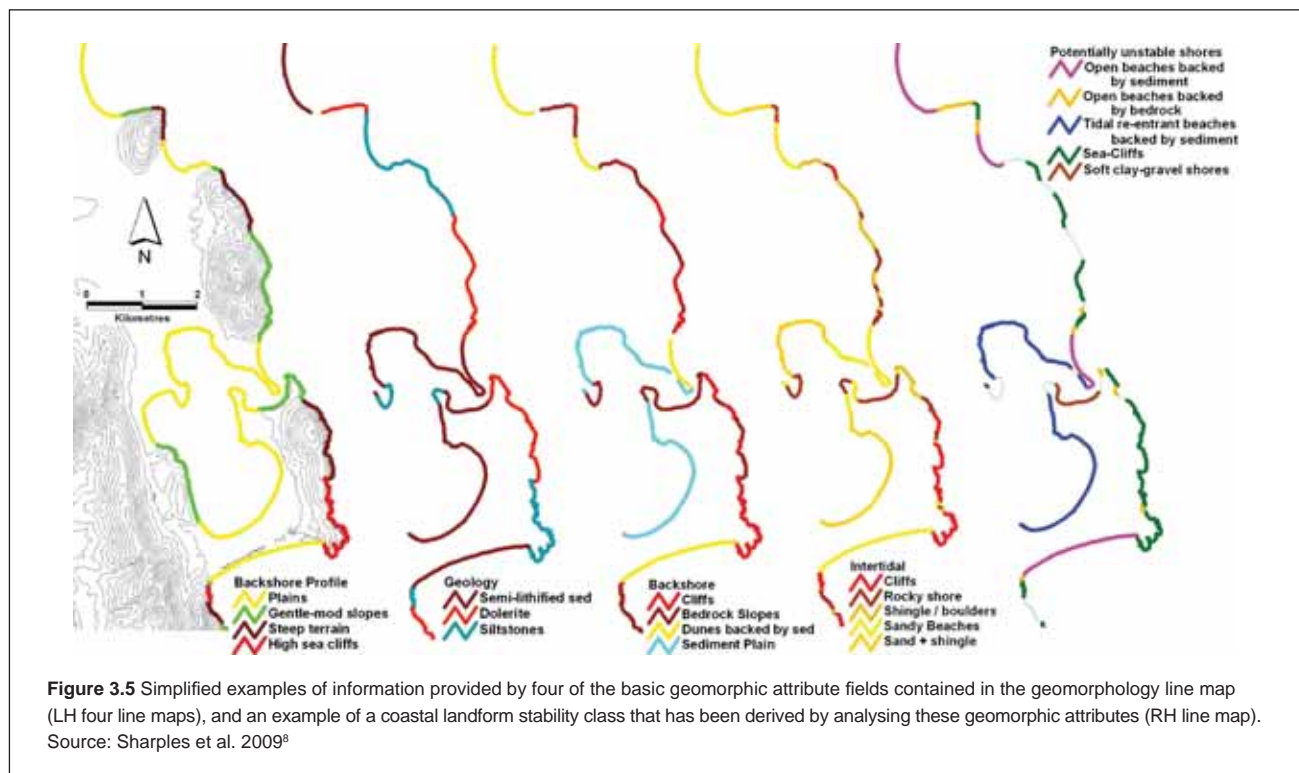


Figure 3.5 Simplified examples of information provided by four of the basic geomorphic attribute fields contained in the geomorphology line map (LH four line maps), and an example of a coastal landform stability class that has been derived by analysing these geomorphic attributes (RH line map). Source: Sharples et al. 2009⁸

Box 3.2 Coastline lengths for coastal stability classes

The lengths of the Australian coastline occupied by each major coastal landform stability class have been measured from the National Coastal Geomorphology Mapping tool (Smartline). Table 3.1 identifies the length of each landform stability type, essentially for open coasts but including a few major coastal re-entrants (estuaries or bays) as noted in the Table 3.1.

