INSURING NATURE TO REDUCE RISK

Risk transfer solutions for coral reefs

ABOUT THIS PROJECT

This Report is a contribution to the Ocean Risk and Resilience Action Alliance (ORRAA). It has been led by the UNDP, through the Insurance and Risk Finance Facility (IRFF), and supported by the Government of Canada.

Ocean Risk and Resilience Action Alliance (ORRAA)

ORRAA brings together the finance and insurance sectors, governments, non-profits, and stakeholders from the Global South to pioneer finance and insurance products that incentivise investment into nature-based solutions in coastal and marine areas, with a focus on protecting the regions and communities that need it most. Our aim is to drive $500 million of investment into nature-based solutions and surface at least 50 novel finance products by 2030, positively impacting the resilience of at least 250 million people in coastal areas around the world.

UNDP Insurance and Risk Finance Facility

The Insurance and Risk Finance Facility (IRFF) is part of the Sustainable Finance Hub (SFH) of the United Nations Development Programme (UNDP), and it is a flagship initiative dedicated to insurance and risk finance. The IRFF manages UNDP's global representation in the insurance space. It is a one-stop shop for innovative solutions for UNDP Country Offices, programme countries and partners. This includes issues related to insurance and risk finance, networking, partner development, policy, and guidelines, technical and implementation, capacity and assistance, and financing opportunities. More information available at irff.undp.org

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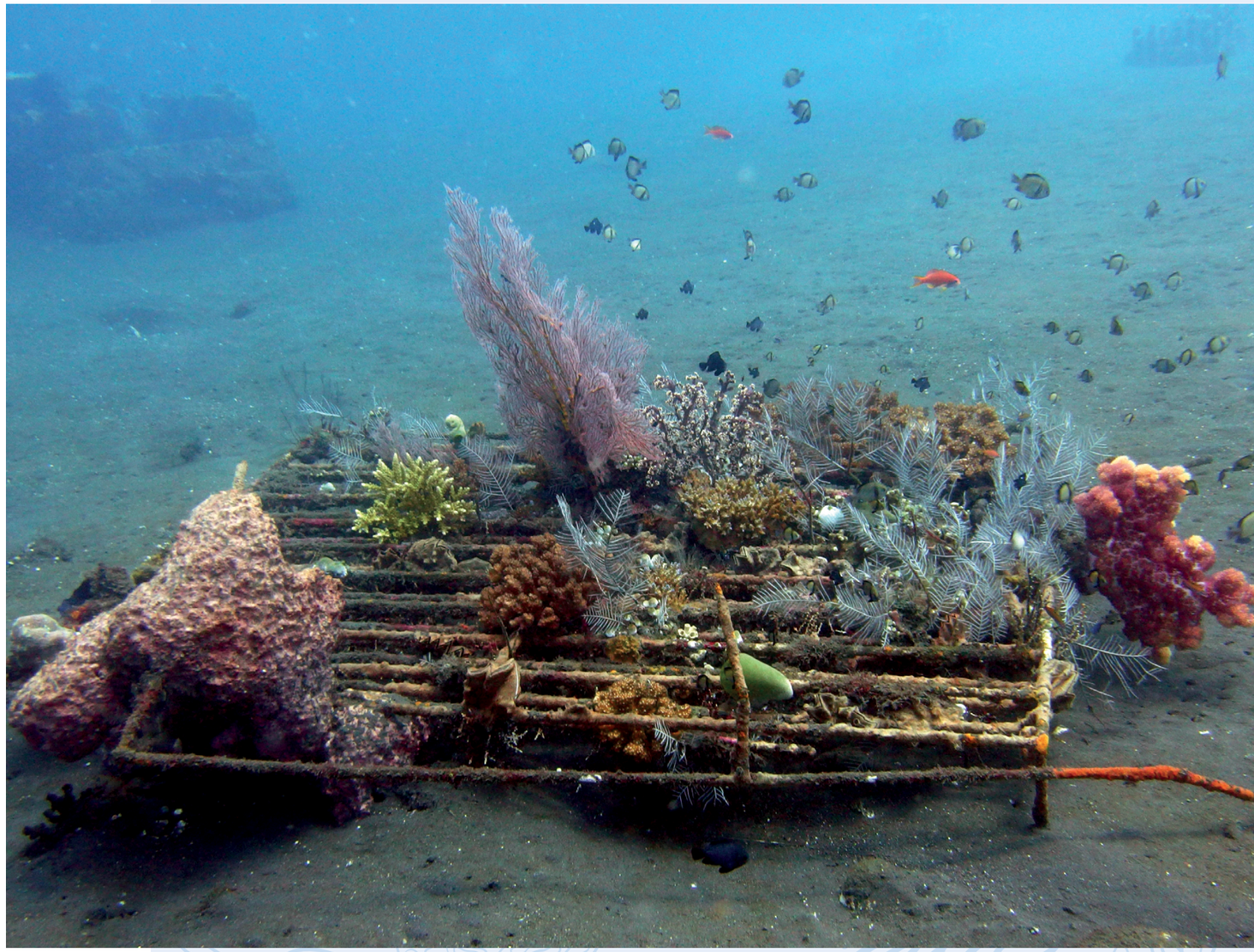
ABBREVIATIONS

ASB	annual severe bleaching
CBDRRM	community-based disaster risk reduction and management
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CO2	carbon dioxide
CRI	climate risk insurance
CRM	coastal resource management
DEM	digital elevation model
DENR	Department of Environment and Natural Resources
DRR	disaster risk reduction
DRRM	disaster risk reduction and management
EIOPA	European Insurance and Operational Pension Authority
GAR	Global Assessment Report
ICM	integrated coastal management
LDRRMF	local disaster risk reduction and management fund
LLMA	locally managed marine area
MOW	mapping ocean wealth
MPA	Marine Protected Area
MSMEs	micro, small, and medium-sized enterprises
NDCs	Nationally Determined Contributions
NDRRMF	National Disaster Risk Reduction and Management Fund
NGO	non-governmental organization
ORRAA	Ocean Risk and Resilience Action Alliance
PCRIC	Pacific Catastrophe Risk Insurance Company
PHP	Philippine Pesos
PIRA	Philippine Insurers and Reinsurers Association
SDGs	Sustainable Development Goals
SIDS	small island developing states
UN	United Nations
UN-CLS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute



EXECUTIVE SUMMARY

There is an opportunity to increase the protection of coral reef systems and to respond positively to global aspirations under the SDGs for equitable and biodiversity positive policies. This starts with defining a '*global standard for risk transfer*' for reef sustainability and requiring a collective approach that involves public authorities at all levels of governance (including cities, rural and coastal communities), private-sector actors across the reef value chain, NGOs, social partners, academics, and citizens.

Highlighting the issues and the opportunities in the global landscape for risk transfer solutions for protecting coral reefs and improving their resilience, this report helps policymakers and practitioners grasp how insurance and alternative risk transfer mechanisms can create a potential stream of financial resources for coral reef restoration. The report argues the merit of restoring reef ecosystems as a way of supporting risk reduction. It also examines insurance's contribution to reef resilience and the need for continued risk awareness and education.

The proposed risk transfer solutions provide options for customization and scalability and support actions that result in reef restoration. The report recommends a workable version of parametric insurance structures for reef insurance, because the rapid payouts that result are straightforward and essential for timely reef restoration. Moreover, the principle is clear and convincing to first-time users.

An ideal structure would be pooling reef risks across different localities, while working closely with local authorities, and coordinating with existing disaster risk reduction and management (DRRM) mechanisms. To minimize the risk of anti-selection and ensure fairness, it is also suggested that insurance participation is made compulsory for specific types of businesses and community members.

A Reef Disaster Risk (RDR) fund (at either a local, national or global level) could provide reef insurance, ensuring that resources are available rapidly in case of a disaster. This multi-layered structure, drawing inspiration and oversight from existing examples, such as the Mexico's reef trust fund, would incentivize reef maintenance and disaster risk reduction. It would help protect against uninsurable losses, provide emergency financing after crisis, and an insurance layer for risks associated with high-severity, low-frequency hazards, while also bringing in additional capital through closely related bond investments.

Through a virtuous cycle of investments, risk, insurance payouts, and costs of premiums are all reduced, while ensuring the protection of critical assets, lives, and livelihoods.

For investments to efficiently work, the right enabling environment is needed alongside the development and roll-out of such instruments. It is essential to work with national and local governments in the Global South on advocacy, research, and evidence, while also improving data and developing innovative insurance distribution channels, and ensuring women empowerment in reef-dependent, coastal communities. Engaging with national and local government is needed for innovative insurance mechanisms to be successful.

BACKGROUND

Coral reefs and associated systems provide food and resources worth US$2.7 trillion per year to more than a billion people in over 100 countries and territories. They add value to fisheries, tourism, and other sectors, and safeguard onshore built-up capital and physical assets against damage from tropical storms. Coral reef fisheries provide $5.7 billion in catch annually. Reef tourism generates $36 billion in revenue a year around the world – and up to $4 million per square kilometre of reef. These ecosystems are also a trove of pharmaceutical compounds including potential cancer treatments. Reefs act as a physical barrier against floods and storms, absorbing up to 97 percent of energy from inbound waves. With around eight percent of the global population living less than 10 metres above sea level, floods could cost coastal cities as much as $1 trillion per year by 2050. Together, this presents a powerful business case for the conservation of coral reefs.

Reefs are in grave danger, with climate change, warming temperatures, pollution and continuous physical damage to their structure due to human activity. A reef cannot provide a physical barrier against floods and storms if its health is compromised. Preserving this natural asset is key when it comes to protecting people from rising sea levels due to climatic factors.

But human activity and climate change are causing bleaching, die-back and physical destruction of reefs that can result in losses of up to 75 to 90 percent by 2050, unless we act now. It is highly unlikely that all reefs can be saved from these threats. This does not, however, imply that nothing can be done.

There are many international pledges and commitments that include the sustainable management of coral reefs, including the UN's Sustainable Development Goal 14: Life Below Water. But progress towards protecting our fragile coral reefs has been slow.

Innovative risk transfer solutions including insurance, have the potential to remedy this situation by transferring the risks faced by reefs, based on the value they hold. The economic value of the services provided by reefs – in protecting livelihoods, biodiversity, tourism, and fisheries - is only now starting to be quantified. Deploying the right risk transfer solutions can diversify risk and improve outcomes for local populations, the economy, and the reef ecosystem itself.

This report reviews the policy and regulatory framework around coral reefs globally, spotlighting existing gaps. The report also provides guidance on developing risk transfer solutions, which includes insurance and investments, for improving coastal resilience and aiding livelihoods that depend on them. The report highlights the potential of risk transfer and improved ocean literacy as mechanisms with the to help countries, communities, and businesses better manage and mitigate reef-related risks and achieve greater resilience.

MAPPING THE CHALLENGES AND THE RISKS

The prime focus of this report is on the risks to coral reefs and coastal areas from tropical cyclones and flooding. The risks faced by a local population in relation to a reef can be expressed as a function of the hazard (storm or any loss event), the exposure (the financial and economic values of assets affected) and the vulnerability (the anticipated damage).

