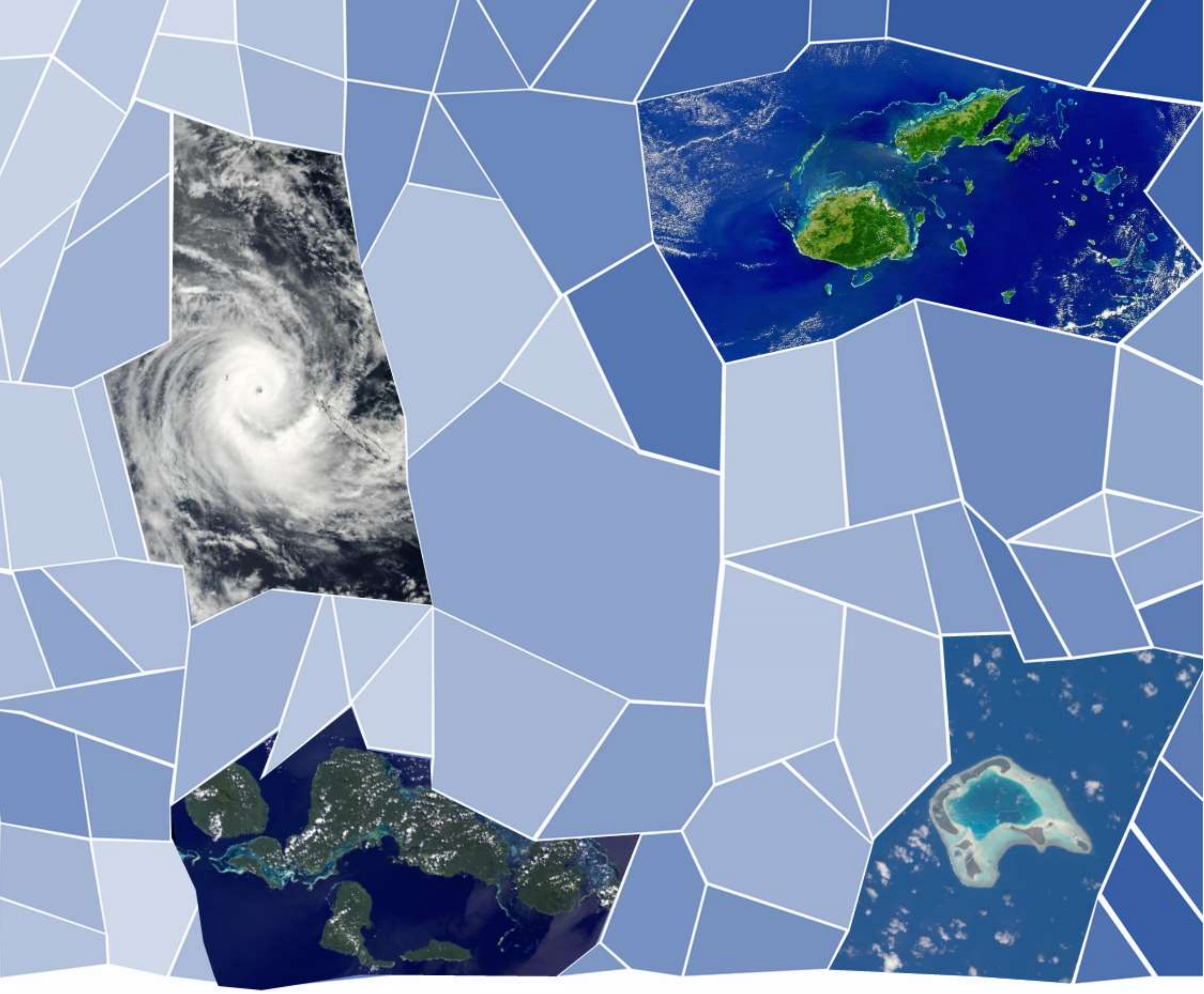

OCEAN ACCOUNTING FOR DISASTER RESILIENCE IN THE PACIFIC SIDS:

A brief note for policymakers

FROM RISK TO RESILIENCE SERIES - 2018

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

*The shaded areas of the map indicate ESCAP members and associate members.**

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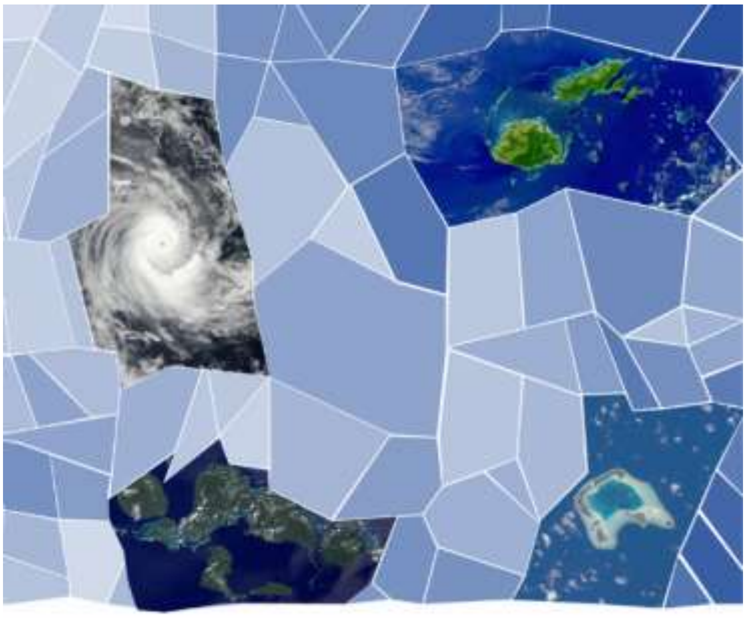

About the cover
The mosaic represents diverse oceanic communities and countries in the Pacific SIDS working together to create resilient and cooperative system of disaster risk reduction that protects the most vulnerable and leaves no one behind.

ACKNOWLEDGEMENTS

This briefing note was produced by ESCAP under the guidance of Tiziana Bonapace, Director, Information and Communications Technology and Disaster Risk Reduction Division of ESCAP.

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The note benefited from comments provided by Michael Bordt, Regional Advisor on Environmental Statistics, Statistics Division, and his team.

A draft version of this briefing note was presented to policy makers at the Asia and the Pacific Regional Expert Workshop on Ocean Accounts held in Bangkok, Thailand from 1-3 August 2018. Feedback from the workshop was considered when finalizing this note.

SUMMARY

Small island developing States (SIDS) in the Pacific continue to be hit by multiple disasters that can arrive in quick succession – often with cascading impacts that transcend national boundaries. In February 2018, cyclone Gita, for example battered many small islands developing States in the South Pacific and as well as large parts of Tonga, affecting more than 80 per cent of the country's population. Between 2000 and 2016, disasters in the Pacific caused over 2,300 fatalities and affected more than 5.5 million people. This report views the impact of disasters on SIDS and maps out the impact on a cluster of Sustainable Development Goals (SDGs). It uses post-disaster needs assessments, and sector-specific estimates to quantify disaster impacts on the range of goals and targets of the SDGs for the Pacific SIDS.

While the Pacific SIDS are heavily reliant on ocean resources, most of the disasters that affect the Pacific SIDS are oceanogenic, such as tsunamis, storm surges, cyclones and floods. Even droughts, to which SIDS are becoming increasingly vulnerable is partly oceanogenic in origin. To build disaster resilient SIDS in the Pacific, there is a need to connect the dots - science, geospatial data, statistics, and policy interfaces.

The SDG 14 on life below water provides ecosystem approaches to conserve and sustainably use the oceans, seas and marine resources. Ocean accounts need to be developed to assess these resources and better guide decision and policy making to protect ocean resources and services for future generations. The report, while analyzing the ecosystem accounting framework, presents its linkages with other SDG targets. Further, it introduces the System of Environmental Economic Accounting (SEEA) based Experimental Ecosystem Accounting (EEA) to deepen the knowledge and quantify the risk of oceanogenic disasters in Pacific SIDS. New technologies and methodologies are now available which may support the development of robust and reliable ocean accounts. Geospatial information and services, in particular, can cost- and time-effectively deepen the quantification of disaster risk. Linking these to international frameworks, such as the SDGs and the Sendai Framework, will help to build the resilience of marine ecosystems and the social and economic development of Pacific SIDS.

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The Asia-Pacific region, unless otherwise specified, refers to the group of ESCAP members and associate members that are within that geographic boundary. Groupings of countries and territories and areas referred to in the report are defined as follows:

- **ESCAP region:** Afghanistan; American Samoa; Armenia; Australia; Azerbaijan; Bangladesh; Bhutan; Brunei Darussalam; Cambodia; China; Cook Islands; Democratic People's Republic of Korea; Fiji; French Polynesia; Georgia; Guam; Hong Kong, China; India; Indonesia; Islamic Republic of Iran; Japan; Kazakhstan; Kiribati; Kyrgyzstan; Lao People's Democratic Republic; Macao, China; Malaysia; Maldives; Marshall Islands; Federated States of Micronesia; Mongolia; Myanmar; Nauru; Nepal; New Caledonia; New Zealand; Niue; Northern Mariana Islands; Pakistan; Palau; Papua New Guinea; Philippines; Republic of Korea; Russian Federation; Samoa; Singapore; Solomon Islands; Sri Lanka; Tajikistan; Thailand; Timor- Leste; Tonga; Turkey; Turkmenistan; Tuvalu; Uzbekistan; Vanuatu; and Viet Nam
- **East and North-East Asia:** China; Democratic People's Republic of Korea; Hong Kong, China; Japan; Macao, China; Mongolia; and Republic of Korea
- **North and Central Asia:** Armenia; Azerbaijan; Georgia; Kazakhstan; Kyrgyzstan; Russian Federation; Tajikistan; Turkmenistan; and Uzbekistan
- **Pacific:** American Samoa; Australia; Cook Islands; Fiji; French Polynesia; Guam; Kiribati; Marshall Islands; Federated States of Micronesia; Nauru; New Caledonia; New Zealand; Niue; Northern Marina Islands; Palau; Papua New Guinea; Samoa; Solomon Islands; Tonga; Tuvalu; and Vanuatu
- **South and South-West Asia:** Afghanistan; Bangladesh; Bhutan; India; Islamic Republic of Iran; Maldives; Nepal; Pakistan; Sri Lanka; and Turkey
- **South-East Asia:** Brunei Darussalam; Cambodia; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; Philippines; Singapore; Thailand; Timor-Leste; and Viet Nam

Developing ESCAP region: ESCAP region excluding Australia, Japan and New Zealand

Developed ESCAP region: Australia, Japan and New Zealand

Countries with special needs

- **Least developed countries:** Afghanistan; Bangladesh; Bhutan; Cambodia; Kiribati; Lao People's Democratic Republic; Myanmar; Nepal; Solomon Islands; Timor-Leste; Tuvalu; and Vanuatu. Samoa was part of the least developed countries prior to its graduation in 2014
- **Landlocked developing countries:** Afghanistan; Armenia; Azerbaijan; Bhutan; Kazakhstan; Kyrgyzstan; Lao People's Democratic Republic; Mongolia; Nepal; Tajikistan; Turkmenistan; and Uzbekistan
- **Small island developing States:** Cook Islands; Fiji; Kiribati; Maldives; Marshall Islands; Federated States of Micronesia; Nauru; Niue; Palau; Papua New Guinea; Samoa; Solomon Islands; Timor-Leste; Tonga; Tuvalu; and Vanuatu

ECONOMIC CLASSIFICATIONS AND GROUPINGS

The classification of countries into income groups is from the World Bank. The World Bank divides countries according to their 2015 gross national income per capita, calculated using the World Bank Atlas method. Group classifications are: low income ($1,025 or less per capita), lower-middle income ($1,026- $4,035 per capita), upper-middle income ($4,036-$12,475 per capita) and high income ($12,476 or more per capita).

- **Low-income economies:** Afghanistan; Democratic People's Republic of Korea; Nepal.
- **Lower middle-income economies:** Armenia; Bangladesh; Bhutan; Cambodia; India; Indonesia; Kiribati; Kyrgyzstan; Lao People's Democratic Republic; Federated States of Micronesia; Mongolia; Myanmar; Pakistan; Papua New Guinea; Philippines; Samoa; Solomon Islands; Sri Lanka; Tajikistan; Timor-Leste; Tonga, Uzbekistan; Vanuatu; and Viet Nam
- **Upper-middle-income economies:** American Samoa; Azerbaijan; China; Fiji; Georgia; Iran (Islamic Republic of); Kazakhstan; Malaysia; Maldives; Marshall Islands; Palau; Russian Federation; Thailand; Turkey; Turkmenistan; and Tuvalu
- **High-income economies:** Australia; Brunei Darussalam; French Polynesia; Guam; Hong Kong, China; Japan; Macao, China; Nauru; New Caledonia; New Zealand; Northern Mariana Islands; Republic of Korea; and Singapore

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References to dollars ($) are to United States dollars, unless otherwise stated.

The term "billion" signifies a thousand million. The term "trillion" signifies a million million.

In the tables, two dots (..) indicate that data are not available or are not separately reported; a dash (–) indicates that the amount is nil or negligible; and a blank indicates that the item is not applicable.

In dates, an en dash (–) is used to signify the full period involved, including the beginning and end years, and a stroke (/) indicates a crop year, fiscal year or plan year.