Approximately 63 per cent of the Australian coast is classed as either sandy or muddy. The remainder is composed of 'soft' or 'hard' rock shores. Sandy and muddy shores are to a large degree quite mobile especially where backed by soft sediments rather than bedrock (47 per cent). This is a significant statistic as it encompasses shores which are unimpeded by human structures and are quite free to move under conditions of climate change and those in more built-up areas where migration of 'soft' shorelines generate planning and management issues for local and regional communities. Sandy shores make up 30 percentage points of the 47 per cent of 'free-moving' unimpeded shores while 17 percentage points are muddy shores. Given the methodology used, muddy shores are potentially underestimated in Queensland where sandy shores are likely to be overestimated.

The high proportion of sandy shores not backed by bedrock in New South Wales (37 per cent) is significant as this is the most urbanised state along its entire length. However, sandy sediment backed beaches also occur over long stretches in other states such as Queensland, South Australia and Victoria.

Territory shores are distinctly different to the other states in that while hard rock and sandy shores are present, the tide-dominated Northern Territory coasts are strongly characterised by significant stretches of highly mobile muddy shores (especially tidal mudflats), and also by erodible lateritic soft rock shores.

Roughly half of the Western Australian coast is rocky. This is mainly in the Kimberley and south coast regions, with the remainder of the coast being dominantly sandy with significant muddy tidal flats north of Exmouth. The proportion of rocky coast that is calcarenite in Western Australia was not able to be identified as it was not included in the source data used to compile the National Coastal Geomorphology mapping (see Notes on Table).

Considerable sections of most states have hard rock shores although the proportion is less in Western Australia and the Northern Territory. This general class includes both sloping (resilient) or cliffed

(potentially unstable) rocky shores. A high proportion of soft rock shores occur in the Northern Territory and Victoria. As noted the proportion for Western Australia may be an underestimate of both hard and soft rock classes.

Source: Sharples 2009⁹

Notes on Table:

Coastal lengths have been measured on the Smartline map, which has been compiled from data of varying base map scales. The lengths have been normalised to an equivalent 1:100,000 scale to provide nationally-comparable coastal lengths for each stability class. The total length for each state and Northern Territory, and for Australia, includes measurements of mainland and major island lengths. The measured length using Smartline of 59,311 kilometres compares quite closely with 59,736 kilometres derived from the Geoscience Australia GEODATA coast 100 kilometres 2004 data base. That database shows mainland coast length of 35,877 kilometres and island length of 23,859 kilometres.

Coastline lengths and percentages summed over all stability classes may add up to over 100 per cent of the total coastal length for some states because some stability classes overlap. For example, 'sandy shores backed by bedrock' and 'hard rocky cliffs' may occur on the same coastal segments, as may 'sandy shores' and 'muddy tidal flats'. While total distances and percentages for Australia sum to less than 100 per cent because 'unclassified stability classes' are not included, and these are significant in a few regions including northern Western Australia, as well as in the numerous small islets with unclassified shores that are included in coastal length distance in each state.

'Hard Rock' shores have been combined with 'Undifferentiated hardness Rock' shores. The latter are rocky shores which were not assigned to a hardness category in the Smartline classification, either because it was unclear how hard the rock type is, or because the rock type making up the rocky shore is not recorded in the source data. Although some of these are likely to be soft rock types, for the purposes of this breakdown they are classed together with hard rock types.

A high proportion (27 per cent or 5,616 kilometres at 1:100,000 scale) of Western Australian shores are not classified into a coastal landform stability class, owing to gaps in the source data. These gaps are most extensive in the northern half of Western Australia, especially the Kimberley region.

Miscellaneous minor coastal stability types and unclassified shores are not included in these stability class figures, but are included in the total coast lengths.

Table 3.1 Coastal Lengths for Selected Coastal Landform Stability Classes.