For example, cyclones physically damage coral reefs, causing significant coral mortality. Earthquakes can cause parts of a reef to be submerged in either shallower or deeper waters than what they can tolerate, which results in die-off and breakages. Tourism activities damage reefs from physical contact when divers step on them, and the toxic chemicals in the sunscreen of divers further harms this fragile ecosystem. Moreover, silty runoff from coastal development or inland floods wreak havoc. Other stressors include blast fishing and acidification due to rising

carbon dioxide (CO_2) levels. Warming water causes bleaching and potential mortality as corals expel the colourful algae that provide them with key nutrients and protect them from disease.

The pandemic has temporarily reduced some of the pressures on coral reefs. For instance, tourist numbers and CO_2 emissions declined for a time. Other pressures increased, for example, the increase in waste from personal protective equipment discharged into the sea.

Quantifying the value of a reef and its services is also complicated and sensitive due to various factors. There are a range of methods available to determine a reef's local value and transpose it to another location for comparison and developing risk transfer solutions. This report focusses on the value of reefs to three sectors: fisheries, tourism, and shoreline protection. It also proposes the creation of a risk indexing system, the Integrated Blue Risk Index (IBRI), for tracking of reef hazards and changing exposures.

A global mapping of coral reefs that captures national-level socio-economic data can help countries in structuring insurance and risk transfer solutions for them. Identifying specific insurance opportunities for coral reefs is possible by cross-referencing the reef locations with local socio-economic indicators and regulations. Many developing countries can benefit from a holistic package of reef-insurance to protect vulnerable communities, critical assets, and livelihoods, helping authorities in drawing up plans to restore and conserve reefs as well as provide options for risk transfer solutions.

THE BASELINE OPPORTUNITY FOR INSURANCE

Insurance can provide payouts to fund the restoration of reefs after damage from a storm or other events. It can also compensate beneficiaries who lose assets, infrastructure, or revenue. Moreover, pooled funds can finance longer-term ex-ante measures to minimize the risk to reefs.

The value of a reef should consider the characteristics of the reef and the developmental level of the coastal area that it seeks to benefit. Global datasets can be useful when combined with inputs from local stakeholders. In addition, differences between locations as well as direct and indirect impacts of reef damage must be considered.

Understanding the local regulatory and institutional context, and assessing which authorities hold the mandate to repair damaged reefs is critical. It is recommended that gaps in the regulatory environment are filled before an insurance mechanism is brought to the market.

Current regulations do not explicitly recognize an insurable interest in coral reefs. However, no legislation to date prohibits either selling or buying of reef insurance.

MODELLING THE RISK

Developing a risk modelling framework requires the identification of different risk elements. Typically, this involves profiling the biophysical condition and health of coral reefs, within the broader socio-economic context of coastal communities and the businesses that rely on them.

Hazards faced by reefs need to be consistently detected and monitored, and the use of innovative approaches with the help of artificial intelligence, like deep neural networks, can provide means of risk monitoring that are largely automated.

Analysing the importance and role of reefs in specific locations can help quantify hazards, exposure, and vulnerability which can inform risk transfer solutions.

Assessing the potential for insurance and other risk transfer mechanisms in relation to a given coral reef system merits a thorough analysis. It is necessary to examine the specific conditions, hazards, and benefits at that location, including both the ecosystem and socio-economic context as well as the local capacity to implement different solutions.

A staggered approach is used to identify the most appropriate solution to implement starting with risk reduction where possible, followed by risk transfer where appropriate, and then an alternative risk transfer, if the insurance model is unviable.

CREATING THE ENABLING ENVIRONMENT

More than 200 existing international legal and policy instruments directly or indirectly support the conservation and sustainable management of coral reef ecosystems. Nation states are generally responsible for their implementation and under the UN Law of the Sea Convention, exercise jurisdiction over reefs within their territorial waters and Exclusive Economic Zones. This includes ensuring their conservation and sustainable use, as well as managing and legislating extractive or destructive activities on and around their reefs.

Gaps, however, persist. For instance, a local government may lack the authority to protect reefs through risk transfer solutions, including insurance; and/or have limited knowledge of the extent of impacts from disasters on coastal resources, including reefs. They may also lack guidance or capacity on securing and financing insurance and other risk sharing mechanisms for the protection or rehabilitation of coral reefs.

To pave the way for reef insurance and other risk sharing solutions, the enabling environment must be improved. Financial solutions that are complemented by a strengthened legislative framework for biodiversity and associated ecosystems, provide a solid starting point for developing insurance and other risk sharing mechanisms. These include insurance for natural capital in line with newly emerging reef insurance projects in different territories.

Lessons can be drawn from the experiences, expectations and challenges those countries are facing when implementing insurance mechanisms for reef restoration. This includes streamlining the role of central and local governments, or other bodies involved in the sustainable management of coastal resources.

SOLUTIONS THROUGH RISK TRANSFER

Risk transfer for natural capital can happen either through insurance to repair the reef and compensate the beneficiaries after any damage, or through investing in the effective management of reefs to reduce the frequency, severity, or impact of the hazards.

The latter is more cost-effective but often is more challenging to implement. Insurance is effective for local authorities when facing hazards of high severity and low frequency, like destructive storms.

Payout calculations can be based on different models. Parametric insurance is triggered when an event reaches a certain threshold, like storm intensity, and then a rapid claim payout is triggered. A loss-modelled insurance is based on an estimated loss in each scenario. Indemnity payouts are based on verified actual losses that are the most accurate but involve a time-consuming, loss-adjustment process.

Key facts

Coral reefs support

25%

of all marine species

Ocean economy provides employment and ecosystem services worth

$6 trillion a year

Coral reefs support oceanic food resources for

1 billion people

in over 100 countries and territories

Protecting reefs could boost economic returns by

34.6 billion

in the Coral Triangle, and by

$36.7 billion

in the in the Caribbean

Coral reefs, together with mangroves and seagrass, provide services valued as much as

$2.7 trillion

Coral reefs support organisms that are critical for

modern-day medical research

Coral reefs provide costal protection to over

600 million

people against flooding

Global cost of coastal flooding are currently

$40 billion

a year and expected to rise by 2050 to

USD 1

trillion a year

With over

35%

of world's coral reefs, the Coral Triangle harbours more than

75%

of all coral species

655 million

people (about 10% of the world's population) live within

100 km

of coral reefs

75%

of people living within 100 km of coral reefs

424 million

are in the poorest developing countries

1. INTRODUCTION AND BACKGROUND

Coasts are essential to our lives and livelihoods. Half of the global population lives within 60 kilometres of the coast,[1] with more than 600 million people, or around eight percent, living less than 10 metres above sea level.[2]

The coral reefs that lie just off our shores are a critical component of the interlocking natural and economic systems of coastal life, both below and above the waterline. They are a fundamental part of the habitat and food chain of the marine environment and provide food and resources for one billion people in more than 100 countries and territories.[3]

In vulnerable coastal areas, coral reefs are also the first line of defence protecting human lives and infrastructure against storms and cyclones; a healthy reef reduces up to 97 percent of incoming wave energy.[4] With climate change increasing the intensity and frequency of flooding along our coasts, the protection that reefs provide becomes even more important.

1 Coastal Zones
2 ibid
3 Communities of Ocean Action: Coral Reefs
4 Ferrario et al 2014

At the same time, reefs are under great threat, with climate change, warming temperatures, pollution and physical damage increasingly worsening their condition. It is highly unlikely that all reefs can be saved from these attacks.[5] And yet, this does not mean nothing can be done.

One critical, and unexplored contribution to reef sustainability is the possibility of transferring the risks of reefs via insurance and risk sharing mechanisms, based on the value they hold. The economic value of these services provided by reefs is only starting to be quantified – with the role of reefs in protecting livelihoods, biodiversity, tourism, fisheries and even lives often unheralded[6] - but it is not incalculable for the purposes of risk transfer.[7] New assessment methods and technologies are bringing improvements[8] to the measuring of the reefs' value to key assets and livelihoods and opening the possibility of insurance and other risk sharing mechanisms.

These solutions pool resources that are then used to repair the reef in case of damage, provide compensation to ensure that livelihoods are protected, and economic activity is restored as quickly as possible, following insured events, and increase the underlying resilience of the reef amid climate change and other challenges. Such risk transfer solutions hold significant potential

5 The Reef Foundation
6 UN Multiple Partner Trust Fund for Coral Reefs
7 Risk transfer means shifting risk from one party to another, such as purchasing an insurance policy and passing on the risk to insurers.
8 See chapter on the risk modelling approaches.

to improve the prospects of the world's reefs, and of those who depend on them. Already models in Mexico[9] and other countries have started demonstrating that the right structures can diversify the risk and improve outcomes for the local population, the economy, and the reef ecosystem itself.

Like any emerging field, challenges remain as more data is gathered, models are tested, and the situation evolves. This report provides an outline of some of the key findings on insurance for reef restoration, along with recommendations on using risk transfer instruments to protect our natural resources.

The report also builds on the increasingly vast body of knowledge on the sustainability of oceans and their resources, including reefs, by highlighting the potential of reef insurance and risk transfer and by improving ocean literacy.[10] The aim of this report is to help countries, communities and businesses to better manage and mitigate reef-related risks and achieve greater resilience.

The report investigates the socio-economic, institutional, and regulatory context for the deployment of reef insurance and other risk transfer mechanisms. It identifies existing gaps and articulates the enabling policy environment necessary, and the impact on underlying vulnerability and development outcomes. The report also outlines the broad parameters of the proposed institutional arrangements and insurance products, and other risk sharing mechanisms, which can be customized by individual countries.

Finally, it aims to raise awareness and acceptance of the potential for insurance and other risk sharing mechanisms to mitigate the risk of shocks to our natural systems which provide essential services and benefits to the environment and livelihood. The areas of common interest and mutual benefit between the conservation sector and the insurance industry are only now being understood and explored. This report can inspire discourse on cooperation and support needed to achieve the Sustainable Development Goals (SDGs) Agenda of 2030 and provide the rationale towards striving for financial resilience for the most vulnerable countries.

1.1 The importance of reefs

Coral reefs occupy only around 0.1 percent of the ocean floor but support 25 percent of all marine species. They are considered among the most biologically rich ecosystems on Earth and are a key asset for tourism[11] as well as many other economic sectors. They provide food and resources for one billion people in more than 100 countries and territories.[12]

The global value of the reefs and associated ecosystems such as mangroves and seagrass has been valued at up to $2.7 trillion per year.[13] The ocean economy, covering both employment and ecosystem services, is estimated to be worth as much as $6 trillion a year.[14] And coastal systems support many interlocking economic sectors, including fisheries, tourism, mineral extraction, oil, and construction.