ABBREVIATIONS

CCA	Climate Change Adaptation
DRR	Disaster Risk Reduction
DRSF	Disaster-Related Statistical Framework
EEA	Experimental Ecosystem Accounting
ENSO	El Niño-Southern Oscillation
EO	Earth Observation
ESCAP	Economic and Social Commission for Asia and the Pacific
GDP	Gross Domestic Product
GIS	Geographic Information System
INCOIS	Indian National Centre for Ocean Information Services
JMA	Japan Meteorological Agency
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
OISST	Optimum Interpolation Sea Surface Temperature
PDNA	Post Disaster Needs Assessment
PFZ	Potential Fishing Zone
PNG	Papua New Guinea
RGB	Red-Green-Blue
SDG	Sustainable Development Goal
SEEA	System of Environmental-Economic Accounting
SIDS	Small Island Developing States
SST	Sea Surface Temperature
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
WFP	World Food Programme

1 Background

The small island developing States (SIDS) of the Pacific suffer immense additional challenges to their development compared with other countries due to their small size, remote location, narrow resource and export base, and exposure to many environmental challenges, including climate change and natural disasters.

Because of their remote location, SIDS rely heavily on their natural resources for their economy and livelihoods, particularly coastal and ocean resources. These resources essentially represent SDG 14 (life below water) and are strongly connected to several others, including SDG 1 (no poverty), SDG 2 (zero hunger), SDG 8 (decent work and economic growth), SDG 10 (reduced inequalities), SDG 11 (sustainable cities and communities), and SDG 16 (peace, justice and strong institutions). Added to this is the link between SDG 14 and the Sendai Framework, as healthy marine and coastal resources can reduce the impacts of disasters.

On the other hand, many activities undermine SDG 14 (life below water) as ocean resources can be affected by over-exploitation, land use change, pollution and climate change. Building the resilience of ocean resources or SDG 14 will ultimately support work towards the other SDGs and the Sendai Framework.

A challenge to this however has been our ability to adequately measure and quantify the extent and value of this natural resource base. With the growth of new technologies and information, work has begun in developing methodologies and statistics for this purpose.

The System of Environmental-Economic Accounting 2012 (SEEA[1]) was adopted by the United Nations Statistical Commission to provide a framework for understanding the interactions between the economy and the environment, and for describing stocks and changes in stocks of environmental assets. It provides a standardized tool for measuring natural resources however it is not presently designed specifically for disaster assessment. Many frameworks that guide disaster risk reduction (DRR) and climate change adaptation (CCA) already exist, and provide common concepts, classifications and methods to ensure that data collected from various sources are coherent and can be harmonized. An international standard such as the SEEA should therefore be informed by existing frameworks, namely the Sendai Framework for Disaster Risk Reduction, the Sustainable Development Goals (SDGs), Disaster-Related Statistical Framework (DRSF), Paris Agreement and COP 23 Ocean Pathways.

There are still gaps in the SEEA though, particularly with respect to ocean accounts. This issue brief will showcase the ways in which incorporating the risks from oceanogenic disasters can strengthen and make ocean accounts more robust, particularly in the context of

[1] The System of Environmental-Economic Accounting is a framework that integrates economic and environmental data to outline the interrelationships between the economy and the environment and the stocks and changes in stocks of environmental assets, as they bring benefits to humanity. It contains the internationally agreed standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics and accounts (SEEA, 2018).

SIDS. It will also provide key recommendations on how to do this, by incorporating the linkages between the frameworks that address oceanogenic disaster risk and those which outline international standards for oceans accounting.

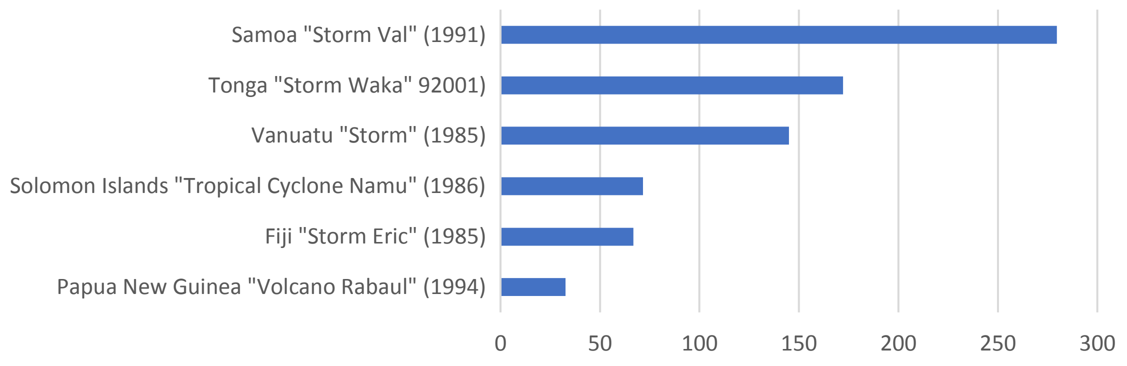
2 Vulnerability of SIDS to disasters

The Small Island Developing States in the Pacific (SIDS) comprise of thousands of islands in the Pacific Ocean, with a population of approximately 10.5 million (SPC, 2018), extending from 25°S to 15°N latitude, and from 130°E to 150°W longitude. The Pacific SIDS include islands located at higher elevation, as much as 13,000 feet above mean sea level, as well as at a lower elevation that is only a few feet above the mean sea level (Finucane et al. 2012). The major source of income for the population comes from agriculture and fishing activities. Limited land availability and vast geographic distances, potential impacts from climate change, limited water resources, small domestic markets based on a narrow range of resources, and greater infrastructure costs are among the many challenges facing SIDS.

Disasters exacerbate these vulnerabilities, creating more challenges for SIDS to recover from a major disaster. To compound this, many of these hazards are projected to have increasing frequencies and intensities due to climate change. Though several SIDS are affected by earthquakes and volcanic activity, the main types of disasters affecting SIDS are oceanogenic, such as cyclones, floods, drought and extreme temperatures.

Disasters are particularly damaging for SIDS, as the disaster can often have a more dramatic impact on its economy and people of SIDS. Though the total monetary impact may not seem as high as more developed countries hit by disasters, as a percentage of GDP, the impact is often multiples of the country's total annual output. As agriculture and fisheries is often important livelihoods in Pacific island countries, any disaster that damages these sectors will create longer term hardship. Furthermore, much of the infrastructure of SIDS located close to coastlines, making it more vulnerable to disasters and the increased cost of developing infrastructure due to the long distances needed to import materials adds to the cost of reconstruction. Figure 1 provides an example of the economic impact of disasters as a function of the economy of a small island developing State.

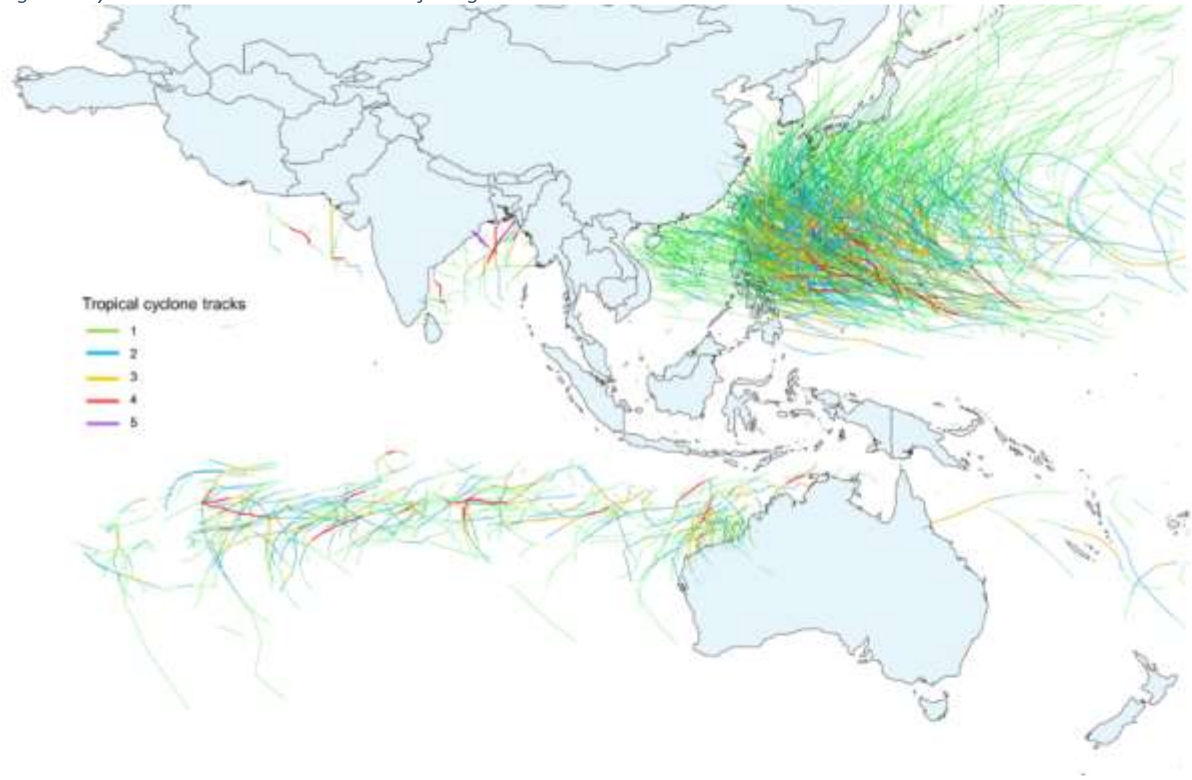
Figure 1 Disaster impacts on the economy of SIDS



Source: ESCAP based on the World Bank's World Development Indicators available from http://data.worldbank.org/data-catalog/world-development-indicators (accessed January 2013) and EM-Dat: the OFDA/CRED International Disaster Database, available from https://www.emdat.be/database (accessed January 2013).

SIDS are very prone to disaster risks. Every year, 50 to 60 tropical cyclones occur in three ocean basins of the Asia Pacific region (refer to Figure 2).

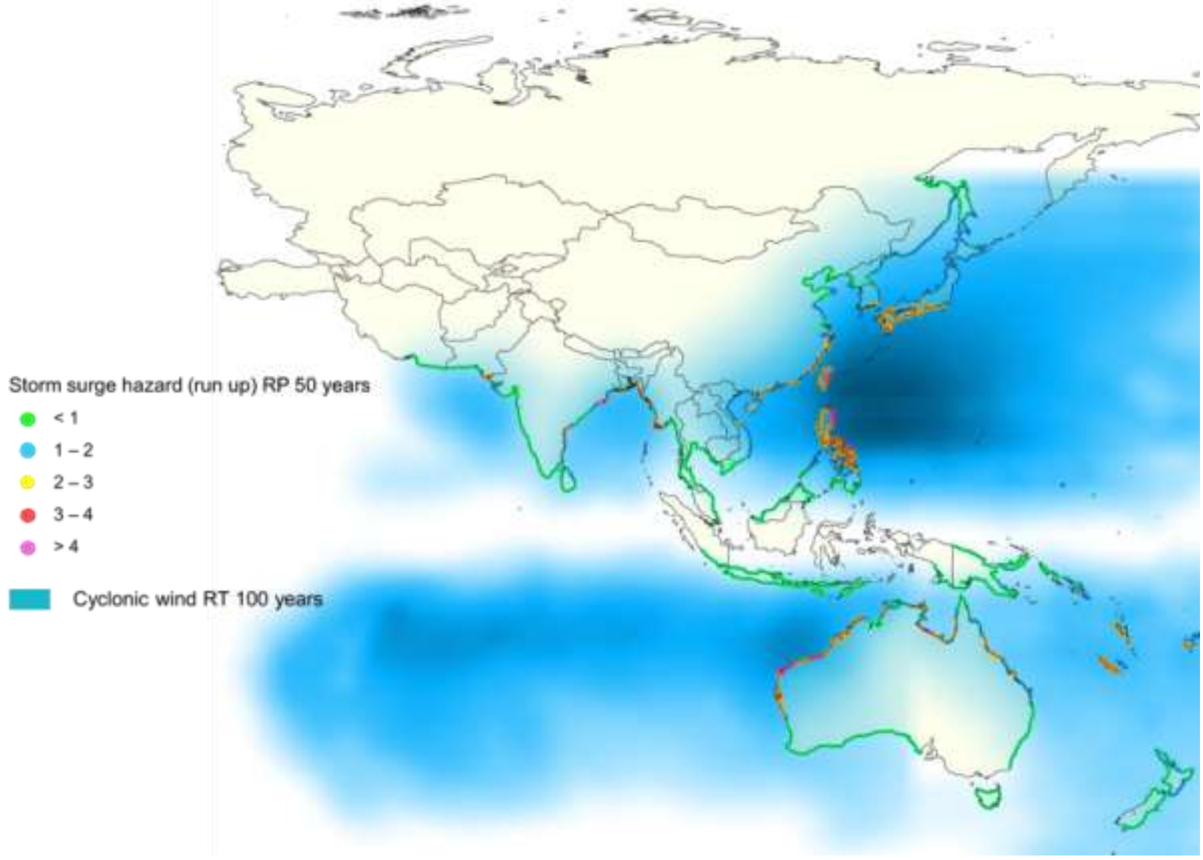
Figure 2 Cyclone tracks within the Asia Pacific region



Source: *ESCAP based on UNISDR, Global Assessment Report on Disaster Risk Reduction Atlas, 2015*

Due to climate change, these tropical cyclones are projected to have shorter return periods with increasing storm surges and wind speeds, whilst their tracks in the Pacific basin may shift eastward or northward. These changes are expected to triple the increase in the number of people and economic assets exposed.