	OPEN COAST LENGTHS – including islands; km, at 100,000 scale)												
	Embayments, estuaries and islands included in analysis												
	Total open coast length												
	Sandy shores undifferentiated (undiff)												
	Sandy shores backed by soft sediment												
	Sandy shores backed by bedrock												
	Muddy & undiff sed. shores (commonly tidal flats) undiff												
	Muddy & undiff sed. shores (commonly tidal flats) backed by soft sediments												
	Muddy & undiff sed. shores (commonly tidal flats) backed by bedrock												
	Soft rock shores – undiff and low profile												
	Soft rock shores – mod. to steeply sloping												
	Soft rock shores – Very steep to cliffed												
	Hard (& undiff hardness) rock shores – undiff and gently to moderately sloping												
	Hard (& undiff hardness) rock shores – cliffed												
Vic	Port Phillip Bay, Western Port, Corner Inlet	2,395	261 (11%)	689 (29%)	487 (20%)	193 (8%)	497 (21%)	106 (4%)	101 (4%)	27 (1%)	147 (6%)	78 (3%)	510
NSW	Botany Bay, Sydney Harbour (to harbour bridge), Hawkesbury estuary (to 18km), Port Stephens (to 22km), Jervis Bay	2,109	94 (4%)	695 (33%)	161 (8%)	16 (1%)	22 (1%)	11 (0.5%)	5 (0.2%)	7 (0.3%)	0	533 (25%)	166 (8%)
Qld	Western Side of Fraser Island, Southern end of Moreton Bay	12,276	1,510 (12%)	5,563 (45%)	1,989 (16%)	217 (2%)	37 (0.3%)	81 (0.7%)	155 (1.3%)	30 (0.2%)	39	700 (6%)	1,241 (10%)
NT		11,147	170 (1.5%)	869 (8%)	2,022 (18%)	624 (6%)	3,419 (31%)	781 (7%)	1,681 (15%)	186 (1.7%)	41	382 (3%)	315 (3%)
WA*	Albany Harbour, Major estuary mouths (only) in Kimberley – Bonaparte Gulf region	20,513	2,154 (10.5%)	1,780 (9%)	1,383 (7%)	2,263 (11%)	1,932 (9%)	1,261 (6%)	26 (0.1%)	53 (0.3%)	29	1,815 (9%)	3,990 (19%)
SA	Several moderate-size re-entrants on Eyre Peninsula, Kangaroo Island	5,876	362 (6%)	1,521 (26%)	885 (15%)	264 (4%)	402 (7%)	113 (2%)	322 (5%)	46 (1%)	129	224 (4%)	1,785 (30%)
Tas	Blackmans Bay (Forester Peninsula), Pittwater, Lower Derwent estuary (only), Lower Huon estuary (only), Cloudy Lagoon, Macquarie Harbour (excludes Birches Inlet), as well as King, Flinders, Bruny, Maria and adjacent islands	4,995	1,053	1,081 (22%)	509 (10%)	7 (0.1%)	53 (1%)	103 (2%)	69 (1.4%)	48 (1%)	25	1,443 (29%)	1,210 (24%)
Total Aust#		59,311	5,604	12,198 (21%)	7,436 (12.5%)	3,584 (6%)	6,362 (11%)	2,456 (4%)	2,359 (4%)	397 (0.7%)	410	5,175 (9%)	9,217 (15.5%)

3.3 Assessment approach

The national mapping of areas of coastal inundation was carried out at the Spatial Science Group, School of Geography and Environmental Studies, University of Tasmania. Counts of the number of residential buildings affected in inundated areas were provided by Geoscience Australia. The counts were derived by intersecting the areas of inundation with the National Exposure Information System (NEXIS) database which contains data on the location and type of infrastructure.

Building counts were assessed at local government area for a lower and upper end estimate of residential exposure. The inundation mapping was based on a 1.1 metre sea-level rise, and included an allowance for tidal influence (modelled high water level) or storm tide values, where they were available for the whole of the state coastline. No provision was made for the potential impacts of inland flooding converging with coastal (from the ocean) inundation. Convergence of inland flooding and coastal inundation could greatly increase the areas inundated.

The high and low estimates are derived from the treatment of the uncertainty in the data inputs to the model. For example there are uncertainties around the elevation data used to describe the landform (height relative to sea level). To express the uncertainties, the model generates a probability of inundation occurring for each 30 metre by 30 metre grid cell. The probability thresholds for the high and low estimates of inundation bounded select areas that were mapped using very high resolution data. This provides greater certainty in the method for identifying likely areas of inundation.