Regarding fisheries, in particular, it is estimated that healthy and well-managed coral reefs provide 15 tonnes of fish and other seafood per square kilometre per year[15] or about one-quarter of the total fish catch in the developing countries.[16] Over a billion people depend on reef fish as a significant source of their dietary protein requirements.[17] In island countries, due to the limited land available for farming, fisheries are a critical source of protein and, often, the only source of income. In Indonesia alone, revenues from marine capture fisheries[18] have been valued at $14 billion, and from coastal and marine aquaculture at $7 billion. The numbers related to reef fisheries and its importance to local populations is somewhat underestimated, as in most of the cases, the subsistence fishing catch is not included in national statistics.[19]

1.2 The threats to reefs

Reefs are experiencing significant loss of living corals and damage to their structures due to coastal development, and coral mining, overfishing and destructive fishing (using explosives or poison), storms, and climate-related bleaching events (temperature rise, acidification, or depth changes). There is clear evidence of reef flattening[20] globally from the loss of corals, from biophysical erosion, and from the dissolution of the underlying reef carbonate structures.[21]

Protection by reefs is becoming more important with climate change increasing the intensity and frequency of flooding along our coasts. By 2050, an estimated 800 million people will be at risk of coastal flooding and storm surges.[22]

Also, climate change is threatening the reef itself, causing bleaching, die-back and physical damage, and with anthropogenic and climate pressures, in the past few decades, contributing to 25 to 50 percent of the total loss of coral cover worldwide.[23] Without urgent action, by 2050 we are likely to lose between 75 and 90 percent of the world's reefs.[24] Around the world, on average by 2043 reefs are projected to be experiencing severe bleaching each year.[25] Many individual major coral reefs are at a tipping point, after which repair might be impossible.

Yet, there is hope. The distressed reefs have a shot at recovery from bleaching, overfishing and storms, if the right interventions are put in place now.[26]

9 More details on Mexico's reef insurance initiative are provided in subsequent sections. Other countries include Belize, Guatemala, Honduras.
10 Cunliffe 2020
11 BIOFIN 2016
12 UN Ocean Conference
13 UNE 2018
14 UN 2017
15 Coral Reef Alliance
16 Moore and Best 2001
17 Reef Resilience Network
18 "Marine capture fisheries" refers to any activity that harvests naturally occurring living resources in marine or freshwater environments, as opposed to the farmed produce yielded by aquaculture or pisciculture.
19 Whittingham et al 2003
20 Reef flattening happens when due to bleaching, damages from disasters, changes in nutrients, overfishing and other human activities, the reef is not able to sustain a more diverse community of species and eventually degrades.
21 Hoegh-Guldberg et al 2019
22 C40 Cities. Staying Afloat: The Urban Response to Sea Level Rise
23 Good and Bahr 2021
24 IPCC 2018; UNEP 2019
25 UNEP 2017
26 NOAA 2021

1.3 Global recognition

The international community is increasingly taking a clear and coordinated position on the value of reefs and their wider ecosystems. In 2019, the United Nations Environment Assembly passed Resolution 4/13, calling for greater coordination between countries in implementing policies on the conservation and management of coral reefs at international, regional and local levels. Other goals and commitments include the SDGs of the 2030 Agenda. The most relevant one is SDG 14 Life Below Water, that aims to "conserve and sustainably use the oceans, seas and marine resources for sustainable development." However, many other SDGs also depend on healthy coral reefs and associated ecosystems, due to their contribution to food security, shorelines protection, fisheries and tourism, and human health and wellbeing.

The goals also include the Coral Reef Target included in the Post-2020 Global Biodiversity Framework (GBF) of the Convention on Biological Diversity, as well as delivering on the Coral Reef Life Declaration.

As per the 2020 Conservation for Biodiversity High-Level Panel, despite significant monetary value attributed to reef ecosystem services, current funding levels for its protection is only one-seventh of the necessary global investment.[27] Prioritizing stabilization and recovery of coral reef ecosystems, and setting clear timescales and targets is key.[28]

27 Alliance Magazine

28 See The Reef World Foundation. Also, the scientists at the International Society of Reef Studies (ISRS) made calls for all nations and negotiators at the Paris Climate Change Conference (COP21) to commit to limiting atmospheric carbon dioxide (CO_2) concentrations to no more than 450 ppm in the short-term, and reducing them to 350ppm in the long-term. See Blue Ocean Network.

1.4 Risk transfer mechanisms

In recent years, policymakers have started taking interest in risk transfer mechanisms, including insurance and other mechanisms. As part of a holistic risk management strategy, these instruments are being considered vital to protect the fiscal bottom line and secure the hard-won development gains like infrastructure and economic performance. Today, many countries are engaged in initiatives relating to disaster risk insurance and financing and have the endorsement of risk transfer by the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement as part of the climate adaptation strategy. Now countries are also looking at solutions to protect natural capital, and the United Nations Development Programme (UNDP), is one among several development agencies, that is identifying and implementing nature-based strategies to support risk transfer solutions.

The United Nations has identified several areas where sustainable finance could improve resilience in the face of threats to sustainable development. These threats include climate and oceanic change; the global pandemic along with economic and financial instability; and natural hazards.[29] These interlinked crises all call for a multi-faceted understanding of both the risks and the solutions, where reef protection can play a significant role in enhancing resilience to shocks.

29 UN 2021

2. MAPPING THE CHALLENGES AND THE RISKS

Coral reefs are subject to both ongoing threats and disaster events.

Ongoing threats include bleaching due to shifts in water temperature, especially warming, as well as human activities such as pollution and overfishing. These factors may not cause immediately visible destruction to reefs but over time they increase the reef's fragility, and vulnerability to subsequent disasters.

A single disaster event like a cyclone can cause severe damage to the reefs. It can break and uproot coral colonies, collapse reef structures, and reduce crest height and rugosity, diminishing the live coral cover. The sand and debris from the mainland that then covers the reefs, compounds the damage.

This section looks at the nature of the risks faced by coral reefs and its impact on people, resources, sectors, and assets.

The prime focus of this report is on the risks to coral reefs and coastal areas from tropical cyclones and flooding. Assessing the three components of risks will require:

Relationship between hazard, exposure, and vulnerability

- The **hazard** is the potential disaster, such as tropical cyclone, storm, or flood. Defining the hazard includes its nature, severity, and estimated frequency.
- The term **exposure** refers to the elements to be protected, such as the property values by location, which is also characterized by the building materials, typical uses, age, and replacement cost.
- The **vulnerability** is the level of damage expected at different levels of intensity of the hazard. For example, buildings with lower-quality construction and limited flood-mitigation measures are more vulnerable to losses from a storm than those with flood-resilient infrastructure and strong building regulations. The vulnerability may also include other impacts such as business interruption and loss of income.

In summary, **risk** can be considered as the product of a hazard's frequency, exposure, and vulnerability.

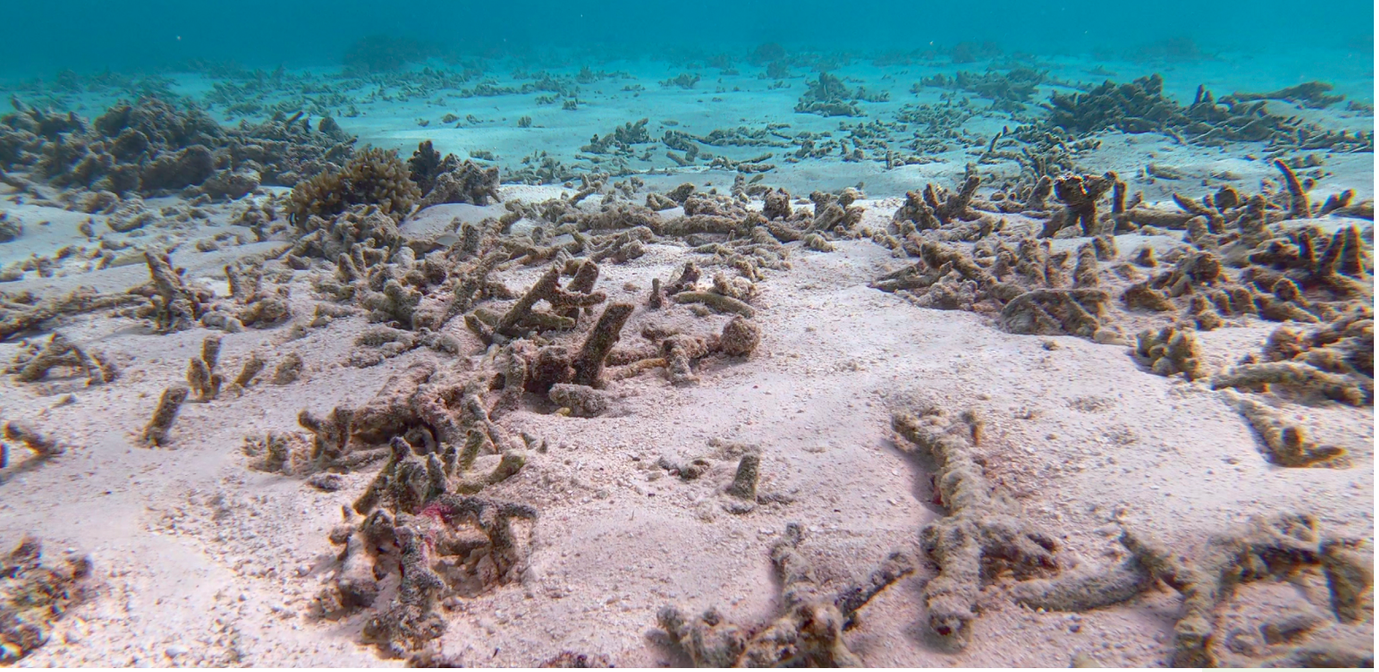
Risk =
Hazard Frequency × Exposure × Vulnerability

- **hazard** data, available over a relatively long time series;
- **exposure** data, with estimates as precise as possible to quantify potential losses; and
- **vulnerability** data based on past losses even if uninsured, to set payout levels.

With the working models to break down and assess the component parts of risk, the quantification is essential to develop appropriate and effective risk reduction, insurance, and risk sharing mechanisms. The exposure data for the reef itself should include measurements of rugosity, as well as length, depth, and water temperature, for each location.[30]

The risk models for each reef can be developed after identifying hazards, exposure and vulnerability. Local experts can support these models by collecting ground data and extrapolating proxy measures for exposure and vulnerability. These are first step towards building the risk models and creating insurance and other risk transfer solutions.

30 There are various datasets, for example, the NOAA's Coral Reef Watch, or the World Resources Institute. In addition, the XL Catlin has also collected 360° imagery on the Seaview Survey, using stereo cameras to compute rugosities. See Global Reef Record.



2.1 The hazards facing the world's coral reefs

A wide variety of threats affect the coral reefs. A recent study supported by ORRAA[31], analyses how the reefs are impacted by several hazards and how there is growing evidence of changes in coral cover and rugosity, that further causes the decline in coral reef population. The hazardous impact depends on various factors, such as severity of the event; its scale; and the frequency at which the events occur. Some of these hazards have been discussed below.

Cyclones

Cyclones, storms, and coastal flooding are an intrinsic part of the climate system, but have been increasing in intensity and frequency due to climate change.[32] In the coastal areas, the impact of weather events is further intensified by the rising average sea levels.

One of the biggest risk that reefs face today are the damage caused by tropical cyclones. Reefs are critical when it comes to absorbing and dispersing wave energy arising from storms, but often during cyclones the reefs are damaged.