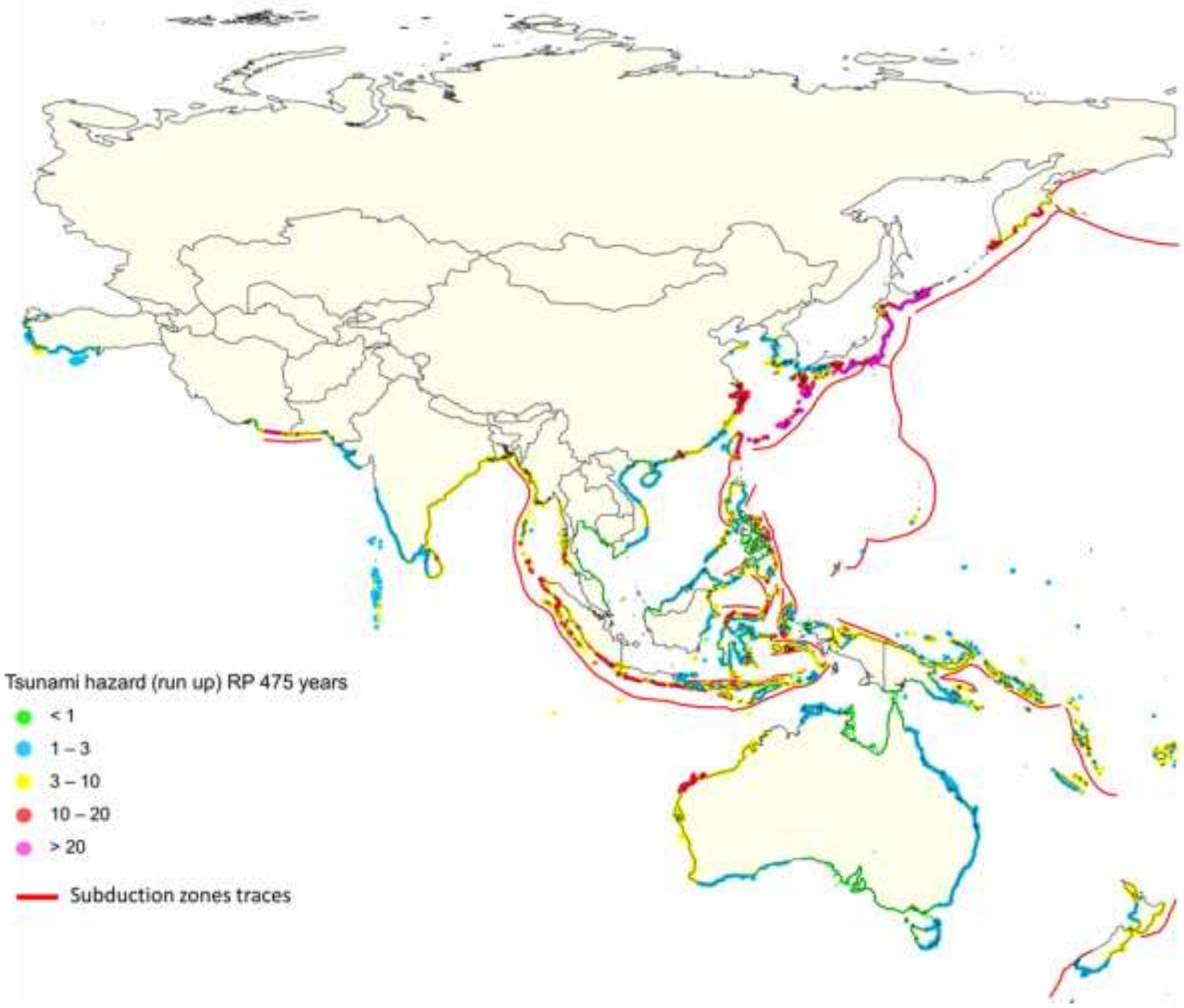
Figure 3 Projected changes to tropical cyclones in terms of wave run-up height and speed.



Source: *ESCAP based on UNISDR, Global Assessment Report on Disaster Risk Reduction Atlas, 2015*

Tsunami-faults, particularly along subduction zones on the ocean bed, generate tsunamis. The Asia-Pacific region is located by actively moving subduction zones, most notably the Pacific Ring of Fire. Within the 475 years return period, the Asia Pacific region's coastal cities face a high level of risk from tsunamis.

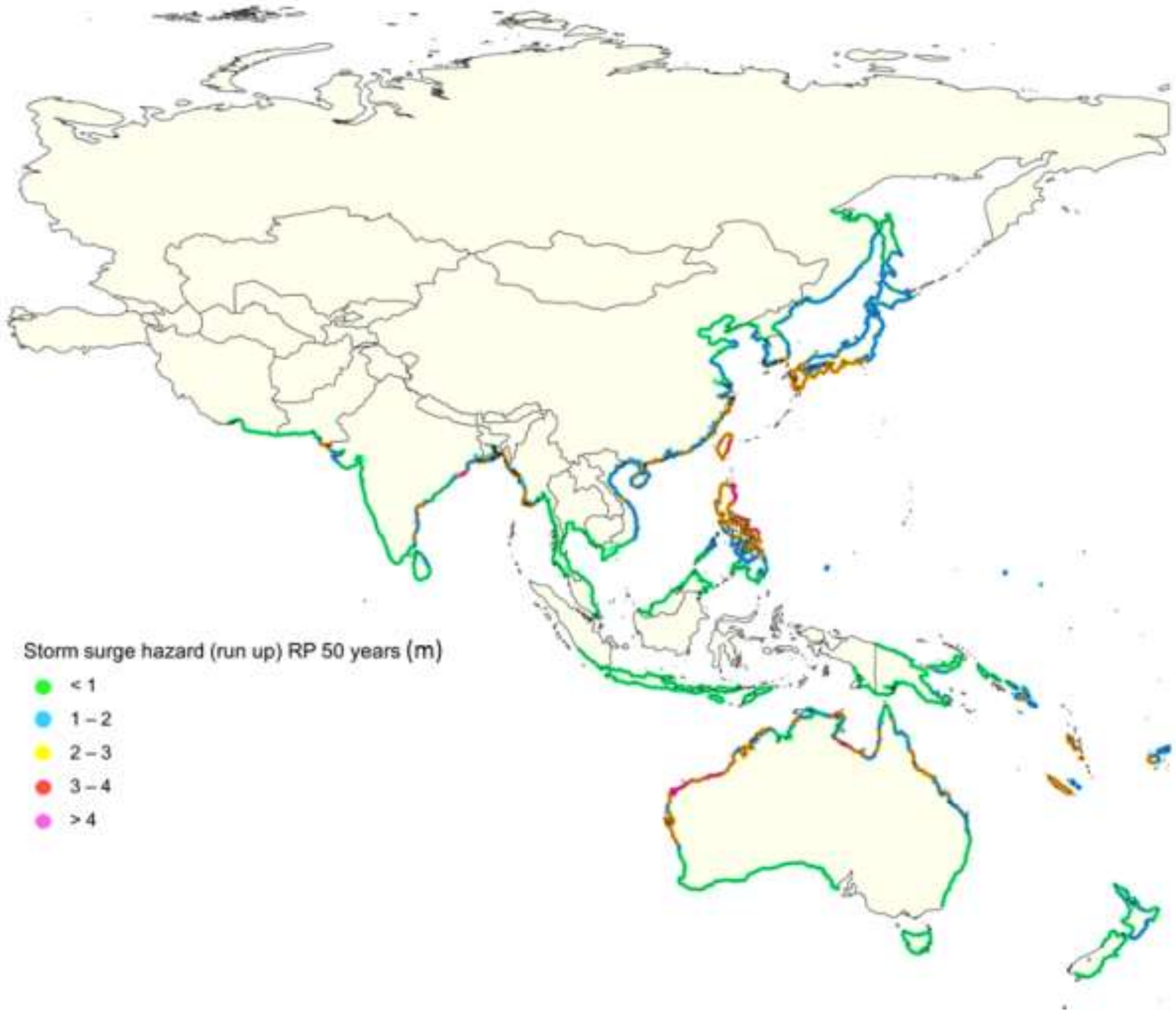
Figure 4 Tsunami hazards with a return period of 475 years and subduction zones traces (tsunami driver)



Source: *ESCAP based on UNISDR, Global Assessment Report on Disaster Risk Reduction Atlas, 2015*

Coastal cities within Asia-Pacific can experience wave heights of more than 7.5 meters as a result of a storm surge. Furthermore, storm tides may occur during high intensity storm surges. These high waves and storm tides can cause extensive flooding, resulting in the destruction of property and infrastructure, and in extreme cases significant loss of life (Harwood, 2012). Storm surges are also associated with other hazards, and as such most fatalities from tropical cyclones are attributed to them (Harwood, 2012). They can also result in the inundation of islands with seawater, contaminating important agricultural land with salt.

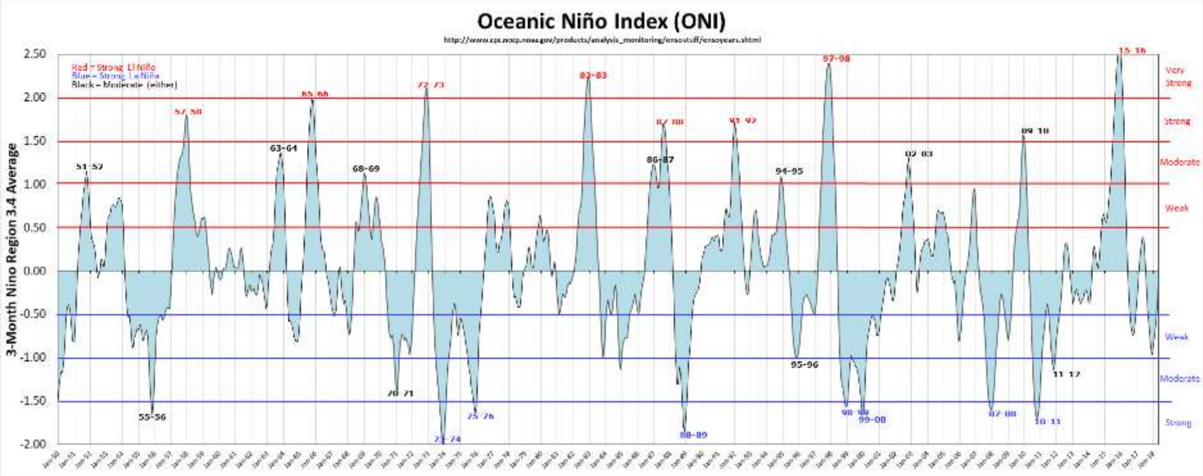
Figure 5 Storm surge run up height 50 years.



Source: *ESCAP based on UNISDR, Global Assessment Report on Disaster Risk Reduction Atlas, 2015*

Drought is also a concern for SIDS as many have limited water resources yet rely on subsistence agriculture. Drought is often associated with El Nino events. The intensities of El Niño events are also increasing with the highest intensities ever recorded in 1982-1983, 1997-1998 and 2015-2016 (Null, 2018). This trend is expected to continue, along with the associated risks of droughts and storms. 2015/2016 saw the strongest El Niño event recorded throughout the past 60 years, which induced severe droughts as a result of seasonal rainfall deficits in India, the Philippines, Indonesia and the Pacific islands (WFP, 2015).

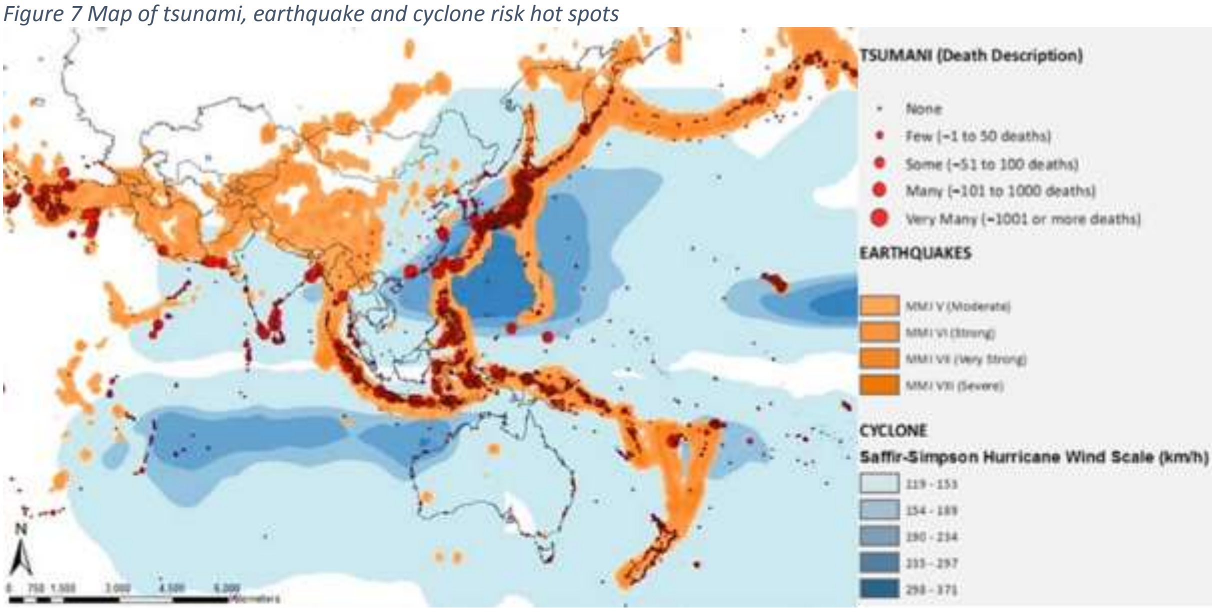
Figure 6 Intensity of El Niño, 1950 – 2018



Source: Golden Gate Weather Services available from http://ggweather.com/enso/oni.htm (accessed August 2018)

These oceanogenic risks are often complex due to their transboundary nature, which means that the people affected fall under different disaster risk management policies. A catchment approach to understanding such risks is therefore required, which considers collective risk so that risk reduction measures can be targeted to support the most vulnerable groups in the area.