Table 3.2 Source of 'tide' data used in analysis.

State	Tide data
Tasmania	1-in-100 storm tide modelling (McInnes 2008 ¹⁰)
Victoria	1-in-100 storm tide modelling (McInnes 2008 ¹¹)
New South Wales	1-in-100 storm tide modelling, however no wave setup used in this modelling; this is likely to contribute to under representation of the values along this part of the coast (McInnes 2008 ¹²)
Queensland	Modelled high water level (NTC 2008 ¹³)
Western Australia	Modelled high water level (NTC 2008 ¹⁴)
South Australia	Modelled high water level (NTC 2008 ¹⁵)
Northern Territory	Modelled high water level (NTC 2008 ¹⁶)

The core elements of the mapping were the inundation analysis and the data inputs. These are each described in more detail below.

3.3.1 Key input data

Digital elevation model

The digital elevation model (DEM) was a key dataset for the national assessment of potential coastal inundation. The DEM identifies the height above sea level of each grid cell (in this case 30 metres by 30 metres) in the national map. The landform described by the DEM also allows for understanding of the geographic patterns of potential inundation, and in particular, whether there is low-lying connectivity to the coast, or a continuous raised landform that provides protection from inundation.

The DEM is derived from satellite data and provides a nationally consistent basis for the assessment.

Sea-level rise

A sea-level rise value of 1.1 metres for 2100 was informed by research since the AR4 and expert advice.

Modelled high water level and storm tide

Storm tide is calculated from models using observations from tide gauges, global tide data and wind models. Modelled storm tide data for a 1-in-100 year event was used for Victoria, Tasmania and New South Wales (Table 3.2). Storm tide values are a 1-in-100 year storm surge, with an allowance for a tidal component included. Storm tide values were used where there was a consistent modelled dataset that could provide storm tide values for the entire state coastline.

For other areas, tidal heights were obtained from continent-wide high tidal height predictions (essentially modelled high water level values) from the National Tidal Centre within the Bureau of Meteorology. There will clearly be some difference in the interpretation of results between the states for which storm tide values were used (representing inundation risk using a current 1-in-100 event) than for those states for which high tide data was used.

The storm tide and high tide values provide a more realistic scenario of flooding as rises in sea level will act on top of existing tidal values. Figure 3.6 provides an indication of the storm tide or high tide values used in the analysis. It should be noted that higher sea level events are possible and have occurred on a regional basis. These events are generally associated with either tropical cyclone storm surge and/or estuarine flooding events from either intense east coast low pressure systems or severe winter storms.