A tropical cyclone can reduce the live coral cover and reef habitat complexity within a few hours. Cyclones with wind speeds from 50 to 100 knots (92 to 185 kilometres per hour) reduce live coral cover by two to three percent on average.[33] Cyclones with wind speeds above 110 knots can cause a loss of live coral cover ranging from 10 to 30 percent, with 20 to 50 percent loss for wind speeds between 110 to 160 knots. This exacerbates an annual loss of about two percent due to other stress factors.[34]

31 Alvarez-Filip et al 2021
32 S.I., N. Nicholls, D. Easterling, et al 2012
33 Gardner et al 2005
34 Ibid

On average reefs lose 25 percent of its coral cover after winds with 110 knots (category four hurricanes) and up to 60 percent with winds of more than 160 knots (category five hurricane). [35]

Cyclone damage eventually reduces the value to biodiversity and ecosystem services provided by the reefs. Recurring cyclones in particular damage the reefs' ability to regenerate and restore economic and protection services. The reduction in height of a reef of just one metre can increase onshore damage twofold. There is evidence that coastal damage and beach erosion are directly proportional to the deterioration of reefs.

This table captures the data needed on hazard, exposure, and vulnerability to model the risks arising from cyclones.

Table 1: The data fields to model the cyclone risk

Element	Data needed	Description
Hazard	Wind	The wind data, especially for areas near the coast, is important to model how much wind will push water force over the surface and bring destruction to reefs.
	Rainfall and weather	Accurate weather data is highly important to model typical wind and cyclone patterns of the past. Moreover, the frequency of events is crucial to estimate the losses under different scenarios over time
Exposure	Information about: • location • building • financial values	High-quality location data to map assets against hazards. Given the high number of locations, it is recommended to prioritize data collection on the most critical built-up capital and other exposed assets.
Vulnerability	• Reconstruction costs • Livelihood needs	Average financial values
Potential loss estimation (risk)	• Historical data on frequency and severity	• Past frequency and future projection • Severity • Potential surface area and locations of impact

Earthquakes and tsunamis

Earthquakes often cause both uplift and subsidence, in and around islands, and they also cause the rise of living coral reefs above the water surface level. Reefs can die in water that is too shallow or that dries out at high ride. Some reefs also sink into deeper waters, altering the ecological zoning.

The reef flat is the part of a fringing reef found closest to the shoreline, at relatively shallow depths. The reef front slopes down on the side away from shore and is adapted to slightly deeper water. Tectonic activity can:

35 Ibid

- move reef-flat corals up and out of the water, causing extensive reef mortality;
- move reef-front corals up to the shallower depth of the reef-flat zone; and
- move reef-flat communities deeper, to the level of the reef front.

Post-earthquake, reefs can also be damaged in the longer term if turbidity and sedimentation persist, killing mature corals.

In addition to many human casualties, the earthquake that struck Indonesia's Sumatra Island in 2004 killed off some of the largest areas of coral ever documented. It raised the island of Simeulue near Nias by up to 1.2 metres, exposing most of the coral reefs ringing the island. The damage to coral reefs from the earthquake was more severe than that caused by the following tsunami, including uplifted reefs, shattered beds of coral, and overturned coral colonies. [36]

After the 2018 earthquake and tsunami in Sulawesi, Indonesia, the coral coverage was reduced from an estimated 35 to 50 percent of the ocean floor, to less than 10 percent.

Tourism and pollution

While coral reefs are lucrative for the tourism industry, increased human activity can compromise the reef's health.

It is worthwhile to invest in maintaining reefs to ensure sustainable tourism [37]. And at the same time limiting tourist numbers to avoid degradation of the reef, and other ancillary impacts because of human activity.

As hotels and resorts mushroom near coastal areas, reefs are more prone to risks from unmonitored tourist activity. Infrastructure development, increased water pollution due to plastic waste, and cruise ships, all contribute to the degradation of reefs.

To counter these adverse impacts of the marine tourism sector, authorities in many countries have levied hefty fines, sought for compulsory donations to avoid overcrowding at vulnerable sites. Also, countries are starting to fund coral conservation and restoration. In some cases, the income from tourism has been used to reverse the damage.

In 20 years, the Great Barrier Reef has seen a significant rise in the fish population. The money earned from tourism has been used in conservation activities to protect the reef and support the natural ecosystem.[38]

36 Foster et al 2006
37 Wressell 2020
38 Ibid

Coral bleaching and ocean warming

Excess heat from greenhouse gas emissions impacts the temperature of the ocean. High oceanic temperature affects coral reefs, marine species, and the overall ecosystem.[39] It also causes coral bleaching and leads to the adverse impacts on the breeding grounds for marine fish and mammals. Bleaching events happen when the ocean has been warming, and a low tide combined with a high sun causes the temperature to pass a certain threshold. The coral then expels its algae living in its tissues, turning it white. If the hot conditions persist the coral dies, and reef's structure becomes more fragile. But corals can recover in as little as a month if conditions return to normal soon enough. Sometimes only the tips are bleached and not the entire reef. The warming of the ocean due to climate change is overall reducing the number of reefs acting as coastal defences.

Most of the globally prominent coral reefs are rapidly declining because of rising sea temperatures.[40] The elevated sea temperatures drive impacts such as mass coral bleaching and mortality, with an analysis of the Coupled Model Intercomparison Project Phase 5 (CMIP5)[41] ensemble projecting the loss of coral reefs from most sites globally by 2050 under mid to high rates of ocean warming.[42]

COVID-19 pandemic

The global pandemic of COVID-19 has had a mixed effect on the global climate. There are some detailed quantitative studies[43] under way that once completed will shed more light on the effect of the COVID-19 lockdown on the coral reef ecosystems. In the meantime, it has been established that the temporary decrease of air travel has reduced global carbon emissions by at least 3 percent.[44] The reduction of overfishing due to intermittent lockdowns has brought some respite to the declining reefs. And the temporary scaling back of the number of tourists has also benefited the environment as it resulted in a reduction in the amount of sunscreen washing into the water near reefs, and less disturbance from visitors.

On the other hand, as an indirect effect of the pandemic there has been an increase in the quantity of microfibers and microplastics washing onto reefs, from improperly disposed-of personal protection equipment. These microfibres and floating plastic from face masks, gloves, gowns, and other equipment can smother or poison corals, or even serve as a vector for spreading invasive species.[45] The material is also broken down into small particles by the elements and

39 IUCN 2017
40 Hoegh-Guldberg et al 2019
41 With the sensitivity of coral reefs to temperature, the IPCC in its 5th Assessment Report has analysed trends in key coral reef regions. It grouped the results into six major coral reef regions and found that coral reef waters (with the notable exception of the Gulf of Mexico and Caribbean) show strong increases in average temperature (0.07°C to 0.13°C per decade) as well as the temperature of the coolest (0.07°C to 0.14°C per decade) and warmest months (very likely) (0.07°C to 0.12°C per decade).
42 IPCC 2018
43 Ocean Sphere
44 Ibid
45 Oceans Asia

consumed by other marine wildlife.[46] According to a report by the Asian Development Bank[47], during the peak of the pandemic, just in a city like Manila, up to 280 tonnes of extra medical waste was being generated per day. Most of the waste, including personal protective equipment, is often discarded and gets washed up on coral reefs close to the city's beaches.

Other stressors

Destructive fishing using a blast of poison is widespread in certain countries.[48] For instance, in Indonesia it threatens nearly 80 percent of the country's reefs across 31,000 square kilometres.[49] The coral reefs in the eastern parts of Indonesia like Sulawesi, Maluku, and Papua Islands, are more vulnerable to the threats of destructive fishing than other provinces in Kalimantan and Sumatra Islands.

Higher tides and intense rainfall also lead to flooding and coastal erosion, which are becoming a growing concern. The erosion is linked to greater sedimentation, impacting coral reefs with heavy silt loads and debris, after flash floods. Sea level rise has also caused the inundation of low-lying coastal areas and atolls.

Increased absorption of CO_2 is also causing acidification of the oceans, with pH set to fall by approximately 0.3 to 0.4 points by 2100, severely impacting the sustainability of coral reefs.

2.2 Mapping the exposure of reefs

To develop suitable risk transfer solutions for reefs, it is recommended that a comprehensive exposure database of all reef assets be developed. A starting point for this can be the very useful Allen Coral Atlas.[50] Some sites have risk data on hazards, but it is still limited and not sufficient for insurance purposes, which require greater information on the levels of exposure and vulnerability. Building a more comprehensive database will be time-consuming and require support from local authorities and stakeholders, which is discussed in the chapter CREATING THE ENABLING ENVIRONMENT. This support will help make sure the database includes exposure, values of all businesses, including micro, small and medium-sized enterprises (MSMEs), and of built-up capital located on land within the reef's impact outreach.

This comprehensive database detailing hazards, exposure and vulnerabilities could then be used as an input to model the impact from events such as cyclones and earthquakes, to then quantify the risk to economic services, built-up capital, and the population in each location.

46 Watch here a short clip by the BBC's Howard Johnson and a group of divers from the United Nations Environment Programme (UNEP)'s Green Fins affiliate.
47 Ibid
48 Common examples include Indonesia, Philippines, and Tanzania.
49 Burke et al 2012
50 Allen Coral Atlas

Integrated Blue Risk Index

The creation of the *Integrated Blue Risk Index (IBRI)* will be useful. This would be locally managed and owned by stakeholders for regular tracking of reef hazards and changing exposures. Such an index would assess the reef risk development and its progression, as well as outline the potential values suitable for risk transfer through solutions including insurance by capturing hazard potential, exposure and coping capacity. Sub-indices of exposure and capacity can be based on the changes in economic data mapped against trends in reef health. The coping capacity index can be constructed from three indicators: (i) business and population headcount at the local level; (ii) a (property) asset index; and (iii) the degree of managing risk with disaster risk reduction (DRR) practices in place. The integrated index would also have the potential to be replicated at other locations.

To keep it simple, there could be multiple pathways. One is by linking reef protection with public assets on the coast, such as roads, public buildings, hospitals, and schools. This would be appealing to governments, since if these assets are damaged and cannot be used by coastal communities, this will hugely impact daily lives and businesses.

A second model to be explored excludes public infrastructure, focusing solely on different types of private businesses such as hotels and tourism service providers, and uses the value of their built-up capital and/or revenue stream in each location to quantify the exposure.

Third option is by joining both previous options together so that the benefits of reef insurance can be spread across the public and private sectors, minimizing the risk of anti-selection.[51]

2.3 Economic sectors dependent on reefs

Below are a set of core sectors that are particularly dependent on reefs, for livelihoods and economic growth as well as protection.