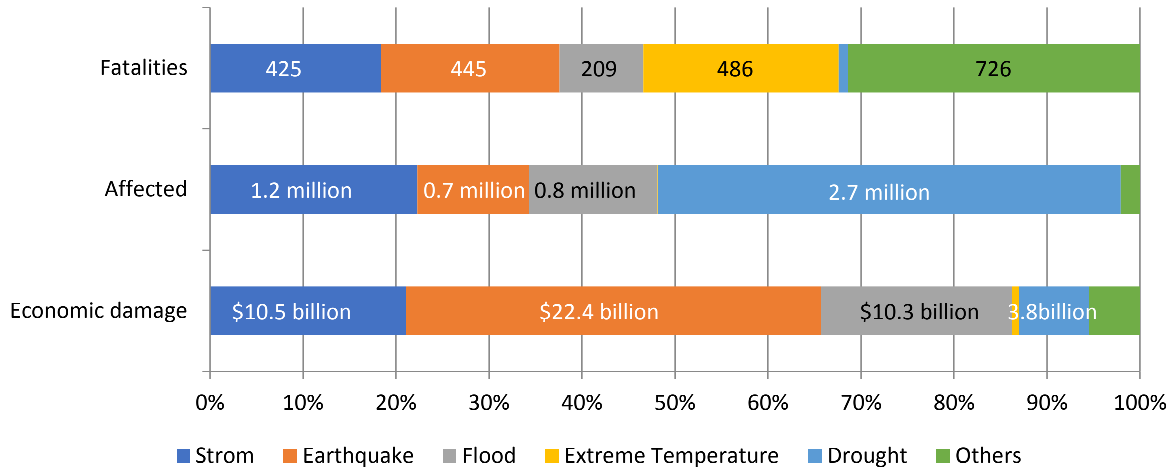
Figure 7 Map of tsunami, earthquake and cyclone risk hot spots



Source: ESCAP based on UNISDR, Global Assessment Report on Disaster Risk Reduction Atlas, 2015

Over the period 2000–2016, the Pacific subregion reported over 2,300 fatalities from various hazards, including tropical cyclones, earthquakes, floods, and extreme temperatures (Figure 8). Among the most damaging were tropical cyclones, which affected over 1.2 million people and caused an estimated $10 billion or more of damage. Earthquakes and floods had considerable impacts.

Figure 8 Mortality and damage and loss estimates in the Pacific region



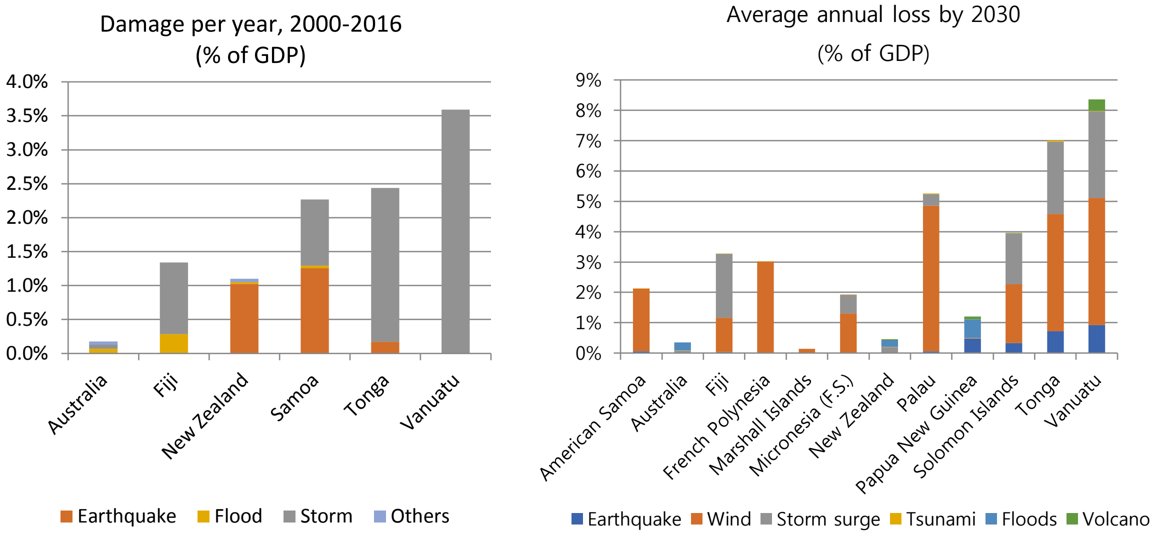
Source: ESCAP, Asia Pacific Disaster Report (APDR) 2017, Bangkok

In Fiji, the 2009 flood resulted in agriculture and infrastructure damage worth FJD100 million, while the 2016 cyclone caused USD 1.1 billion in damage, of which USD 100 million was with the agriculture sector. The 1997-1998 El Niño-associated drought in the Pacific caused a) 26 per cent decline in sugarcane production in Fiji corresponding to a 1.3 per cent decline in the country's GDP; b) failure of crops in PNG, resulting to food insecurity for about 1 million people; c) drought-associated fires in Samoa; and d) agricultural damage and severe impacts on livestock in Tonga. Cyclones in 2004 damaged 80 per cent of Vanuatu's food crops and caused damage in Samoa equivalent to 230 per cent of the country's 1991 GDP.

In 2016, around 490,000 people suffered from tropical cyclones, droughts and earthquakes, with estimated damage of $5.1 billion (in 2016 US dollars), largely due to the earthquake in New Zealand which caused damage of $3.9 billion (ESCAP, 2017). Except for Australia, countries in the Pacific subregion during the period 2000 to 2016 recorded significantly higher average damage per year as a percentage of GDP than countries in other subregions. Vanuatu recorded more than 3.5 per cent of GDP of average damage per year from tropical cyclones, while Samoa and Tonga also recorded over 2 per cent of average damage per year from tropical cyclones and earthquakes (Figure 10). Future estimates for average annual loss by 2030 indicate similar outcomes. Vanuatu, Tonga and Palau, in particular, are expected to have an average annual loss more than 5 per cent of their GDP, mainly from tropical cyclones. Countries in the Pacific are also particularly at risk from the impacts of climate change, including sea level rise.

Clearly, the impact of various hazards on agriculture in Pacific SIDS is significant, and these are only likely to get worse with projected changes in climate, including a projected shift toward increased El Niño events. Apart from low-frequency yet high-impact extreme climate events-associated risks, high-frequency but low-impact weather aberrations such as dry/ wet spells impair crop/ livestock/ fishery productivity and result in recurring losses each season. Climate variability has been one of the most significant agriculture production risks in the region, constraining investments and neutralizing development gains.

Figure 9 Damage and future loss estimates for Pacific countries



Source: EM-DAT, the OFDA/CRED International Disaster Database, available from https://www.emdat.be/database (accessed August 2018).

3 Impact on Sustainable Development Goals in SIDS

<u>A focus on disaster risk, sustainable development and climate change can reinforce the robustness of ocean accounts and connects it to global frameworks such as the Sendai Framework.</u>

SDG 14 (to conserve and use the oceans, seas and marine resources for sustainable development) is linked to a multitude of other SDG targets. Figure 10 uses a systems analysis approach to uncover links between resilience, or health, of oceans, seas, coastal areas and marine resources (SDG 14) with the other SDGs and their corresponding targets. The left-hand side demonstrates how SDGs and targets can contribute to strengthening resilience, and the right-hand outlines how the SDGs and corresponding targets can in turn be achieved by strengthening resilience. Arrows between the central circle and goals symbolize the direction and depth of each relationship, with a thicker arrow indicating a higher level of impact.

These arrows reveal the importance of SDG 6 which is related to water pollution, SDG 15 which protects ecosystems and biodiversity, and the Regional Road Map which focuses on transboundary cooperation in the management of climate change and natural resources, for developing resilient oceans, seas and marine resources. Ocean resilience will also be strengthened through efforts to reduce pollution (SDG 3), make city infrastructure more sustainable to diminish CO2 emissions (SDG 9), harness clean energy technologies through international cooperation (SDG 7), decrease hazardous waste that would otherwise pollute coastal areas (SDG 12) and to intensify climate action through education and adaption plans (SDG 13). The SDGs that will most benefit from strengthened resilience in the oceans, seas and marine resources are SDG 1, which aims to reduce poverty and vulnerability and thus depends on marine livelihoods, and SDG 11, which aims to enhance the safety and resilience of cities and human settlements safer and thus depends on the reduction of ocean acidification. Resilience of oceans, seas and marine resources will also contribute towards ending malnutrition (SDG 2), promoting sustainable economic growth (SDG 8), reducing income inequality (SDG 10), and decreasing violence (SDG 16).

Figure 10 System analysis of SDG 14

Source: ESCAP, 2018

The SDGs and the Sendai Framework also have several linkages (Figure 11). Whilst SDG 14 is not directly linked to the Sendai Framework, a focus on SDG 14 can impact Sendai targets A, B, C and D from an economic standpoint.

Figure 11 Links between targets of the Sendai Framework, and the SDGs

	Disaster Effects (F$ million)	Share of Disaster Effects (%)	% of GDP	% of AAL	Connections to SDGs

Source: ESCAP, Asia-Pacific Disaster Report (APDR), 2017

This demonstrates that the Sendai Framework indicators are related to four of the SDG targets. Compiling data for these indicators will therefore support ESCAP in its aim to synchronize the Sendai Framework with related SDGs, in order to meet resolution 73/7 on "enhancing regional cooperation for the implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 in Asia and the Pacific".

Adding to the above, these links between the SDGs, ocean resources and the Sendai Framework needs to be assessed at the national and local level as different countries have different economic structures and resources. To demonstrate this, the Post Disaster Needs Assessment of three natural disasters in three different SIDS were analyzed.

Fiji – Cyclone Winston, 2016

In February 2016, Cyclone Winston struck Fiji causing 44 fatalities and affecting around 350,000 people. Table 1 shows the losses and damage from the cyclone, along with the impact on the economy. In addition, the impact on particular SDGs was mapped alongside the damage and losses to various sectors. The degree to which coastal and ocean resources can affect or support the sector is also displayed.

Fiji has a large subsistence agriculture sector, which includes fisheries, though the economy is heavily reliant on the service sector, particularly tourism, followed by industry and then agricultural exports (ESCAP, 2018b). Fishing for export and subsistence is also very important in the country. In terms of the percentage of GDP, the agriculture sector was the worst hit. However overall, damage to housing cost the most from the disaster.

Table 1 PDNA of Cyclone Winston on Fiji, 2016

	Damage	Losses	Total	Public	Private			
Productive Sectors	241.8	594.5	836.3	12	88	8.6	298.3	
Agriculture	81.3	460.7	542.0	7	93	5.6	193.3	1, 2, 6, 8, 12, 13, 14, 15
Commerce and Manufacturing	72.9	69.9	142.8	49	51	1.5	50.9	1, 6, 8, 9, 10, 12
Tourism	76.1	43.9	120.0		100	1.2	42.8	1, 6, 8, 13, 15
Mining	11.5	20.0	31.5		100	0.3	11.2	1, 6, 7, 8, 12, 13, 15
Social Sectors	827.9	40.0	867.9	12	88	8.9	309.6	
Education	69.2	7.4	76.6	100		0.8	27.3	3, 4, 5, 8, 10, 16
Health	7.7	6.2	13.9	100		0.1	5.0	1, 2, 3, 4, 5, 8, 10, 11
Housing	751.0	26.4	777.4	2	98	8.0	277.3	1, 6, 9, 11
Infrastructure Sectors	208.2	40.4	248.6	84	16	2.6	88.7	
Transport	127.1	2.4	129.5	98	2	1.3	46.2	9, 11, 13
Water and Sanitation	16.9	7.9	24.8	100		0.3	8.8	1, 3, 6, 10, 11, 14, 15
Electricity	33.0	8.1	41.1	100		0.4	14.7	1, 3, 7, 8, 9, 10, 11, 12, 13
Communications	31.2	22.0	53.2	30	70	0.5	19.0	8, 9