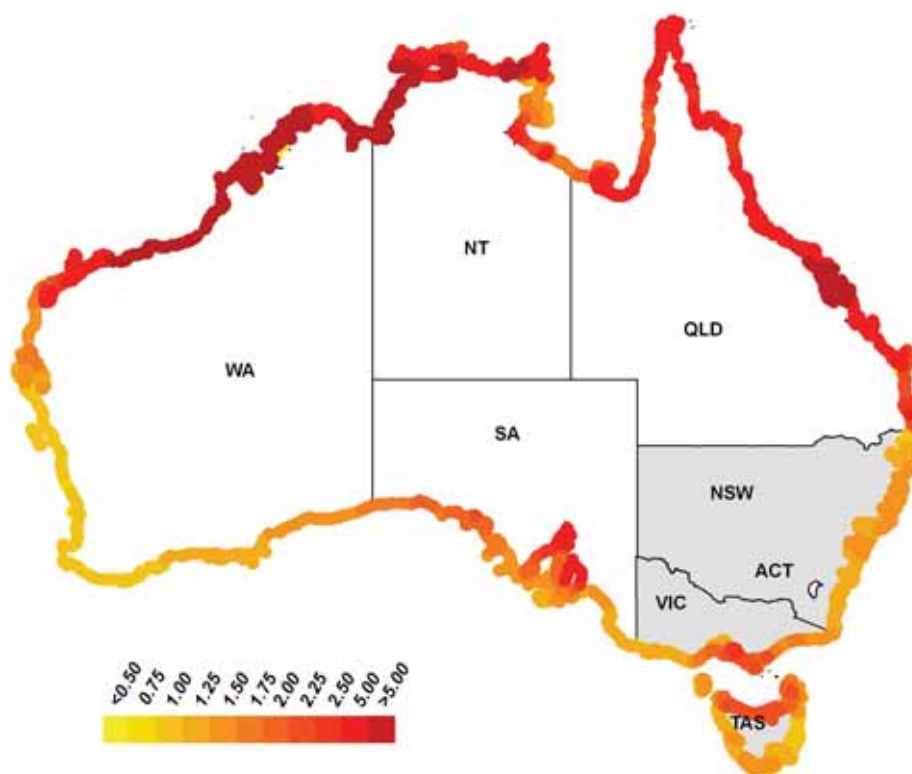


Figure 3.6 The range of modelled high water level and storm tide values applied in the analysis. States for which 1-in-100 storm tide estimates were applied are in grey, the modelled high water level values are shown elsewhere.
Source: Geoscience Australia 2009¹⁷

Additionally, the intensity of the 1-in-100 year storm tide event may also be impacted by climate change, for example through increased wind speeds (see Figure 2.15), but this has not been modelled in this analysis.

No allowance for the potential impact of riverine flooding was included in this analysis. Areas that are currently prone to flooding from catchment based sources (as opposed to sea-level rise) would be at much greater risk than is identified through this analysis. Investigation of the hazard of coincident events – storm surge with a high rainfall event leading to riverine flooding, for flood prone areas should be an immediate priority.

Coastal geomorphology

Areas of ‘soft’, potentially erodible coastline were mapped as these areas are more vulnerable to rising sea levels. Increased erosion of soft coastlines would result in a future shoreline that is further inland than it is today. It may also mean that tides and storm surges are able to penetrate further inland than is currently the case. Where ‘soft’ coastlines are identified, the inundation model ‘considered’ a new shoreline position that was 110 metres inland, and then applied the inundation modelling rules – i.e. is the land low enough to be flooded and what areas of inundation are close enough to each other to be considered connected.