Fisheries

Coral reefs maintain biodiversity and natural habitats. Coral fisheries provide an average annual seafood yield of 1.42 million tonnes, which translates to $5.7 billion a year.[52] Across 99 countries,[53] there are six million reef fishers, representing more than a quarter of the world's small-scale fishers,[54] and half of whom are in South-East Asia.[55] Globally, one billion people depend on coral ecosystems for food.[56] Approximately 95 percent of all commercially significant fish species depend on coastal habitats supported by reefs.[57]

51 Anti-selection in insurance can occur because of adverse selection: Those most at risk become overrepresented among policyholders, as they are more motivated to secure insurance. This adverse selection forces insurers to raise premiums, which in turn further deters those less at risk from taking out policies.
52 Cesar et al 2003
53 Coral Reef Alliance
54 The Conversation
55 Teh et al 2013
56 Quass et al 2016
57 Mapping Ocean Wealth

Protective services

Approximately ten percent of the world's population lives within 100 kilometres off the coast,[58] including around eight percent at elevations of just 10 metres or less.[59] This highlights the need for protection against sea level rise and flooding. Coastal floods and storm surges already costing the world up to $40 billion a year.[60] By 2050, floods will cost coastal cities nearly $1 trillion dollars a year and jeopardize billions of dollars' worth of infrastructure.[61]

Reefs can reduce the energy of incoming waves by up to 97 percent,[62] depending on the depth and the rugosity.[63] Many calculations have been made of the value of the protection provided by coral reefs. Some have placed the value very high,[64] while others have found significant variations between countries.[65]

Healthy coral reefs absorb the destructive energy from waves before they reach the shore, dramatically reducing flooding and beach erosion. It has been estimated that in the absence of reefs and the protection it provides, the flood damage from a 100-year storm[66] would increase by almost 91 percent, i.e., almost double, and the costs from less severe but more frequent storms would be triple. [67]

58 CIESIN 2013
59 Coastal Zone
60 Global Climate Forum
61 Global Commission on Adaptation. Adapt now: A Global Call for Leadership on Climate Resilience.
62 Ferrario et al 2014
63 Rugosity is a measurement of the surface roughness. High levels of rugosity can allow corals to attach and grow in shallow areas if other conditions are met. They also dissipate wave energy more than low levels of rugosity.
64 Based on Spalding et al 2017
65 External data sources extrapolated with calculations based on Beck at al 2018.
66 The term "100-year storm" refers to a weather event that has a statistical probability of happening once in a hundred years, or a one-in-a-hundred (i.e. one percent) chance of occurring in a given year.
67 Beck et al 2018

Good reef management protects against floods and results in increased savings of more than $400 million in each of these countries: Philippines, Malaysia, Mexico, and Cuba.[68]

Effective protection of coastal assets is becoming urgent. Reefs protect the people and infrastructure in these fast-developing coastal towns. With, the threat of climate change, frequency and severity of storms and flooding has been on a steep rise. This means reefs need urgent protection and maintenance.[69]

Coral reefs have served as natural breakwaters along with other coastal habitats like salt marshes, mangroves. They represent a more cost-effective measure to ensure the ongoing protection than other approaches such as building walls and dykes.[70]

Recreation and tourism

More than 30 percent of the world's reefs support some degree of tourism activities. Around 350 million people annually travel to the coastal countries with coral reefs. Reef tourism is around $36 billion a year, with more than half of this money coming from on-reef activities such as: diving, snorkelling, glass-bottom boating, and reef-related wildlife experiences. The remaining profit is from reef-adjacent tourism, like beaches, local seafood, paddle-boarding, and more.[71]

68 Ibid
69 Kumar et al 2015; Reguero et al 2015; Hinkel et al 2014; Hallegatte et al 2013
70 World Bank 2016; Quataert et al 2015; Ferrario et al 2014; Monismith et al 2013; Sheppard et al 2005
71 Spalding et al 2017; The Nature Conservancy

Popular coral reefs can generate up to $4 million in tourism revenue per square kilometre per year.[72] More than 70 countries and territories have individual reef formations generating more than $1 million in annual tourism revenue.[73]

The establishment of Maldives' entire territory as a biosphere reserve is expected to help maintain almost 89 percent of the country's GDP, which is dependent on coastal and marine biodiversity.[74]

Reefs in Puerto Morelos National Park in Mexico showed a direct revenue stream of almost $20 million for tourism business operators.

Pharmaceuticals

The rich biodiversity of coral reefs[75] includes many organisms such as sponges, corals, and sea hares, which contain molecules with potent anti-inflammatory, anti-viral, anti-tumour, and anti-bacterial properties. From these molecules, new treatments for diseases like Alzheimer's, heart disease, viruses and inflammation are being developed. More than half of all new cancer-drug research focuses on marine organisms.

$34.6 billion of increased economic returns in tourism, commercial fisheries and coastal development are possible if strong steps are taken to preserve and restore the health of coral reefs in the Coral Triangle in South-East Asia. Similarly, a 2018 report, estimated that there is a potential to protect economic gains of $36.7 billion in the Mesoamerican Reef in the Caribbean, in 2016-2030 if coral reef restoration is given priority.[76]

2.4 Geographical mapping of countries with prominent reefs

A global mapping of coral reefs crossed with national-level socioeconomic data will provide an idea of countries with insurable coral reefs. More precise opportunities for coral reef insurance can be identified by cross-referencing the map of locations where reefs provide valuable services with local socio-economic, policy and regulatory data. The socio-economic data should include: the value of built-up capital, the number of people protected, the total (coastal) area protected by reefs, the revenues from reef-based tourism, the values of local fisheries, and a quantification of the livelihoods protected by the reefs.

72 External data sources extrapolated with calculations based on the Spalding et al 2017. Standard deviation for the same calculation is $6.75 million.
73 Brumbaugh 2017
74 Paxton 2017a
75 UNEP et al 2018
76 UNEP 2018

The analysis will help assess the potential for risk transfer solutions including insurance, as well as the capacity and potential support for such products and solutions among local stakeholders.

A non-exhaustive list of countries with significant reefs is presented here.

Table 2: Countries with prominent coral reefs and their economic classification

Reef region	Country	Country income classification[77]	Per capita GDP (in US$)[78]
South-East Asia	Indonesia	Lower-middle	3,870
	Malaysia	Upper-middle	10,402
	Philippines	Lower-middle	3,299
	Viet Nam	Lower-middle	2,785
	Timor Leste	Lower-middle	1,381
South Asia	Maldives	Upper-middle	7,456
	Sri Lanka	Lower-middle	3,682
Africa	Kenya	Lower-middle	1,838
	Tanzania	Lower-middle	1,076
Pacific	Fiji	Upper-middle	4,882
	Papua New Guinea	Lower-middle	2,637
	Solomon Islands	Lower-middle	2,258
Caribbean	Aruba	High	30,253
	Bahamas	High	28,608
	Belize	Lower-middle	4,436
	Bermuda	High	117,098
	Curacao	High	19,701
	Mexico	Upper-middle	8,347
	Saint Martin	High	29,160
	Saint Vincent and Grenadines	Upper-middle	7,298
	Turks and Caicos Islands	High	23,880
	United States	High	63,544
Australia	Australia	High	51,812

While covering only two percent of the global ocean area, the Coral Triangle area, which includes Indonesia, Malaysia, Timor-Leste, the Philippines, Papua New Guinea and the Solomon Islands, harbours more than 75 percent of all coral species, 35 percent of the world's coral reefs, and more than 3,000 fish species.[79] Except Malaysia (which is classified as an upper-middle income country), all these countries in the coral triangle area are classified as lower-middle income countries, with an average per capita GDP of $3,975, overall rendering the Triangle as the region of lower-middle income countries.

The lower and upper-middle income developing countries with largest segment of population that is dependent on coral reef ecosystems for coastal protection, and income from fisheries and tourism sectors, have limited levels of industrialization and are often considered as less responsible for emitting the world's greenhouse gases.[80] One of the studies combined the layers of human population data with the coral reef mapping revealing that over 655 million people (about 10 percent of the world's population) live within 100 km of coral reefs, whereas about 91 percent of these people live in low and middle-income developing countries.[81] Discounting developing countries that have no direct relevance or economic dependence on coral reefs, data points that 75 percent of the people living within 100 km of coral reefs (424 million) are in the poorest countries.[82]

There is a vast regional spread, ranging from small island developing states (SIDS) in the Pacific and Caribbean to the highly populous and large countries in South-East Asia such as Indonesia and the Philippines, where many communities are directly dependent on reef resources.

A brief analysis showed Indonesia and the Philippines to have highly vulnerable reefs combined with high levels of population and property value protected by those reefs. SIDS such as the Solomon Islands and Fiji have smaller populations and less infrastructure, but the risks are significant in terms of the proportion of those assets that they threaten. Those countries are also particularly prone to extreme events and flooding due to their extensive coastlines.

Table 3: Estimated value of protection from reefs for different countries, assets and scenarios[83]

	Annual averted losses to built-up capital from current reef protection (in US$)	Estimated protection from reefs in a simulated 100-year coastal flooding event		
		People	Built-up capital (in US$)	Land area (in km^2)
Indonesia	639 million	1.8 million	36 billion	2,837
Philippines	590 million	2.4 million	31 billion	2,678
Solomon Islands	530,000	3,091	52 million	16.6
Fiji	410,000	2,830	49 million	72.5

Other countries can also be assessed according to their potential for reef insurance and risk sharing mechanism, including their economic and geographic category.

A granular, region-specific mapping of coral reefs will be useful. This will give an idea about the area of reefs in km^2, the reefs that are lost, the reefs that are in critical conditions, the reefs that are at a threatened stage (in percentage), and the reefs that are at a low threat level. This region-specific mapping is beyond the scope of this report however forms the basis of future research and development direction, if and when a region-specific reef risk and insurance mapping needs to be done.

77 The World Bank fiscal year country economic classification based on GNI per capita, calculated using the World Bank Atlas method.
78 2020, World Development Indicators database by the World Bank. Rounded to the nearest dollar.
79 The Coral Triangle Initiative
80 Donner 2007
81 Ibid. It is important to note that this study was carried out in 2007 using the population data from 2004, hence certain adjustments to data may be required to arrive at more accurate results in the current situation.
82 Ibid
83 These are author's calculations based on the research study by Spalding et al 2016

3. THE BASELINE OPPORTUNITY FOR INSURANCE

3.1 The opportunity for insurance products

Once the benefits of the reef are quantified, this information can be categorized by insurance sector and community groups and mapped into data portals such as the Mapping Ocean Wealth (MOW).

South-East Asia's coral reefs are vital to food security, employment, tourism, pharmaceutical research, and shoreline protection. The region's sustainable coral reef fisheries are estimated to be worth $2.4 billion per year. The reefs of Indonesia and the Philippines provide annual economic benefits estimated at $1.6 billion and $1.1 billion per year.[84]

Such a composite map can then be compared with demographic information and qualitative data on the insurance market to identify market challenges and demand opportunities for insurance products, including damage to property, casualty insurance, business interruption, and loss of livelihoods.

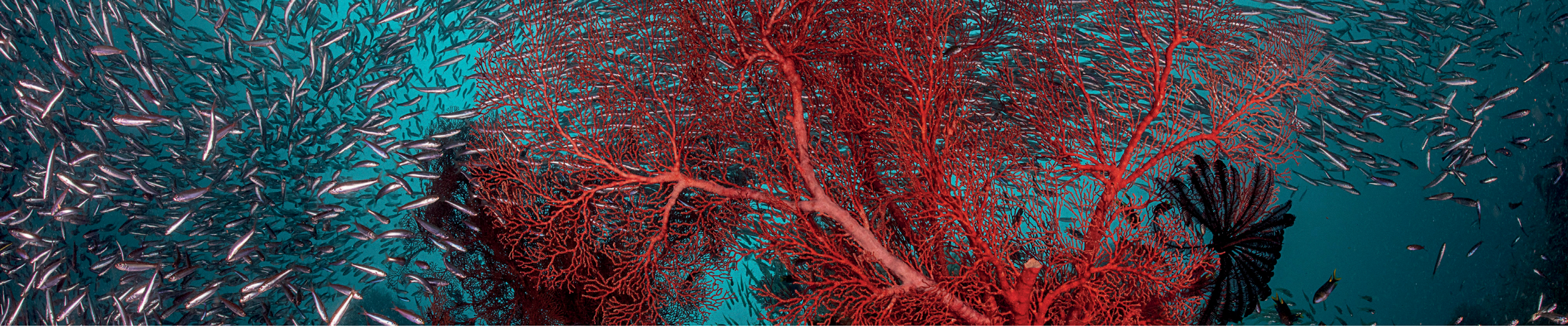
84 Burke et al 2011. It is important to note that this study was published in 2011, acknowledging that the financial values are likely to require adjustments against inflationary and other factors.