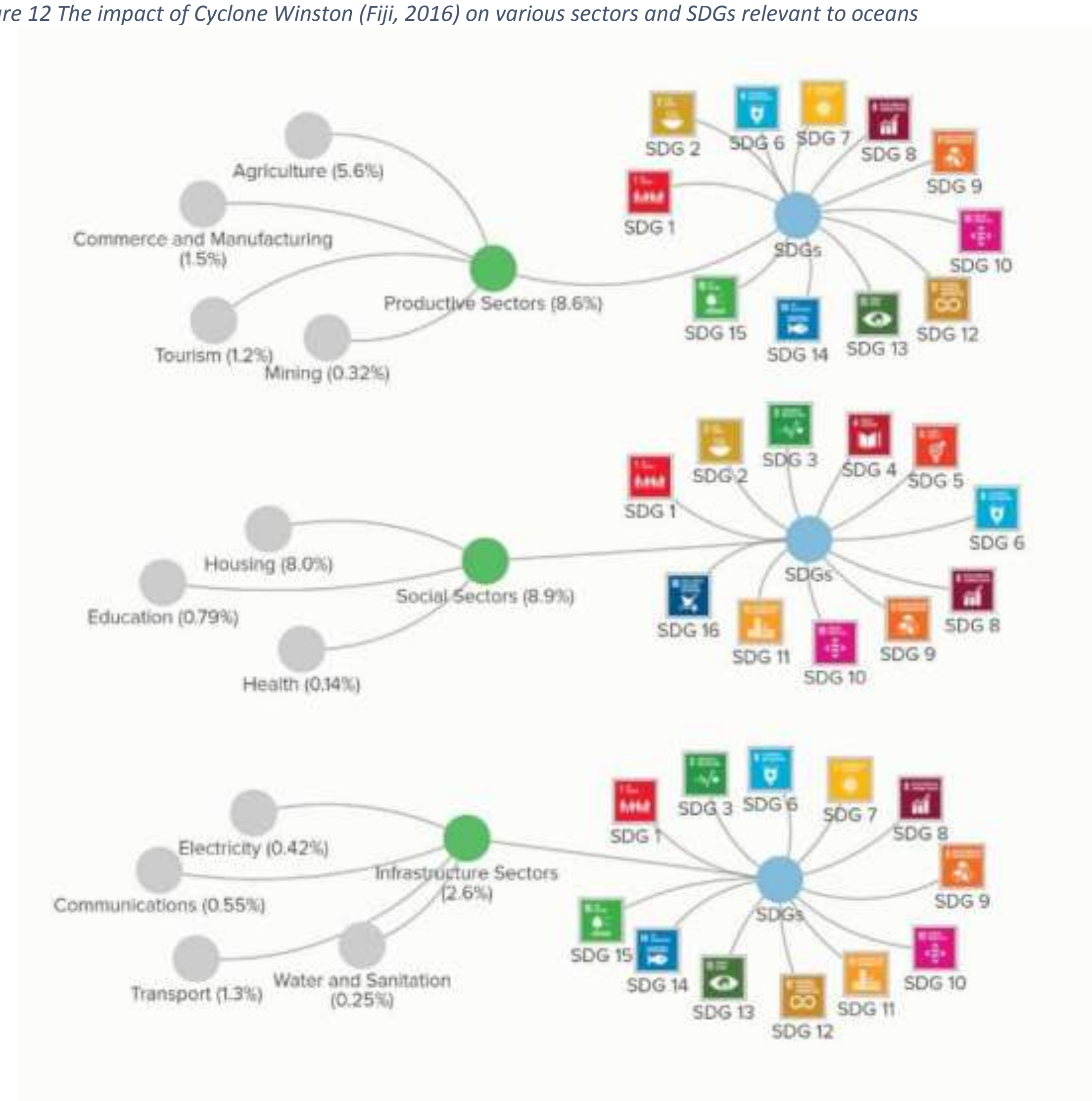
Source: *Government of Fiji. Post Disaster Needs Assessment, Tropical Cyclone Winston, February 20, 2016*. (*May 2016*).

Figure 12 depicts the impact of this damage and loss on the SDGs. Damage to the productive sectors has knock on affects in reducing poverty (SDG 1) as it takes away many people's source of income (SDG 8). It impacts the availability of food and fresh water (SDGs 2 and 6) and damage to power infrastructure undermines all activities requiring energy (SDG 7). Damage to manufacturing facilities, or infrastructure that they rely on such as energy, roads, ICT and water, also influenced commerce (SDG 9) and people's income (SDG 8). This can further compound inequalities (SDG 10), for example women's subsistence activities and earning contribute directly to nutritional security and the economic welfare of the household (Government of Fiji, 2016). Infrastructure damage can also lead to pollution (SDG 12) which can further damage natural resources (SDGs 14 and 15). Furthermore, the disaster can have a direct impact on reefs, fisheries, forestry and other natural resources, reducing the buffering capacity of these ecosystems (SDG 13).

A similar analysis can be made with the social and infrastructure sectors. The loss of housing (SDG 9), being the most significant loss in terms of per cent of GDP, has a direct impact on poverty (SDG 1), hunger (SDG 2), clean water and sanitation (SDG 6), health (SDG 3), inequality including gender inequality (SDGs 5 and 10), income generation (SDG 8) and personal security (SDG 16). Loss of schools, ICT and transportation facilities can reduce access to education (SDG 4), and other social facilities such as hospitals will impact health (SDG 3).

The loss of basic services and infrastructure is interconnected to the other sectors, so many impacts have already been mentioned. It should be noted that damaged commercial and industrial facilities, waste and wastewater infrastructure and other facilities storing hazardous chemicals can have significant impacts on land and ocean ecosystems (SDGs 14 and 15). Furthermore, energy, roads and transport, communication, health, sanitation and education facilities are the core to almost every development need.

Figure 12 The impact of Cyclone Winston (Fiji, 2016) on various sectors and SDGs relevant to oceans



Source: ESCAP, 2018

The Marshall Islands – drought, 2015-2016

From 2015 – 2016, the Marshall Islands experienced a severe drought which had serious impacts on health, agriculture and commerce. Though subsistence agriculture is significant, some commercial agriculture is also important for the economy and people's important livelihoods, along with fisheries, handicrafts and tourism. From Table 2, it can be seen that drought affected the health sector, livestock and commerce to some degree.

Table 2 PDNA of drought impacts on the Marshall Islands, 2015 - 2016

	Changes in Flows (USD thousand)		Total Effects (USD thousand)	% of GDP	% of AAL	Connections to SDGs
	Production Disruption	**Higher Costs of Production**				
Productive Sectors	**2,125.5**	**11.5**	**2,146.1**	**0.06**	**43.00**	
Agriculture	1,772.6		1,772.6	0.14	102.76	1, 2, 6, 8, 12, 13, 14, 15
Livestock			9.1	0.64	483.16	1, 8, 15
Manufacturing	107.5		107.5	0.07	55.16	1, 6, 8, 9,12
Commerce	245.4	11.5	256.9	0.57	428.00	1, 8, 10, 12
Social Sectors	**1,070.0**	**137.9**	**1,207.9**	**1.14**	**858.44**	

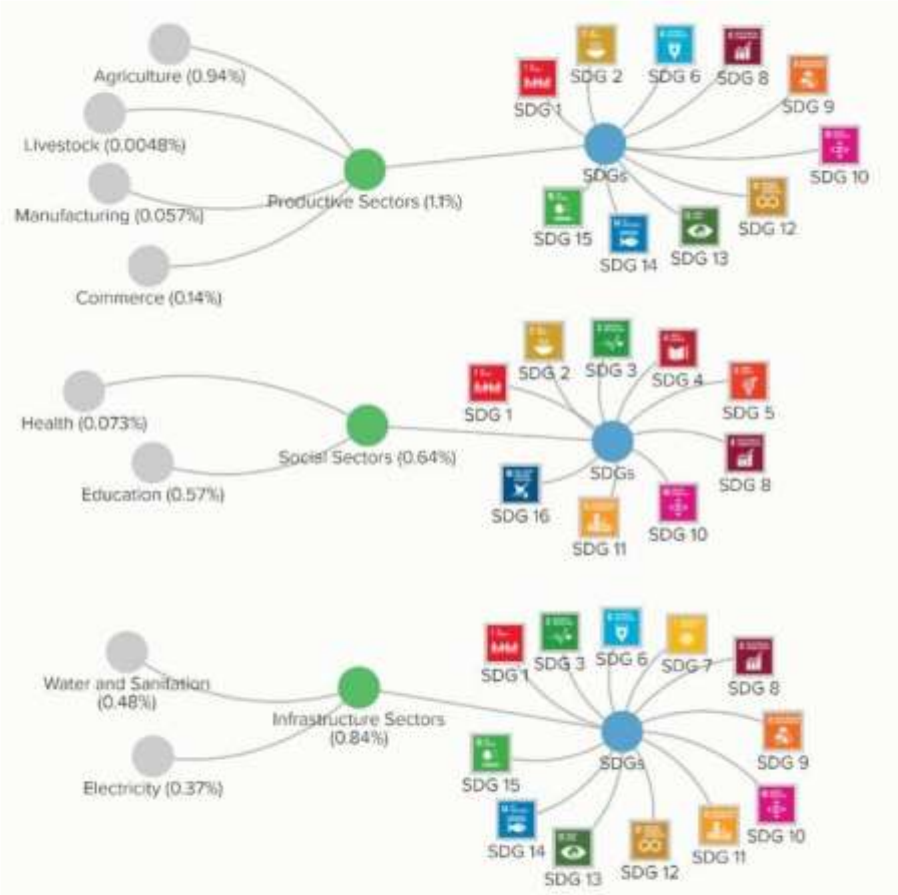
Health		137.9	137.9	0.94	709.04	1, 2, 3, 4, 5, 8, 10, 11
Education	1,070.0		1,070.0	0.00	3.64	3, 4, 5, 8, 10, 16
Infrastructure Sectors	**848.8**	**733.0**	**1,581.8**	**0.84**	**632.72**	
Water/ sanitation	162.4	733.0	895.4	0.48	358.16	1, 3, 6, 10, 11, 14, 15
Electricity	686.4		686.4	0.37	274.56	1, 3, 7, 8, 9, 10, 11, 12, 13

Source: Republic of the Marshall Islands. Post Disaster Needs Assessment of the 2015-2016 Drought (2017)

Figure 13 and Table 2 maps out the connections between damage and loss in the various sectors and the potential impacts on the SDGs. As the productive sectors, particularly agriculture, is the most affected by the drought, this has the potential to impact food security (SDG 2), access to clean water (SDG 6), and terrestrial resources (SDG 15). These could have knock-on effects similar to those described for cyclone Winston above, in that they contribute to poverty (SDG 1), inequality (SDGs 5 and 10), health (SDG 3), work (SDG 8), education (SDG 4) and personal security (SDG 16).

Drought can also impact other sectors outside of agriculture, as many commercial and industrial facilities rely on water. Additional energy may be required to access more remote sources of water. Health and education facilities also require a reliable amount of water to function well.

Figure 13 The impact of the 2015-2016 drought on various sectors of the Marshall Island and SDGs relevant to oceans (damage and losses as % GDP 2016)



Source: ESCAP, 2018

Tonga – Cyclone Gita, 2018

Tonga's economy is reliant on agriculture and fisheries, followed by tourism. This is reflected in the PDNA from Cyclone Gita which struck Tonga in February 2018, damaging agriculture, housing and other infrastructure. The disaster also affected the commercial and tourism sectors.

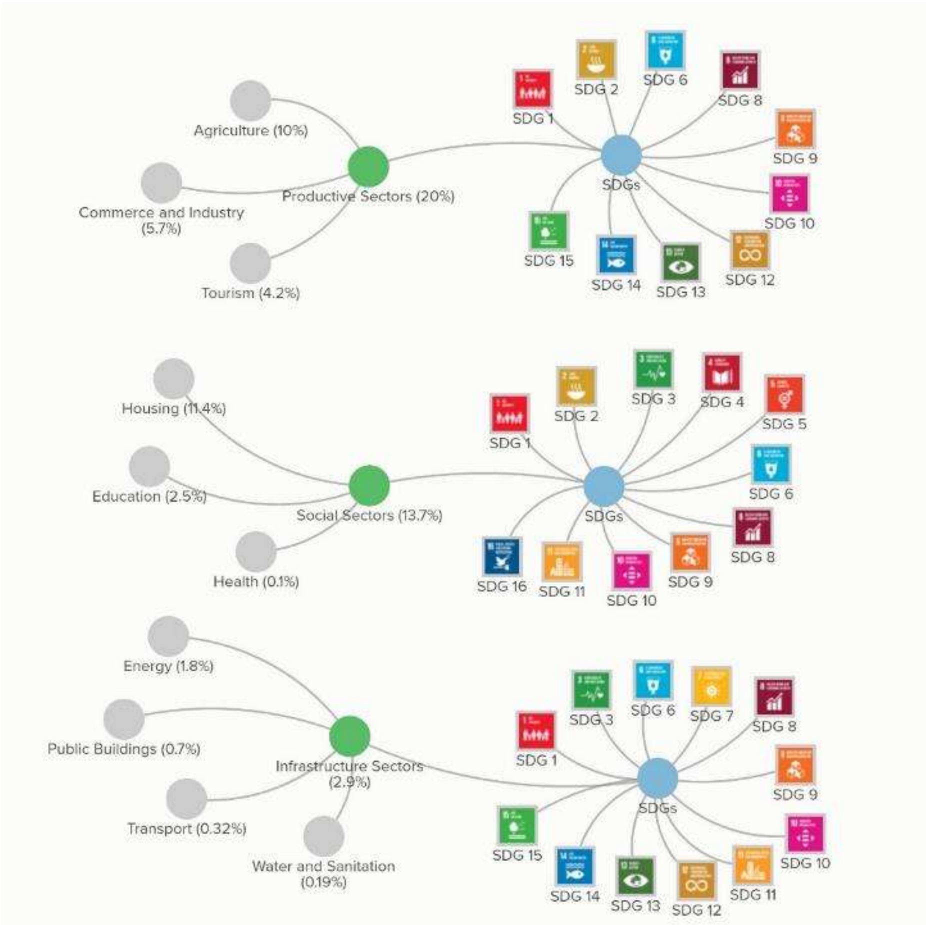
Table 3 PDNA of Cyclone Gita on Tonga, 2018

	Disaster Effects (T$ million)			% of GDP	% of AAL	Connections to SDGs
	Damage	**Losses**	**Total**			
Productive Sectors	**54.88**	**138.47**	**193.35**	**19.79**	**268.13**	
Agriculture	5.10	92.38	97.4813.1	9.98	135.18	1, 2, 6, 8, 12, 13, 14, 15
Commerce and Industry	23.48	31.79	55.27	5.66	76.65	8, 9, 10, 12
Tourism	26.30	14.30	40.60	4.16	56.30	8
Social Sectors	**131.48**	**2.74**	**134.22**	**13.74**	**186.13**	
Housing	111.60	0.02	111.62	11.42	154.79	1, 6, 9, 11
Education	19.78	2.17	21.95	2.25	30.44	3, 4, 5, 8, 10, 16
Health	0.10	0.55	0.65	0.07	0.90	1, 2, 3, 4, 5, 8, 10, 11
Infrastructure Sectors	**22.46**	**6.08**	**28.54**	**2.92**	**39.58**	
Energy	13.41	3.73	17.14	1.75	23.77	1, 3, 7, 8, 9, 10, 11, 12, 13
Public Buildings	5.47	1.00	6.47	0.66	8.97	9, 11
Transport	2.32	0.76	3.08	0.32	4.27	9, 11, 13
Water and Sanitation	1.26	0.59	1.85	0.19	2.57	1, 3, 6, 10, 11, 14, 15

Source: ESCAP, based on Government of Tonga. Post Disaster Needs Assessment Tropical Cyclone Gita// February 12, 2018 (2018)

The impact of Cyclone Gita on the work towards the SDGs in Tonga is similar to that of the effect of Cyclone Winston on Fiji discussed earlier. Tonga's economy is less diversified than Fiji's and heavily reliant on agriculture and fisheries, therefore the impacts on these sectors are more pronounced. The most significant impact of this disaster though was the loss of housing, with 808 private dwellings totally destroyed and 3,985 houses damaged out of a total of 13,838 houses in the affected areas, meaning that a third of all households were damaged or destroyed due to the cyclone (Government of Tonga, 2018).