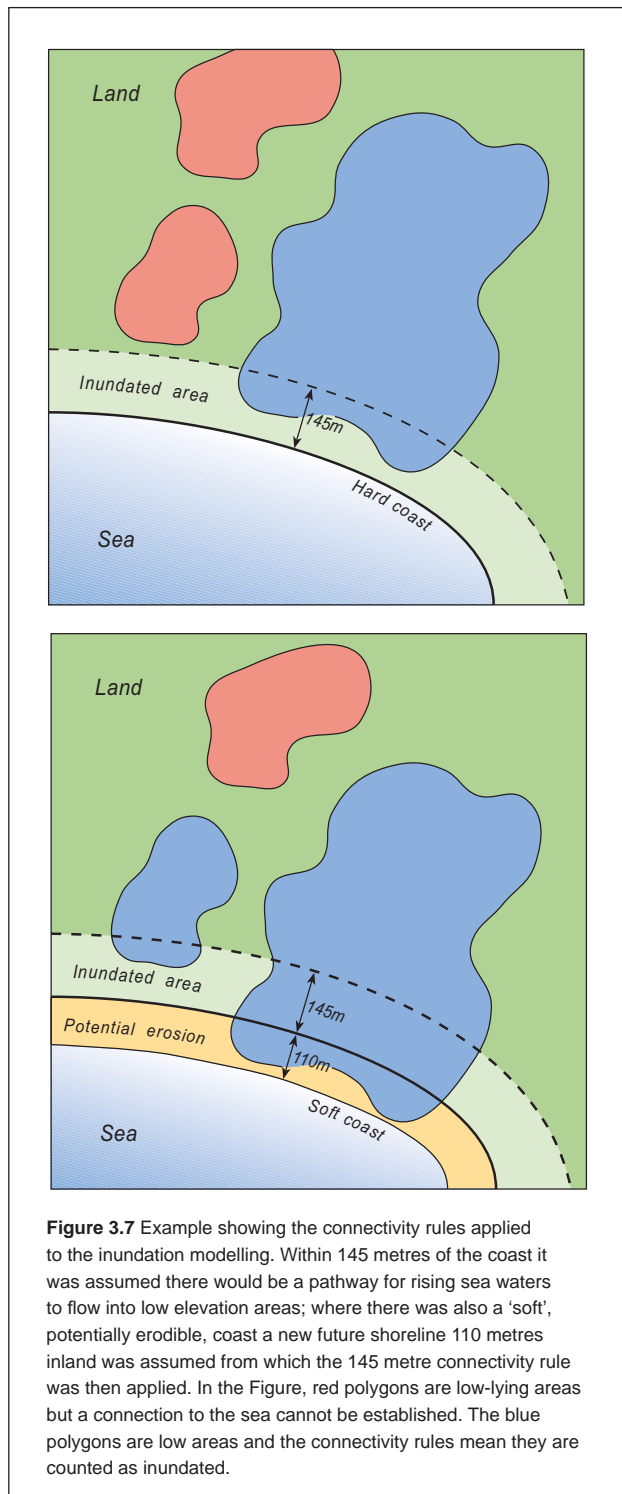
3.3.2 Inundation modelling

The inundation modelling used a relatively simple ‘bucket fill’ approach to determine areas that would be inundated at certain sea-level rise and tidal conditions. This form of modelling projects the water height inland and inundates all land areas at an elevation below this level; it therefore does not take into account the hydraulic processes, such as the width and depth of channels for flooding, which can be important when assessing inundation from storm events on top of a given sea-level rise. However, for the analysis of inundation from sea-level rise and modelled high water level, a bucket fill approach is likely to be quite robust within areas of reasonable proximity to the coast; as rising sea levels will essentially flow into low-lying lands.

To determine the extent of coastal flooding, the potential sea-level rise was combined with the modelled high water level and, for areas where data was available, storm tide values. These two components were assessed around the coast approximately every 10 kilometres and combined to provide a potential high water level at a distance approximately 50–100 metres from the coast. This predicted high water level was then projected onto the coastal topography (provided by the medium resolution SPOT DEM) to estimate areas that might be flooded.

The modelling approach has several features that also reduce the potential overestimation that can occur from a bucket fill approach:

- Rules for connectivity to the coast were applied so that the area would be inundated under the sea-level rise scenario, and the area had to be within 145 metres of low elevation coastline (Figure 3.7)
- The presence of soft, erodible shorelines informed the potential for a 'new' shoreline position by 2100; wherever soft shoreline areas were also of low elevation a greater connectivity to the sea



was assumed, for example, seawater was assumed to find a pathway within an extra 110 metres (utilising the Bruun Rule¹⁸ for soil erosion, that is, 100 times the sea-level rise height)

- An uncertainty analysis was applied to recognise possible data limitations. The model outputs gave a likelihood rating of inundation to each 30 metre by 30 metre grid cell potentially subject to inundation.

The bucket fill approach is useful because it is a simple, fast method that indicates potential areas at risk with a level of spatial resolution that can, if used carefully and with other lines of evidence, assist in prioritising further activity. For a national assessment, it was considered to be a cost effective approach that would provide an estimate of extent and magnitude of risk and assist in identifying areas of further attention.

3.3.3 Integration with NEXIS

The National Exposure Information System (NEXIS) infrastructure database, being developed by Geoscience Australia, has been designed to provide nationally consistent exposure information for regional or national impact analyses. The information is categorised into residential, business (commercial and industrial), institutions and infrastructure components. In its current form NEXIS is not intended to provide national precinct-level analysis involving one or two buildings. This would require more specific information than is currently contained within NEXIS, although this is available for some major cities.

The NEXIS database used in the analysis provides 'nationally consistent' information to identify the extent of residential buildings exposed to an inundation hazard.

NEXIS utilises the best available national address dataset from the Geocoded National Address File (GNAF) sourced from Pitney Bowes Business Intelligence and PSMA (Public Sector Mapping Agency Australia Ltd) along with specific building data sourced from state and local agencies.