Regulatory and institutional data is also needed to understand the issues and opportunities for the insurance market, and any changes that are required to create an enabling environment. For example, current regulations do not explicitly allow the insurable interest in reefs, nor do they recognize potential reef investments made by insurers as part of admissible assets, under the solvency calculations for supervisory purposes.

The selection of the specific sites will be within the scope of on-the-ground, country-specific feasibility, and design studies, that may be a result of extensive dialogue with key local stakeholders, and intensive evaluation of local issues and opportunities.

3.2 Reef ownership and restoration

If a reef is to be insured for possible repair and restoration following storm damage, it is necessary at first to assess the viability of such insurance products with regards to both the reef itself, and its context. To do so, the reef's current condition and biological health needs to be studied. Then there should be an analysis of the legal and regulatory framework for restoration activities. Next, the capacity of local government and stakeholders to carry out reef restoration work also needs to be assessed.



Involving the local stakeholders, such as businesses, planning authorities, tourism departments, environment, and fisheries agencies, is key when it comes to assessing which parties hold a legal mandate and authority in carrying out reef restoration work.

In certain locations, hotel owners and tourism operators are investing their own resources towards restoring coral reef ecosystems and undertaking other conservation activities that benefit both their business and the environment.[85]

Moreover, to arrive at a quantitative valuation, it is important to assess the local capacity for the insurance mechanisms themselves, i.e., how insurance and risk transfer premiums will be funded. This depends on accurate information on tourism revenues and identification of other potential funding sources and mechanisms.

Similarly, if the reefs provide habitat for fishing activities, then the local data about the financial values of the catch can help determine the *ex-ante* insurance pricing. And the insured value for built-up capital, such as coastal hotel properties or other businesses, can be calculated based on some combination of the real estate value and the protective capacity of the reefs.

3.3 Reef valuation and quantitative methodology

Natural capital valuation measures the economic benefit of a given element of natural capital to a particular sector. This improves economic decision-making by policymakers. For instance, failing to value the coastal protection services provided by coral reefs can lead to their neglect. And with the reefs being impacted due to disasters it also has a repercussion on people's livelihoods and economic activities.

Accounting for the risk of physical degradation of coral reefs will underline the importance of incentives to address and prevent it. It is estimated that an average hectare of open ocean provides about $490 per year in ecosystem services, while an average hectare of coral reefs provides $350,000 annually in ecosystem services.[86]

85 Paxton 2017a
86 Groot et al 2012

Assessing not just the overall benefits provided by reefs, but also how these benefits are distributed among each stakeholder is key.

There are several methodologies to assign a value to reef ecosystem services. These can then be mapped and measured against different locations and contexts. The best one to use in each scenario will depend on the sector, the information collected, and the local context.

- **Choice modelling** mainly analyses trade-offs that individuals are willing to make between environmental factors. It estimates the relative value of multiple attributes of reefs. It allows for the simultaneous valuation of multiple environmental attribute changes such as beach width, water quality, reef health, or park entry fees. [87]
- **Contingent valuation method** subjectively determines value by directly asking people to state their willingness to pay (WTP) for the provision of certain ecosystem goods or services, or willingness to accept (WTA) changes in that provision. This method is useful for assessing non-use values such as the value of simply knowing that a coral reef exists.[88]
- **Market price approach** uses actual prices paid to analyse the economic activity generated by an ecosystem good or service and includes economic impact analysis and financial analysis.[89]
- **Production function method** estimates a change in value by measuring the change in a provided good or service, for example after a change in the underlying environmental resource.[90]
- **Benefits transfer method** applies a combination of results (values or functions) from existing studies to different areas, example, estimating the value of one beach using the value calculated for a different beach of a similar size and type in a different location. Both value transfer and function transfer are types of benefits transfer.
- **Cost of avoided damage** looks at the costs of disasters that are avoided thanks to a given ecosystem service.[91]

The table below gives an idea of which method is most appropriate and effective for a range of given scenarios.

87 Schuhmann 2012
88 Edwards 2009
89 McClanahan 2010
90 White et al 2008
91 Simpson et al 2010; Haites et al 2002

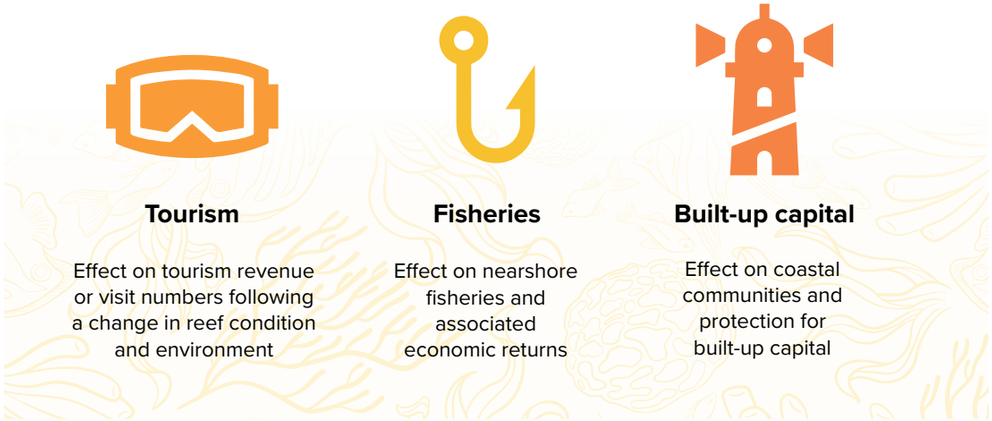
Table 4 Choice of methods depending on the assessment need

If the assessment requirement is:	Economic impact of reefs on tourism	Economic impact of reefs o fisheries	Protective value of reefs and their impact on coastal built-up capital and population
Then the appropriate method is:	• choice modelling • contingent valuation	• market price approach • production function method	• benefits transfer • cost of avoided damage • choice modelling method[92]

Some of the services provided by reefs are readily quantifiable, such as damage avoided, food supply (fisheries, etc.), raw materials, pharmaceutical resources, and tourism. On the other hand, other services are subjective and difficult to price, such as religious and cultural value, biodiversity protection, environmental aesthetics, climate regulation, and nutrient recycling.

For this report, our focus will be on the economic value generated by tourism, fisheries, and shoreline protection, and how these values can be quantified and then used, along with a database on hazards, exposure, and vulnerabilities, to build insurance and other risk transfer mechanisms that can protect coral reefs. Benefits provided by reefs to tourism can be based on average revenues, to fisheries based on average catch values, and to shoreline protection using the average value of built-up coastal capital and infrastructure in the area.

Figure 1: Quantifiable aspects of benefits provided by reefs.



Issues to be considered

For the benefits transfer approach, careful conditions must be satisfied. For instance, the valuation methodology from the study of the first location must be theoretically and procedurally valid; and assumptions at the different locations should have some similarities (example: environmental characteristics, population, infrastructure, economic services, or ecosystem).

Any errors usually arise from either the measures of value at the original study site or the application of these estimated values to another location. Depending on the context, the value may be adjusted or modified to reflect the attributes of the new site. The method of benefits transfer is useful since it reduces the cost and time spent on primary valuation studies.

92 Forster et al 2012.

The main steps of the benefits transfer method[93]

1. Describing scenarios by identifying the ecosystem goods and services to be valued at the policy site.
2. Describing the characteristics and consequences of the scenarios including the built-up capital or population. Information will generally be converted to per-person, per-household, or per-unit area values to an aggregate benefit estimate.
3. A literature review to find valuation data relating to the specific goods and services.
4. Assessing the available studies for quality and applicability, including the relevance of the studied sites to the target site. Any recalibration and adjustments necessary to account for the differences should be made.
5. Estimating the transferred benefits by referencing the value of measures from the site used in published studies to the target sites. This can be done by:
   - value transfer, by using a single value from a study site (or a mean value from multiple sites) to provide an estimated value at the target site; or
   - function transfer, by using a valuation function (from a single study site) to estimate the value at the target site, which is then calibrated to the conditions of the policy site by adjusting the variables in the function equation. Wherever possible, function transfers are generally more accurate than value transfers.
6. Determining the population and spatial extent over which impacts at the policy site are aggregated. Value estimates are generally aggregated over the affected population, or the area of ecosystem affected to compute overall benefits estimate.
7. Addressing the uncertainty by describing any possible variances and their impact on results and final estimates, as well as any other sources of uncertainty inherent in the analysis.

Several studies have examined the world's coastlines to identify countries and areas most likely to benefit from investment in the protection of coral reefs.[94] Many of those have tremendous potential for risk transfer solutions, including insurance. For example, the contribution of reefs to tourism and fisheries sectors, including their protective services, is estimated at $13.9 billion per year in the Coral Triangle[95] and $6.2 billion in Mesoamerica.[96] However, by 2030, reef degradation could see that value fall by almost 16 percent in the Coral Triangle and 50 percent in Mesoamerica. Also, a transition towards healthy reefs by 2030 could unlock an additional estimated value of $2.5 billion per annum in Mesoamerica.[97] In Indonesia, which has a coastline of almost 55,000 kilometres and is one of the largest fishing and aquaculture producers in the world,[98] investments in reef protection and restoration is expected to boost the value of reef services by about $2.6 billion per annum in the same period.[99]

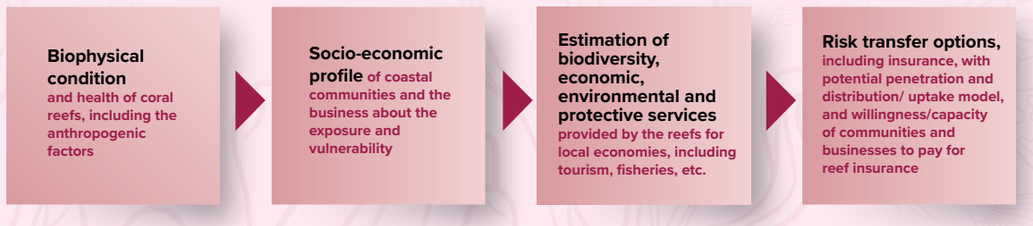
93 Boyle et al 2010; U.S. EPA 2010; Navrud and Ready 2007; van Beukering et al 2007; Wilson and Hoehn 2006
94 Beck et al 2018; Spalding et al 2016
95 The Coral Triangle is a triangular area in the tropical waters around Indonesia, Malaysia, Papua New Guinea, the Philippines, the Solomon Islands and Timor-Leste, containing more than 500 species of reef-building corals in each ecoregion.
96 UNEP 2018
97 Billions to be gained in coral reef investment, new analysis shows by UNEP
98 CIA 2021; World Bank 2015
99 UNEP 2018

4. MODELLING THE RISK

The elements of risk identified in previous chapters allow us to develop a risk modelling framework. This involves profiling the biophysical condition and health of coral reefs, along with the socio-economic profiling of coastal communities and the businesses dependent on reef vulnerability.