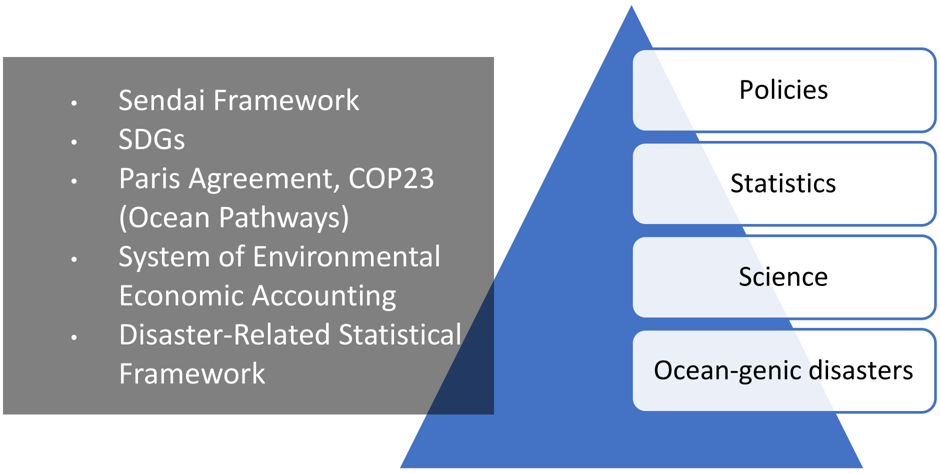
Figure 14 The impact of Cyclone Gita (Tonga, 2018) on various sectors and SDGs relevant to oceans (Damage and losses as % GDP 2018)



Source: ESCAP, 2018

4 Connecting the dots – the linkages between disaster resilience and climate change frameworks, and ocean accounts

Figure 15 Connecting the frameworks related to disaster risk, sustainable development and climate change to the interfaces of ocean accounts



Source: ESCAP, 2018

What can be noted from the PDNA examples above is that sufficient information and statistics are available for some sectors, particularly when associated with economic and social systems, but the environmental and natural resource services are often neglected in the accounting process.

The System of Environmental-Economic Accounting 2012 (SEEA[2]) was adopted by the United Nations Statistical Commission to provide a framework for understanding the interactions between the economy and the environment, and for describing stocks and changes in stocks of environmental assets. It provides a standardized tool for measuring natural resources however it is not presently designed specifically for disaster assessment.

Within the SEEA-EEA[3] there is already some guidance on data collection and its use related to disaster risk and climate change. The SEEA-EEA provides a spatial framework for delineating ecosystems (e.g. mangroves, coastal beaches) that mitigate or are affected by ocean-related disasters, illustrating how aspects of oceanogenic disasters can be integrated into calculations of ocean accounts. The SEEA also includes guidance on the collection and calculation of data parameters related to climate change, such as the SEEA-EEA's guidance on tracking biocarbon (Carbon Account) as a component of ecosystem condition, and the SEEA Central Framework's guidance on calculating GHG emissions. Furthermore, the UN Economic Commission for Europe has developed a set of key climate change related indicators, many of which can be derived from the SEEA.

Similarly, there is also guidance within the disaster risk related frameworks. The Sendai Framework provides several disaster-related definitions, indicators, and priorities for action, and the Disaster-Related Statistical Framework (DRSF)[4] ESCAP (2017) provides guidance on measuring disaster risk and impacts, as well as the basic range of disaster-related statistics.

Furthermore, there are strong linkages between the oceans, climate change, disaster risk and sustainable development. For example, the Paris Agreement aims to strengthen the global response to the threat of climate change, by providing climate change countermeasures, from mitigation to adaptation, for extreme weather events and slow onset events (UNFCCC, 2018). It also highlights the role of sustainable development in reducing loss and damage due to disasters. Other frameworks and agreements highlight the need to strengthen the ocean resilience. For example, the 2030 Agenda for Sustainable Development, particularly SDG 14,

[2] The System of Environmental-Economic Accounting is a framework that integrates economic and environmental data to outline the interrelationships between the economy and the environment and the stocks and changes in stocks of environmental assets, as they bring benefits to humanity. It contains the internationally agreed standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics and accounts (SEEA, 2018).

[3] The SEEA-EEA is the System of Environmental-Economic Accounting (SEEA)'s project to advance its Experimental Ecosystem Accounting (EEA). It aims to review data availability and measurement practices, in order to support the advancement of Ecosystem Accounting in pilot countries, and therefore policy and analysis of the environment and its relationship with economic and human activities. By integrating environmental information into standard measures of economic activity, it helps to mainstream environmental information in economic development and planning discussions. (UNSD, 2018).

[4] The DRSF provides technical guidance on how to develop a common and nationally standardized basic range of disaster-related statistics that can be used for multiple purposes and for comparisons with other countries. It provides a basic range of disaster related statistics, compiled by integrating data and meta-data that are typically dispersed across many source (ESCAP, 2018a).

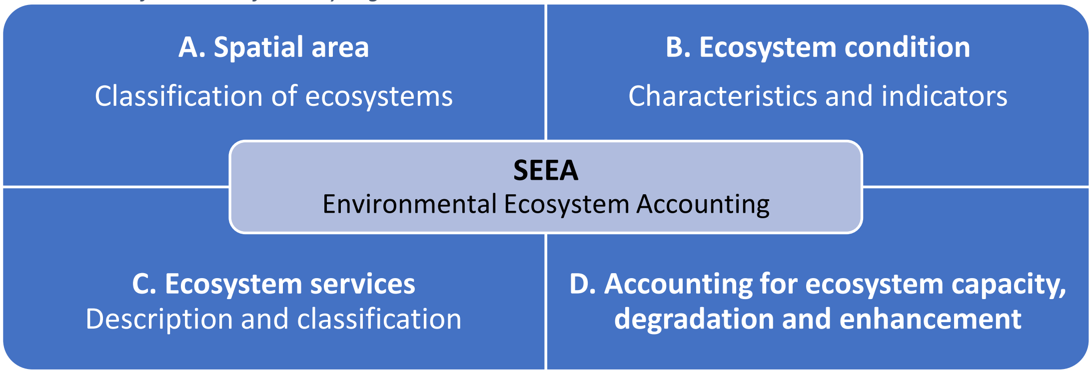
highlights the link between sustainable development and the oceans, seas, and marine resources. The urgency of strengthening ocean resilience is also promoted by the COP 23 Ocean Pathway, which outlines a strategy to increase the role of ocean considerations in the UNFCCC process and actions in priority areas relating to climate change (COP23, 2018).

Examining ecosystem accounts through an oceanogenic disaster risk lens

Ocean accounts need to be risk informed

The Asia Pacific region is affected by many oceanogenic hazards, including tsunamis, storm surges, cyclones, droughts and floods. Therefore, there is a need to understand the science, statistics, and policy interfaces for these hazards using an ecosystem accounts framework. In this regard, the SEEA-EEA framework can be extremely useful to conceptualize and account for these risks (potentially in terms of monetary value) in an integrated manner (Figure 16). Analysing the risk profile of the Asia-Pacific region in this way also highlights the extent of the linkages between oceanogenic disasters and important dimensions of ocean accounting, such as ecosystem conditions, services and degradation.

Figure 16 SEEA-EEA framework for analyzing the environment and its relation to economic and human activities

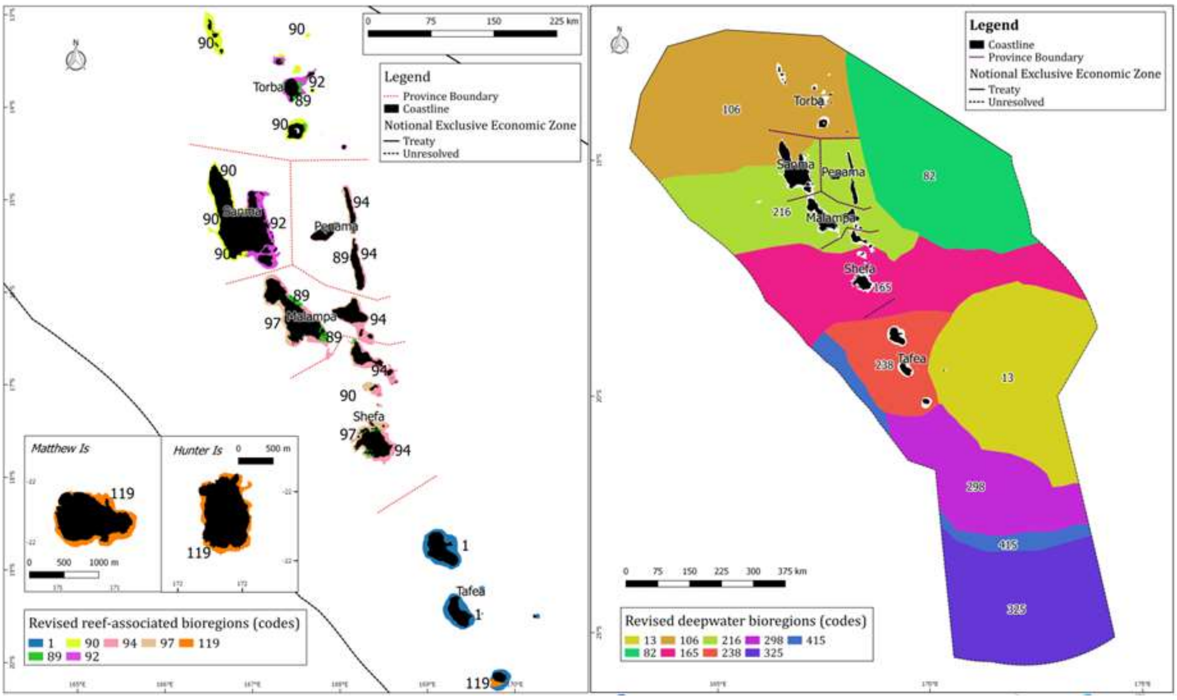


A. Geospatial Area

There is a need to identify and quantify the spatial areas of ecosystems and ecosystem services. For example, mapping changes in coastlines, mangrove and fisheries habitats, reefs and seagrass resources over time can provide valuable insight of the impact of climate change or disasters on ocean ecosystems, and how that can cascade into other social and economic sectors.

Work on this has already begun. As an example, Vanuatu has undertaken a study to map reef and ocean bioregions systems around its islands (Figure 17). Several countries are also using a combination of sea surface temperature and remote sensing to map potential fishery zones. Others, such as Kiribati, have been mapping coastal erosion using satellite data.

Figure 17 Mapping bioregions around Vanuatu

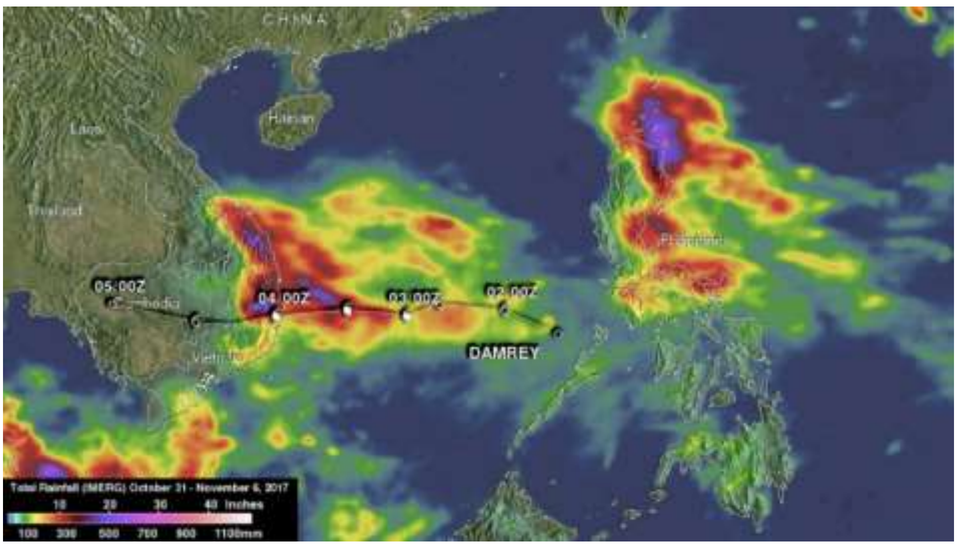


Source: *Wendt H, Beger M, Sullivan J, LeGrand J, Davey K, Yakub N, Kirmani SN, Grice H, Mason C, Raubani J, Lewis A, Jupiter S, Molisa V, Ceccarelli D, Fernandes L*. *Marine bioregions of Vanuatu*. (*MACBIO* (*GIZ, IUCN, SPREP*), *Fiji*: *2018*)

B. Ecosystem Condition

Climate related phenomena are known to cause degradation of ocean ecosystem conditions. Ecosystem conditions within the Asia Pacific region exhibit high variability as a result. This is demonstrated by Figure 18, which shows extreme weather conditions during Typhoon Damrey in 2017. The extensive purple and red areas represent regions of low atmospheric pressure, which created the necessary conditions for the deadly cyclone. The coverage was so widespread that 580 mm (22.8 inches) of rain was reported near the coast well north of where Damrey came ashore (NASA, 2017).