Caveats associated with NEXIS include:

- Building locations are represented as single points rather than the area of the building footprint. This may have led to an under estimation of risk as some buildings that may actually be within the area identified as subject to inundation (and therefore potentially impacted) may not have been captured in the analysis.
- The June 2008 version of the NEXIS information was used in this analysis. As building numbers will have increased in the past year this may have resulted in an under estimation of buildings at risk.
- Potential error (between what NEXIS holds for physical infrastructure and what is actually present) is expected to be larger in rural areas that have not



Figure 3.8 Example of overlay of NEXIS with an inundation footprint.
Source: Geoscience Australia 2009

been surveyed as frequently or extensively. This error may have underestimated risk, for example the Tiwi Islands and East Arnhem LGAs do not contain any residential building information.

- Due to the lag time between the release of an address and the time a building is constructed on that address, proposed buildings may be represented in NEXIS. This may have slightly overestimated the total number of buildings at risk.

In addition, NEXIS was used to calculate the number of buildings within 55 and 110 metres of ‘soft’ and potentially erodible shorelines. These buildings could be at risk over the coming century from accelerated coastal erosion.

The approximate total replacement value of the residential properties was also calculated based on information held in NEXIS. The values have been based on average replacement values per state or local government area (where available). These figures represent the total value of assets at risk though it should be noted that the extent of damage due to flooding would not always, or often, result in a total replacement of all infrastructure affected.

3.4 Emerging priorities for methods development and assessment

Undertaking the first pass assessment has led to the identification of a number of areas where national datasets and methods need to be developed or enhanced in order to better assess risk of inundation or erosion.

The timing limits of this report constrained the breadth of sectors considered in the risk assessment. An early priority would be to extend this assessment to the transport, energy, water and waste sectors, and to industrial and commercial infrastructure in the coastal zone. The development of accessible datasets on the location of important infrastructure is required to underpin this work.

A key issue which emerged was the need for an improved consideration of estuaries – for both inundation and erosion hazards as well as consideration of coincident events (i.e. riverine flooding with storm surge events). Estuaries are where many people live, where most infrastructure is located, and they have complex hydrological characteristics making them challenging to model.

Given the diversity of estuaries, analysis needs to be at a regional or catchment scale using finer resolution data. To support this, the shoreline geomorphology of most estuaries and tidal lagoons needs to be better incorporated into the national geomorphic map. Tidal re-entrants such as estuaries and tidal lagoons are likely to be sensitive to erosion resulting from sea-level rise, and they often include more soft erodible muddy and clayey shoreline types than do open coasts. Additionally estuaries tend to behave individually in relation to storm surge and tidal processes and hydrodynamic modelling is necessary to capture this variation in hazard extent.

More generally regional and local influences on coastal instability need to be better understood to improve the understanding of the magnitude of risk associated with coastal instability. While the mapping of coastal geomorphology provides an indication of vulnerable areas of the coast, it cannot identify potential rates of erosion. Further development of detailed site-specific case studies of representative coastal geomorphology types would improve our understanding of regional and local processes, such as wave energy and direction, which can influence the rate of erosion.

For highly populated areas with shallow elevation gradients, an analysis using high resolution DEMs (based on LiDAR) would increase the accuracy of the inundation modelling and hence the estimation of risk to physical infrastructure. Similarly, bathymetric data or elevation data for the seabed for near shore areas would enable a more informed assessment of how sea-level rise may affect inundation patterns through changing wave directions and energy. This will be important in understanding how risk to physical and natural assets will change at regional scales.

In addition, adequate national data was not available in some areas to assess the risks from storm tide which is known to lead to flooding of assets in low-lying areas. The science of combined hazards analysis is also improving and should be able to inform a future assessment of coastal inundation risk.

Key gaps were also identified in the areas of economic data and socio economic information, for example a valuation of damage to infrastructure, which is needed to inform cost-benefit analysis, was not possible. An analysis of socio economic implications will also be needed to identify vulnerable communities and to understand local and regional population projections and associated implications for potential infrastructure

stock into the future. Figure 3.9 presents a concept of risk assessments at different scales and the data/research needed to underpin the assessments.