The risk modelling begins with an in-depth analysis of data on selected coral sites, using information from all available sources including engagement with local stakeholders.

Figure 2: Risk modelling approach



Valuations should include the services provided by the natural resource and moreover assess its inherent value. Policymakers need to start factoring in the natural wealth into national accounting, the same way they do for other public assets, such as roads, buildings, highways, or hospitals. Economic and financial valuation of reefs are important, to arrive at recommendations for suitable risk transfer solutions, including insurance. An in-depth analysis will be helpful in determining the values, costs and to develop the business case for reef insurance at the site.

4.1 Hazard data structure needs for insurance

Coral reefs are under threat from various hazards, as discussed in previous sections of the report. Gradual shifts in the environment such as warming oceans, sea level rise, altered ocean currents and increasing acidification, as well as localized man-made stressors like pollution, and overfishing, are hard to quantify and transfer through insurance or other risk sharing mechanisms, without innovative hazard monitoring approches.

On the other hand, damage from severe climatic events such as tropical cyclones can cause heavy damage to reefs by breaking and uprooting the coral colonies, shaking and collapsing their structures, damaging and reducing the crest height and rugosity, or eliminating live coral coverage.

Innovative approaches to hazard monitoring: Deep neural networks

A deep neural network is an artificial neural network with numerous decision-making layers between the input and output. It is part of a broader family of machine learning methods based on artificial intelligence using representation learning, which can be supervised, semi-supervised or unsupervised.

The regular detection and monitoring of hazards faced by coral reefs is a challenge. A human-only approach is susceptible to errors as even experts can fail to recognize a reef's underlying conditions. Some of the monitoring can be automated by investing in underwater robots.

With the help of temporal cues, using a tracker on a high confidence prediction by a convolutional neural network-based object detector, the reef hazard dataset can be used to continuously retraining the object detector.

Deploying a simple deep neural network to identify hazards or declining trend in coral population, can help in regular monitoring of reefs. This has also been empirically evaluated[100] in a coral object dataset, collected via remotely operated vehicles or autonomous underwater vehicles and human divers, showing the benefit of incorporating extracted examples from tracking, by using deep neural networks. [101]

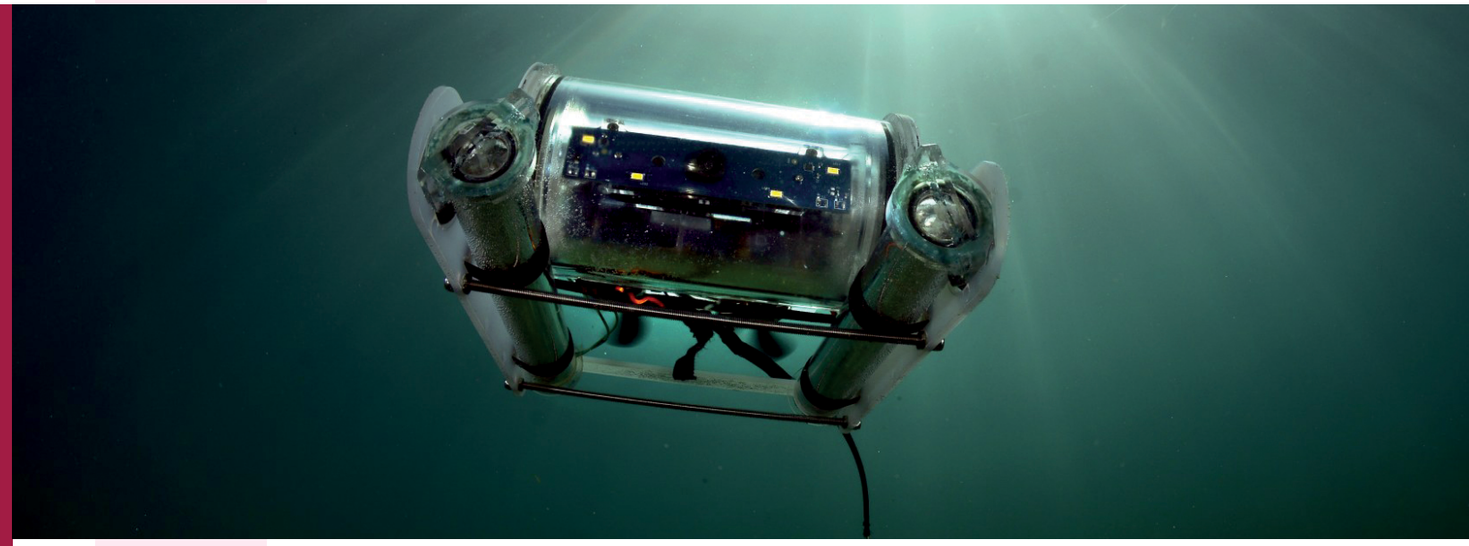
4.2 Geographical dispersion of risks

While reefs generally bring similar economic and protective benefits regardless of their geographical locations, it is imperative that their role and importance be analysed in location-specific pockets so that the hazards, exposure, and vulnerability can be quantified for risk transfer purposes. However, where possible, risk pooling at a regional level is preferred, to benefit from economies of scale.

The countries with reefs have some similarities, but their reefs face different hazards. For instance, Indonesia and the Philippines, which together account for almost 27 percent of world's coral reefs, are sizeable middle-income countries, while Fiji and the Solomon Islands, which also have significant coral reefs, are small island developing states (SIDS). These countries all score prominently on the existing reef mapping, and each has a unique set of needs for reef insurance and risk transfer models, owing to their different nature and hazards. Other factors that affect their coral reefs include varied levels of pollution linked with population growth, coastal development, and dependence on fisheries and tourism sectors.

One of the recent studies, though not limited to coral reefs, assessed the potential investment needs by comparing the business-as-usual (BAU) investment-approach and sustainable ocean-related investments in natural assets. The Navigating Ocean Risk study[102], supported by ORRAA, finds that key sectors stand to lose up to $8.4 trillion over the next 15 years without immediate action to safeguard ocean resources and align financial portfolios with the Paris Agreement's target to keep a rise in global temperatures within 1.5°C. The analysis highlights dispersion of

100 Modasshir and Rekleitis 2020
101 Mahmood, A., Bennamoun, M., An, S., et al 2016
102 WWF and Metabolic 2021



financial risks cumulatively in the blue economy, across sectors such as coastal real estate and infrastructure, fisheries, aquaculture, ports and shipping, tourism, and marine renewable wind energy. For developing insurance and risk transfer solutions, the need is to expand on this and explore the geographically specific data on exposure values that will help in estimation of sum insured values and required level of financial resources to support insurance premium funding.

4.3 Exposure data modelling

Direct exposure and vulnerability

To calculate the onshore disaster impact on the built-up capital, and population, segments can be analysed in spatial units using the digital elevation model.[103] The data showing the population count and built-up capital can then be mapped against historical disaster data with the socio-economic exposure estimates.

In line with various published methods on risk quantification[104], WorldPop[105] is a good source for spatial data on population, which can then be mapped against the latest local census data as available.

The value of built-up capital can be calculated based on global datasets, such as the Global Assessment Report (GAR) on Disaster Risk Reduction (DRR).[106] The latest edition (2019) provides data with at least five-kilometre resolution, including values of residential, industrial, services, and government buildings. The per-capita values can be calculated by using the population information in the same publication. All data can be scaled back to the appropriate resolution.

103 Paxton 2017b
104 See footnote 87 on CFTs
105 WorldPop provides peer-reviewed, open-source, and high-resolution geospatial data on population distributions.
106 The UN Global Assessment Report on Disaster Risk Reduction (GAR) is the flagship report of the United Nations on worldwide efforts to reduce disaster risk.

To assess the impact of events on the tourism economy, numbers can be extrapolated from multiple sources and mapped against data provided by the local businesses. For example, the economic census and online tourism portals can provide information about hotel locations, room prices, star ratings, number of rooms, and other variables. Financial exposure to a disaster can be taken as the maximum probable loss from property damage in the absence of the reef protection. This ideally must be done for each type of risk and with multiple intensity levels, such as varying cyclone category, or flood heights, formed with the help of vulnerability curves from historical losses. Once a baseline estimate is established, this will then provide a function or lookup table for estimating the sum of insured values, based on the hotel's rating.

No model can provide complete certainty; however, any model will need to be well-calibrated by intercepting potential modelled loss values along with the historical losses.

Historically, many reefs have provided effective protection against disaster events, such as tropical cyclones. One approach for examining this effect can be by studying the differences in modelled losses and actual losses,[107] mapped against the impact of the hazard. For example, in the case of a tropical cyclone, the net onshore water levels can be compared with the modelled levels of water in the absence of a reef. Extrapolated with the weighted intensity factor of the hazard, the power of attenuation can be computed as: $\alpha = \beta \left(\frac{\delta}{\delta' - 1}\right) + \bar{E}$

Where
α = attenuation
β = weighted intensity level of the hazard
δ = modelled water level without the reef
δ' = actual water level with the reef
$\bar{E}$ = error term

107 See Table 1 for approach on estimating 'on-shore damage intensity'

The same approach can be used to model the financial impact on built-up capital, in a situation with and without the reef, as well as other areas such as loss of income for tourism businesses and hotels. Knowing these figures will form the basis of the sum of insured values.

Indirect exposure and vulnerability

It is hard to precisely quantify the exposure and vulnerability levels with regards to indirect losses. Such indirect damage often takes the form of economic losses surfacing because of direct losses. These may include opportunity loss due to business interruption, or impact on the regenerative capacity of future revenues due to loss of current customers. However, some rough estimates show that the loss of coral reefs potentially puts $1 trillion at risk globally[108], including the loss of shoreline and coastal erosion costing $9 billion per year by putting at risk the coastal housing, agricultural land, and beaches.[109]

The quantification of indirect losses is a challenge due to various subjective factors. However, estimates of indirect damage can be calculated by multiplying the modelled direct damage with an average ratio of indirect and direct damage for past disasters. Some adjustments may be needed as the ratio of indirect to direct damage may increase where the overall disaster is more severe.