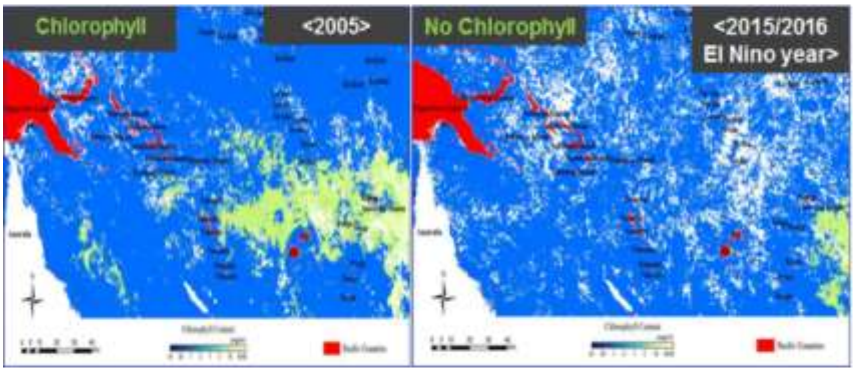
Figure 18 NASA IMERG Estimates Rainfall over SE Asia During Typhoon Damrey, 31 Oct -6 Nov 2017



Source: *NASA* (*2017*) *Retrieved from*: http://neo.sci.gsfc.nasa.gov/view.php?datasetId=MY1DMM_CHLORA

El Niño events are also of particular significance in the Asia Pacific region, for their influence on natural resource bases such as planktons and corals. This can cause excessive strain on natural resource-based livelihoods such as fisheries during El Niño years. However, these effects are difficult to anticipate, as El Niño events themselves are sporadic and not sufficiently understood, making them difficult to predict. Moreover, when El Niño events do occur, their impacts manifest in a variety of ways in different sub-regions.

Figure 19 Impact of El Niño on livelihoods, demonstrated by changing chlorophyll levels



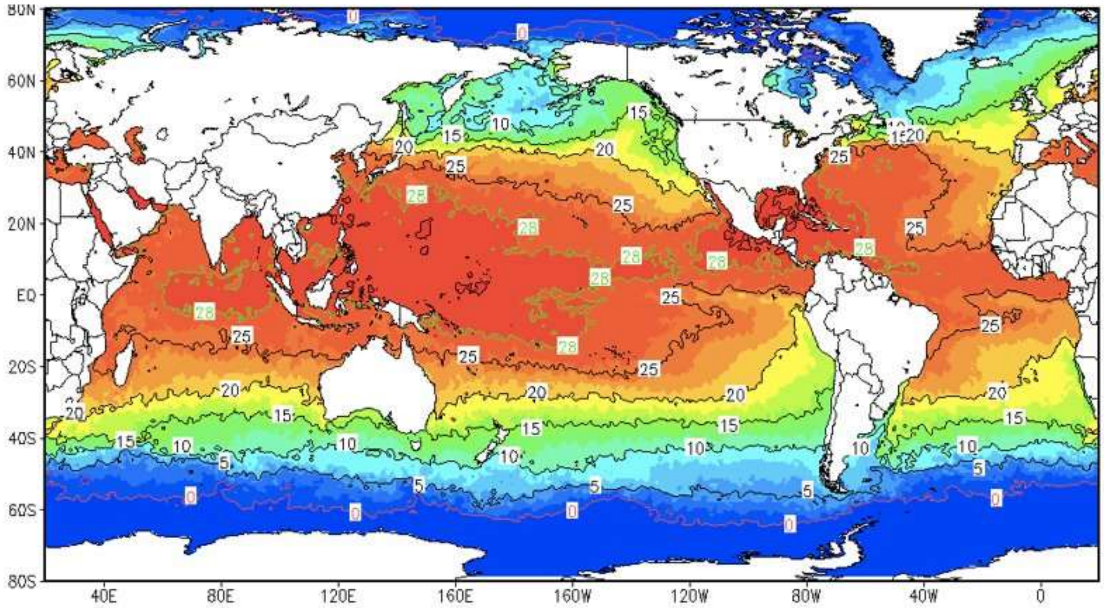
Source: *ESCAP based on NASA, Approaches for assessing risk and losses on fisheries and agriculture, available from http://neo.sci.gsfc.nasa.gov/view.php?datasetId=MY1DMM_CHLORA*

C. Ecosystem Services

Defining coastal and marine ecosystem services are extremely important for SIDS, but can be difficult to quantify or associate with a value. Direct services provided by ecosystems are for the provision of food in the case of fisheries and agriculture. Ecosystems such as coral reefs and mangroves provide buffers during some disasters. Some ecosystems, such as wetlands, provide water purification, while others regulate air quality and climate.

To understand how ecosystem services and oceanogenic hazards interact, parameters such as Sea Surface Temperatures (SSTs) need to be measured. This is achieved through complex methods that combine data observed through different platforms. For example, the National Oceanic and Atmospheric Administration (NOAA) developed the NOAA 1/4° daily Optimum Interpolation Sea Surface Temperature (OISST), an analysis constructed by combining observations from different platforms (satellites, ships, buoys) on a regular global grid. A spatially complete SST map is produced by interpolating to fill in the gaps (Figure 20). Using various platforms of observation gives a more accurate dataset and analysis.

Figure 20 Optimum Interpolation Sea Surface Temperature (OISST)



Source: *ESCAP, Asia Pacific Disaster Report (APDR) 2017, Bangkok*

D. Accounting for ecosystem capacity, degradation and enhancement

Impact forecasting is necessary to understand projected ecosystem changes, and how these will affect households and livelihoods. This will require analysis of multiple, integrated data sets including ocean statistics and climate data. One successful example of this is demonstrated by the Indian National Centre for Ocean Information Services' (INCOIS) identification of Potential Fishing Zones (PFZs). By integrating remote sensing data sets on SSTs and chlorophyll concentration, they were able to alert fishing communities to potential shoals of fish aggregation in the Indian waters. Additionally, data sets on SSTs, mixed layer depths, wind speed and direction and wave height and direction support the creation of Ocean State forecasts, which alert fishing communities to dangerous weather conditions to be avoided. As a result, fishing communities have been provided with timely and accurate information on fish stocks and weather conditions that has boosted their productivity and safety. This example thus demonstrates how ocean statistics can be used to track and adapt to future changes in ecosystem services, and to enhance resilience to disaster risk by reducing exposure to dangerous weather and ocean conditions.

Ocean accounts can also track ecosystem changes in order to build resilience to cyclone, through the use of technological innovations such as coupled ocean-atmosphere models. This is of increasing significance given the shifting geography of cyclone risk, which is resulting in shorter return periods of tropical cyclones, with increasing storm surges and wind speeds. Within the Pacific basin, the track of tropical cyclones may also change, and is expected to shift eastward or northward. One innovation that aims to cope with these changing risks has been developed by the Japan Meteorological Agency (JMA). The Himawari Satellite, a second generation EO Satellite, uses 10-minute observation intervals to capture data that is composed of multiple spectral bands which are visualized into an RGB colour scheme. This optimizes the visualization of atmospheric/surface features of interest and is therefore expected to contribute to earlier detection of severe weather in Asia and the Western Pacific.

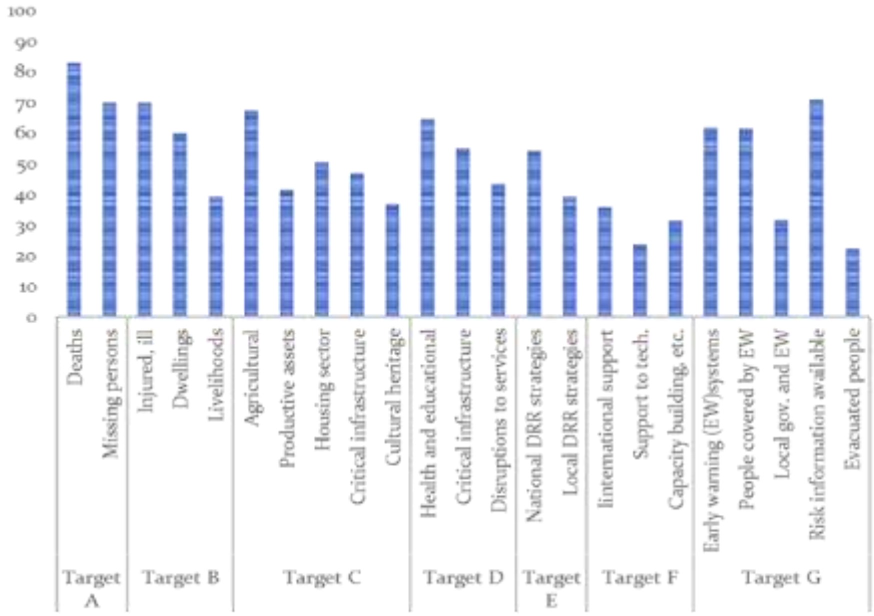
These examples demonstrate the potential applications of ocean accounts to improve understanding of risk, from smaller scale weather events to higher intensity tropical cyclones.

5 Recommendations to further develop the links between ocean, disaster risk and climate change statistics

A. In alignment with the Sendai targets, determine a core set of statistics common to oceans, disaster risk and climate change

Data concerning coastal communities, infrastructure, ecosystems, and ocean conditions such as SST variability, weather patterns and phytoplankton levels are required to build an understanding of oceans, disaster risk and climate change. However, there are many data gaps that need to be filled to monitor indicators such as those related to coastal infrastructure, disruptions of ocean related services, early warning and risk information services, and that are required for measuring the global targets of the Sendai Framework (and disaster-related targets of the SDGs). This can be generated through linking SDG 14 and the Sendai Framework, through a core set of common statistics (Figure 21).

Figure 21 The availability of data to monitor and report on the indicators measuring the global targets of the Sendai Framework and disaster-related targets of the SDGs



Source: *UNISDR, Sendai Framework data readiness review 2017 – Global summary report* (*2017*)

B. Promote ocean accounts to establish the coherence between the SDG 14 and the Sendai targets

SDG 14 aims to conserve and sustainably use the oceans, seas and marine resources for sustainable development. Two targets within this goal can be linked to ocean accounts.

Target 14.2 aims by 2020 to sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, strengthening their resilience. This is assessed by Indicator 14.2.1: The proportion of national exclusive economic zones managed using ecosystem-based approaches. The link to ocean accounting can be enhanced through SEEA Aquatic Resources, Ecosystem Extent, Environmental Protection Expenditures, and Ocean Services.

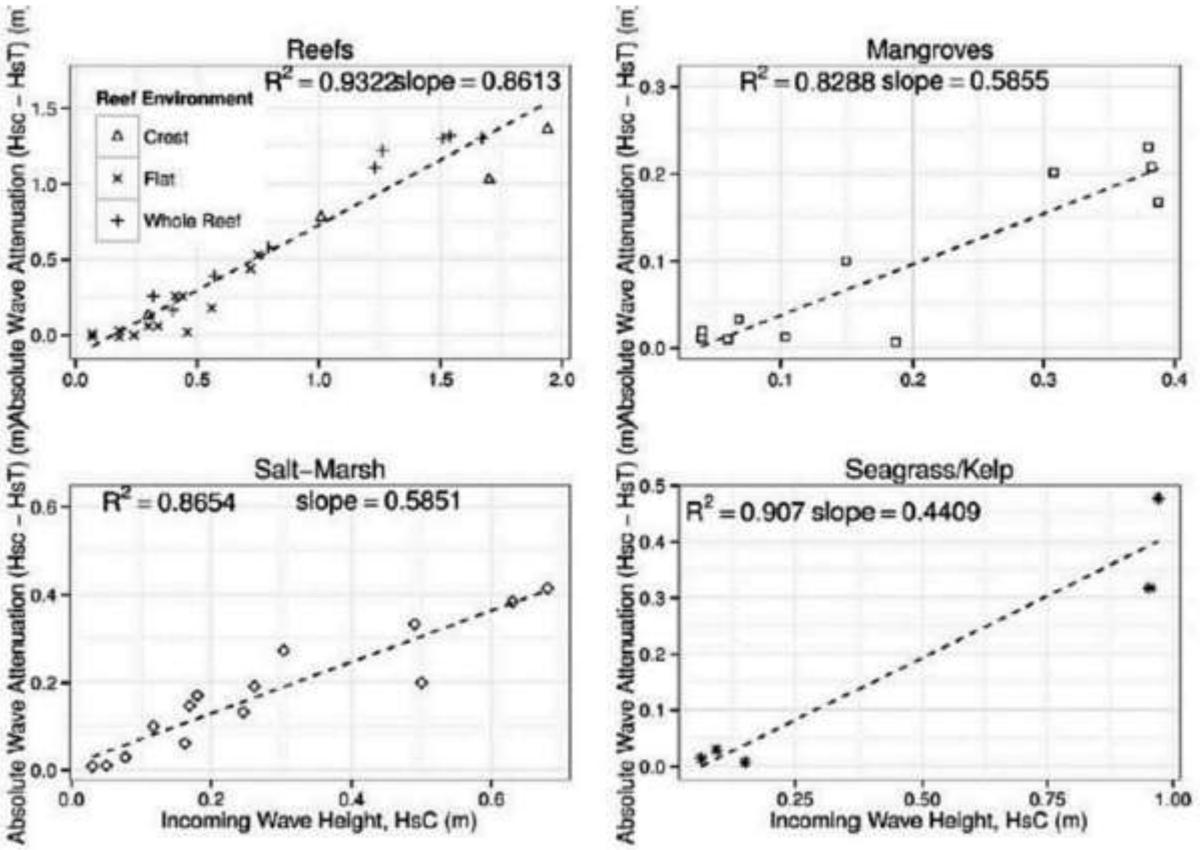
Target 14.5 aims by 2020 to conserve at least 10 per cent of coastal and marine areas, based on the best available scientific information. This is assessed by Indicator 14.5.1: The coverage of protected areas in relation to marine areas. The link with ocean accounting can be enhanced through SEEA Aquatic Resources, Ecosystem Extent, Environmental Protection Expenditures, and Ocean Services.