Further information on research priorities to underpin refined assessments of risk and to support informed decision-making on adaptation is provided in Chapter 6.

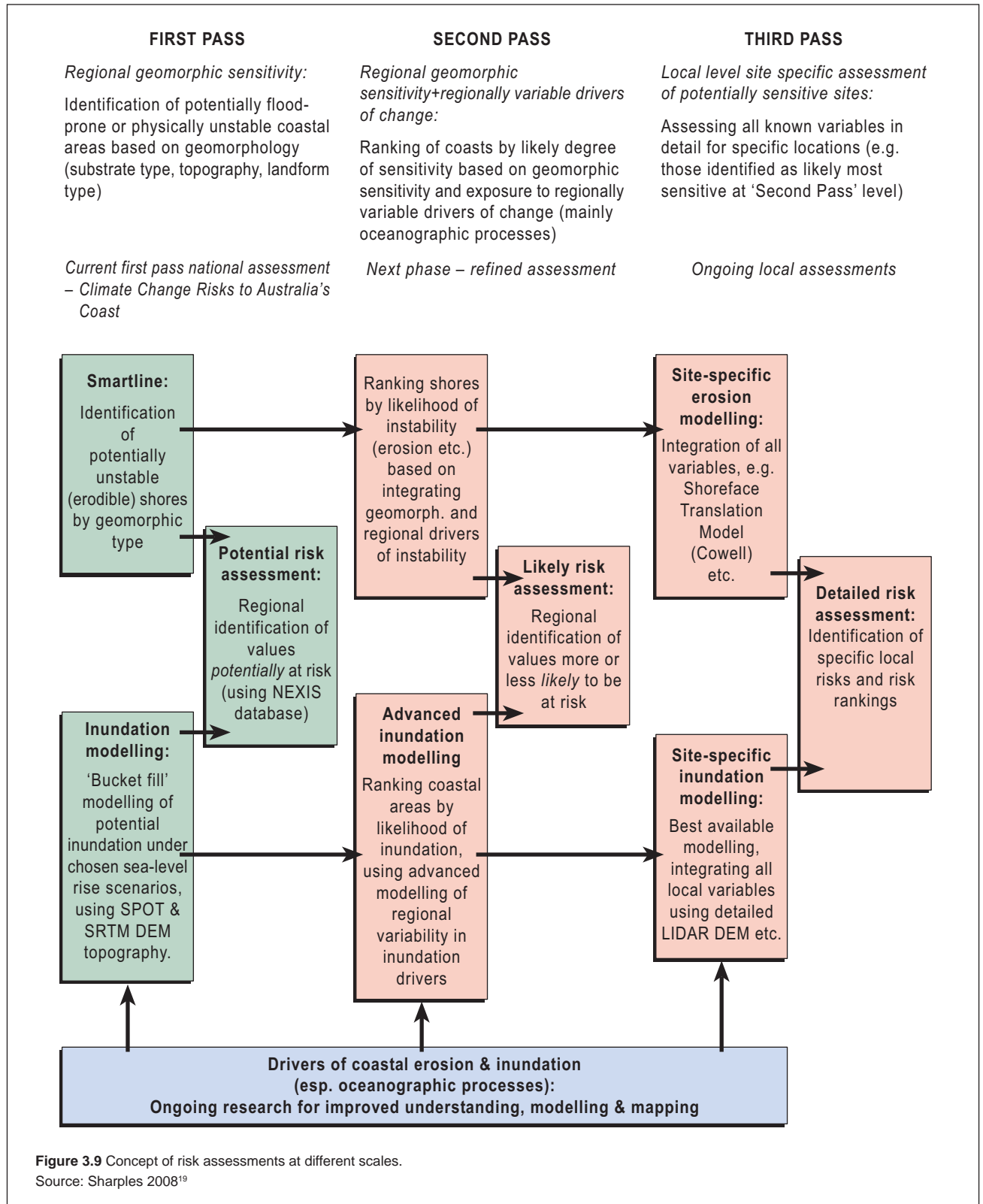


Figure 3.9 Concept of risk assessments at different scales. Source: Sharples 2008¹⁹