Oceanogenic disasters in the Asia Pacific region cause damage to livelihoods, particularly fisheries. The Sendai Framework therefore addresses economic losses from disasters in global target c) Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030. Accordingly, strengthening targets 14.2 and 14.5 of SDG 14 supports the Sendai Framework.

C. Support policy actions through ocean accounts for nature-based solutions, and coastal ecosystem- based Disaster Risk Reduction and Climate Change Adaptation approaches

DRR and CCA measures based on nature-based solutions in coastal ecosystems such as utilizing reefs, mangroves, salt-marsh and seagrass can be highly effective. This is demonstrated by plots of absolute wave reduction extents against incident wave heights for coral reefs, salt marshes, mangroves and sea grass. These plots show that nature-based solutions can contribute to coastal ecosystem sustainability by reducing wave height and thus the intensity of destructive coastal erosion, storm surges and tsunamis (Figure 22).

Figure 22 Coastal ecosystem and wave-height reduction: absolute wave reduction extents are plotted against incident wave heights for coral reefs, salt marshes, mangroves and sea grass



Source: Narayan S, Beck MW, Reguero BG, Losada IJ, van Wesenbeeck B, Pontee N, et al. The Effectiveness, Costs and Coastal Protection Benefits of Natural and Nature-based Defenses. Plos ONE 11(5): e0154735. doi:10.1371/ journal.pone.0154735. (2016)

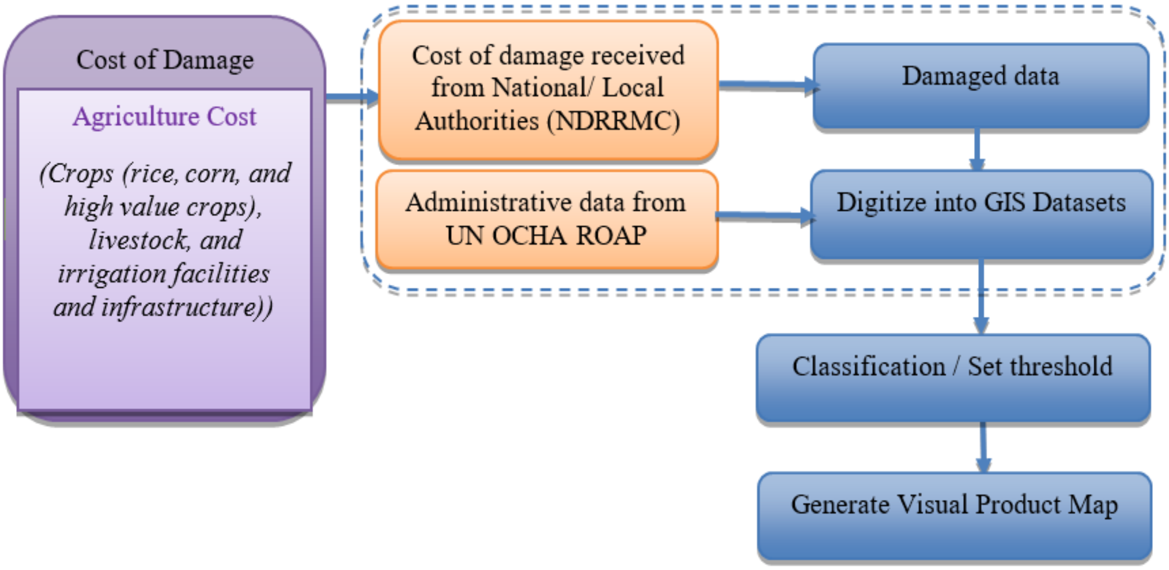
D. Promote innovative means of data capture

Innovative means of data capture could be gained by adapting and applying global oceanographic and weather satellite datasets/products to climate monitoring and operational ocean forecasting. The calculations of Global SSTs can be improved by merging data from various sensors, and by studying spatial and temporal variability including fronts and upwelling; and data can be validated using ship-based infra-red radiometry. Satellite observations can be used to improve estimates of air-sea fluxes of momentum, heat and gases. The oceanic data products as output of climate monitoring and operational ocean forecasting can be found from remotely sensed ocean colour, and these can be assimilated into numerical ecosystem models.

E. Link ocean accounts with national statistics for Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA)

Linking ocean, DRR and CCA statistics facilitates new investigations into the impact of disasters. In one successful example, the agricultural damage caused by Typhoon Haiyan was investigated by combining cost of damage data from national and local authorities with administration data from international agencies. This was subsequently visualized by digitalizing it using GIS data, in order to produce a map of estimated agricultural damage for the whole of the Philippines.

Figure 23 Methodology for developing visual product map for estimating cost of agriculture damage during Typhoon 'Haiyan' in The Philippines



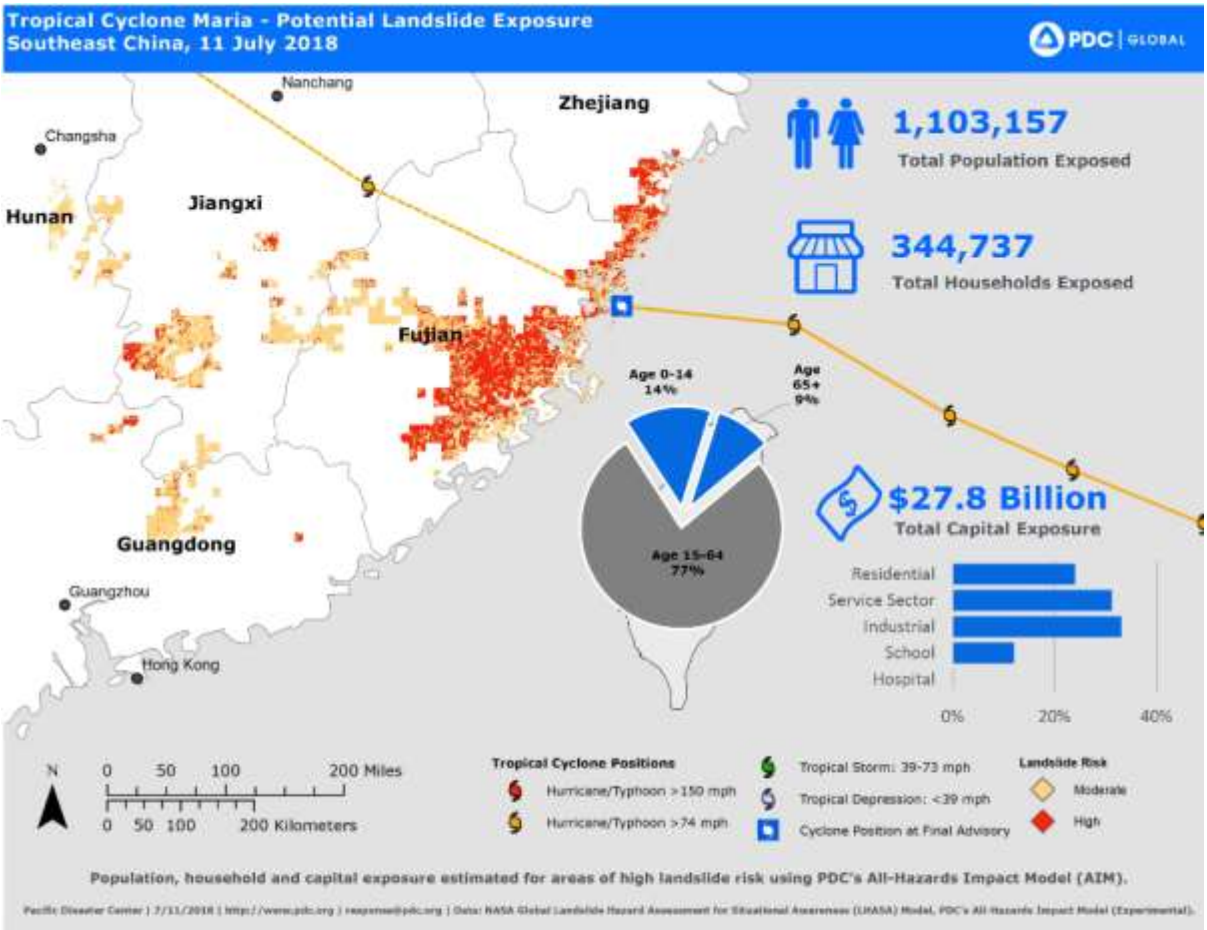
Source: *ESCAP, Asia Pacific Disaster Report (APDR) 2017, Bangkok*

In consideration of developing and integrating statistics and geospatial data, global agreements such as the "Strategic Framework on Geospatial Information and Services for Disasters" (United Nations, 2018) can provide guidance. The recommendations from this Policy Brief builds on and supplements the five priorities for action under this Framework, namely governance and policies; awareness-raising and capacity building; data management; common infrastructure and services; and resource mobilization. Recommended action at the global and regional levels for the first three priority areas in particular can compliment this work, such as encouraging collaboration and coordination among various partners on geospatial information for disaster risk management, promoting mutual learning, sharing of technical knowledge and the exchange of good practices, and to conduct studies and research into practices which can be of mutual benefit to member States.

F. Impact based forecasts for oceanogenic disasters are a key entry point for ocean accounting

Impact forecasting assesses ocean hazards by considering the coastal vulnerability and exposure to determine the risk and resulting impacts. This is exemplified by figure 25, in which potential landslide exposure for Tropical Cyclone Maria has been investigated by combining population and settlement data with geographical information about the cyclone.

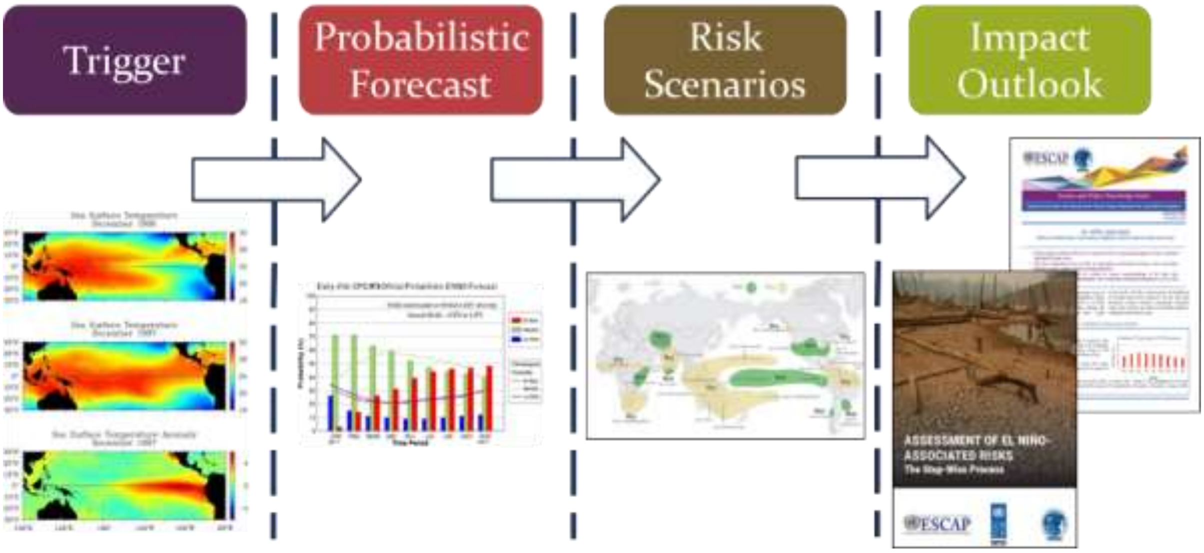
Figure 24 An example of impact forecasting, for Cyclone Maria in Southeast China



Source: *ESCAP, Asia Pacific Disaster Report (APDR) 2017, Bangkok*

Understanding how hazards will interact with the coast itself is vital to understanding projected ecosystem changes, and is therefore a key entry point for ocean accounting. One such approach uses probabilistic ENSO forecasts that are executed based on SST anomalies. These are used to develop risk scenarios within the region based on the potential impacts of El Niño related extreme weather events, such as dry and rain possibilities, combined with potential vulnerabilities. Ultimately, the risk scenarios created can then be used to inform policy that addresses such risks.

Figure 25 Impact-based forecast through risk scenario and impact outlook as the final product



Sources: *National Oceanic and Atmospheric Administration, International Research Institute for Climate and Society, Food and Agricultural Organization of the United Nations and ESCAP*

G. Ocean Accounts can support Post-Disaster Impact Assessment in the fisheries sector

Much data is required to conduct thorough assessments of the impacts of oceanogenic disasters. This is particularly true within the fisheries sector, as fish stocks, infrastructure and livelihoods can all be affected. However, within the Asia-Pacific region at present, there are often shortages of data on ocean conditions following disasters, which prevents sufficient understanding of how fishery sectors may be impacted. Improving ocean accounts can therefore support disaster recovery in coastal regions, by increasing the provision of timely and accurate data needed to assess the impact of damage to the fisheries sector and to subsequently allocate resources for recovery.

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