108 Climate Council
109 The Reef World Foundation

5. ASSESSING, REDUCING AND SHARING RISKS

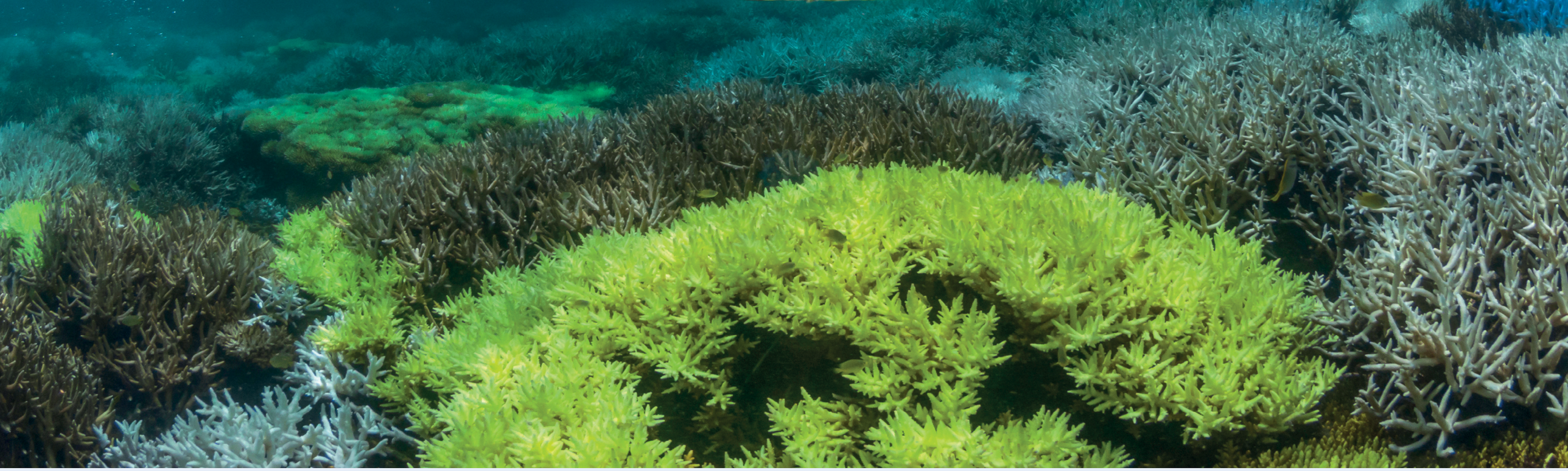
5.1 Developing a business case for reef insurance and financing

To fully understand the potential for insurance and other risk transfer mechanisms in relation to a coral reef system, it is necessary to examine the specific conditions, hazards, and benefits at that location, including both the ecosystem and the socio-economic context. This helps identify the challenges and opportunities vis-à-vis creating an enabling environment for insurance and other investments.

This approach can be presented in five stages:

Figure 3: Developing a business case for reef insurance and financing

The first three stages are widely practised among policymakers and conservation practitioners. Keeping these key parameters in mind, it becomes easy to understand the reef landscape and assess the potential scale of insurance coverage, including how much investment is required to get the desired results. More attention is required at stage four (estimating the conditions and the potential for insurance to help) and five (assessing possible insurance and other risk sharing mechanisms) for an effective development of insurance instruments to mitigate the impact of damage to coral reef systems. A better understanding of the technical and financial aspects of risk protection needs will help policymakers, managers, and local communities to build reef resilience and adjust plans for disaster response, increasing the protection of the environment, infrastructure, and coastal communities.



These stages allow solutions to be categorized into three layers:

- **Firstly**, wherever possible, disaster risk reduction (DRR) should manage risk exposure, bringing down losses and the cost of insurance.
- **Secondly**, where DRR is not possible, risks can be modelled, and suitable insurance products can be designed to transfer the risk to the insurance sector.
- **Thirdly**, where insurance is not possible nor viable, other forms of risk transfer solutions must be explored, such as the alternative risk transfer (See Section 7.4).

Figure 4: The step-up objective approach

To process this aim, the profiles of each location must be compiled, which will help in documenting hazards, their risk exposure, and the vulnerabilities. As an entry point, carrying out an analysis of risks, socioeconomic, and regulatory data enables insurance products and the prioritizing of investment decisions for reef risk management.

Figure 5: Process of risk indentification and transfer

5.2 Macro challenges to reef risk transfer

Some of the macro challenges and recommendations to promote reef insurance, improve reef risk reduction, and encourage risk transfer are as follows:

Challenges	Description	Recommendations
Absence of risk exposure values	The availability of data on risks or hazard details is useful, but the data around the building blocks exposure values and vulnerability is largely absent. There is no significant mapping of datasets on exposures in the line of such hazards, such as data on the economic valuation of exposed built-up capital, the coastal businesses and livelihood of communities. This is one of the limitations and an area that will require further work to improve understanding of exposure values and avoid possible over- or under-utilization of insurance coverage. The current datasets available have useful information regarding the reef location that can be mapped against the risks and hazards, but the same information may not be sufficient from an insurance point of view. For example, the data pertaining to the risk map with the description of hazards (floods, cyclones, etc.) is largely available, but without the financial values of exposure and vulnerability of various elements (economic use, etc.), assets and reconstruction costs, it may not be possible to quantify the value insured or estimate the costs of insurance premiums.	One of the key solutions is to support and promote the local authorities in establishing the risk transfer dataset needed for the development of suitable insurance and risk sharing products. Historical disaster data on hazards, exposure, and vulnerability needs to be made available. This must include data on loss and damage at the local level.
Anthropogenic factors discouraging insurance and other risk transfer mechanism	Various anthropogenic factors, like wastewater disposal, etc. increase the density of inorganic substances and turbidity, thus threatening reefs, that is further exacerbated by rising sea temperatures and acidification. The reduction in hard coral cover due to this results in decreased fish biomass and an increased macroalgal density, making reefs fragile and potentially less insurable. Another common threat is due to dumping plastic waste which affects reef health and regeneration capacity.	There is a need to invest in improving sewage and sanitation practices and implementing stricter regulations to control and prevent spills. This will not only have a positive impact on reef health and coral recovery, but also the viability and sustainability of insurance and other risk transfer solutions.
Exogenous factors affecting insurability of reefs	Various species of fish in different locations have varying impacts on reefs. For instance, the long-spined sea urchins promote coral health by reducing algae, especially in the case of overfishing or decline in the population of other grazing fishes. Further the declining population of other important species which are critical to maintaining the reef health, such as parrotfish being effective in grazing macroalgae and keeping reefs clean, is a major challenge.	The number of protected areas and fish replenishment zone areas should be increased to protect and maintain the balance of fisheries population. This can also become an important indicator for measuring the reef health as the maintained or increasing biomass of the herbivorous fishes which help corals grow and thrive. Also, increased enforcement of fishing regulations will be helpful, which will also bring improvement in fisheries supply chain and reducing the risks to reefs, thus reducing the insurance and risk transfer costs.
Unsustainable tourism	Tourism is one of the most important and fastest-growing sectors in the countries with prominent reef presence. The physical coral-tourist contact leads to abrasion in the epidermis of corals, which is essentially their skin layer, and can make them vulnerable to infections or disease. Also, sunscreen used by most beachgoers contains octinoxate and oxybenzone. These chemicals are harmful to the coral's ability to reproduce and hinder their embryonic development.	There is a need to align the management of reefs with the tourism impact. Sustainable and eco-tourism practices may help ensure that coral reefs are not under pressure, prone to damage and/or threat, thus benefiting the economy, and decreasing the needs and costs of risk transfer. Increasing education and awareness about reef importance for tourists and locals can play a key role in ensuring reef survival. Making people aware of simple issues such as not touching or stepping on coral reef, or avoiding the use of chemical sunscreens, may bring about a significant positive impact as local community members and tourists tend to understand the merit of reef protection practices. Moreover, this will also have a positive impact on the insurability of reefs.

5.3 Reef restoration

It is imperative to share and transfer risks to improve the resilience of the coral reefs and secure the lives of those that depend on them. This starts with an ecosystem of reef restoration facilities, supported by reef insurance and compensation management scheme.

The services provided by reefs are of high value. It is more cost-effective to insure and maintain the structure and integrity of existing reefs, even if they are degraded, than to build new coastal defences and let the reefs to continually get damaged.

Insurance payouts can fund vital and prompt reef repairs, supported by government commitments couple with on-the-ground rapid response. Such an insurance mechanism will require innovative financing models with the private sector.

Post-storm reef restoration

Cleaning debris and starting the restoration activities for broken coral colonies - within a few days after the storm - increases the chances of survival for the corals,[110] reducing long-term damage and improving the reef's future ability to withstand events and protect the coastline.

The Post Storm Protocol[111] for such reef restoration includes:

- Clearing the debris, such as sand, loose stones, or broken corals, from the main reefs to avoid further damage.
- Reattaching the loose colonies and broken fragments.
- Transporting broken pieces to nurseries for recovery and future transplantation.

Typically, the insurance industry relies on verifiable, longitudinal data to generate risk models and actuarial analysis. However, due to availability of limited data on reefs, not all risks can be insurable. In such cases proxy measures need to be developed.

Certain risks, such coral disease and bleaching, are not easy to model for insurance purposes. But these can be built into the overall risk framework. Increases in water temperature can be modelled and monitored. Such changes can cause coral bleaching (uninsured event) rendering the reef weaker and more vulnerable to cyclones (insured event), and therefore calling for an overall insurance payout.

In case of the prominent example of Mexican Caribbean reef insurance, hurricanes were the greatest hazard to reefs. The tourism industry of the coast of Quintana Roo was primarily interested in insurance to recover from the impacts of Sargassum overgrowth,[112] but for such events there is not enough data available to predict the probability of the event to occur, making

110 Fernando et al 2019
111 Zepeda et al 2019
112 The Sargassum is a genus of brown macroalgae, distributed throughout the temperate and tropical oceans of the world, where they generally inhabit shallow water and coral reefs. The genus is widely known for its planktonic species. Deforestation and fertiliser use are among the factors thought to be driving the growth, inundating the beaches, causing an environmental nuisance.

it less viable for insurance. However, with the broader risk coverage of the insurance policy, when Hurricane Delta hit in October 2020, the reef insurance policy was triggered, resulting in a payout of almost $800,000 to offset the costs of repairing the insured reefs and restoring beaches along the Mesoamerican Reef in the Yucatan Peninsula.

A combined approach

One study examined the benefits to the reefs and to the local economy from investment in a combination of:

- marine protected areas;
- construction of wetlands for enhanced wastewater management;
- afforestation for erosion management; and
- vegetative filter strips to reduce erosion on cropland.

It found that these interventions together could reduce the projected loss of benefits due to reef degradation between now and 2030 by 70 percent in the Coral Triangle, and 45 percent in Mesoamerica.[113]

113 UNEP 2018

6. CREATING THE ENABLING ENVIRONMENT

There are more than 200 international legal and policy instruments that directly or indirectly support conservation and sustainable management of coral reef ecosystems, addressing almost every risk factor they face, and including several that are legally binding.[114]

These instruments are focused on action by countries, that have the primary responsibility for fulfilling most of the commitments. The United Nations Convention on the Law of the Sea (UN-CLS) provides the legal framework for all activities in the oceans and seas and establishes the rights and commitments of countries within different maritime zones. In their territorial sea, coastal countries exercise sovereignty over natural resources. The UN-CLS treaty also establishes the general obligation for countries to protect and preserve the marine environment, though only a few governance mechanisms have been established at the country level.

Continuous engagement of stakeholders which includes reef managers, policymakers, local businesses, hotels and tourism operators, and the insurance and financial industry, is important to assess the feasibility of reef insurance and ensure ongoing commitment. Common institutional issues start with the reef being seen as a publicly owned asset. Typically, only governments and public authorities have the legal mandate to undertake or allow reef maintenance and restoration activities.

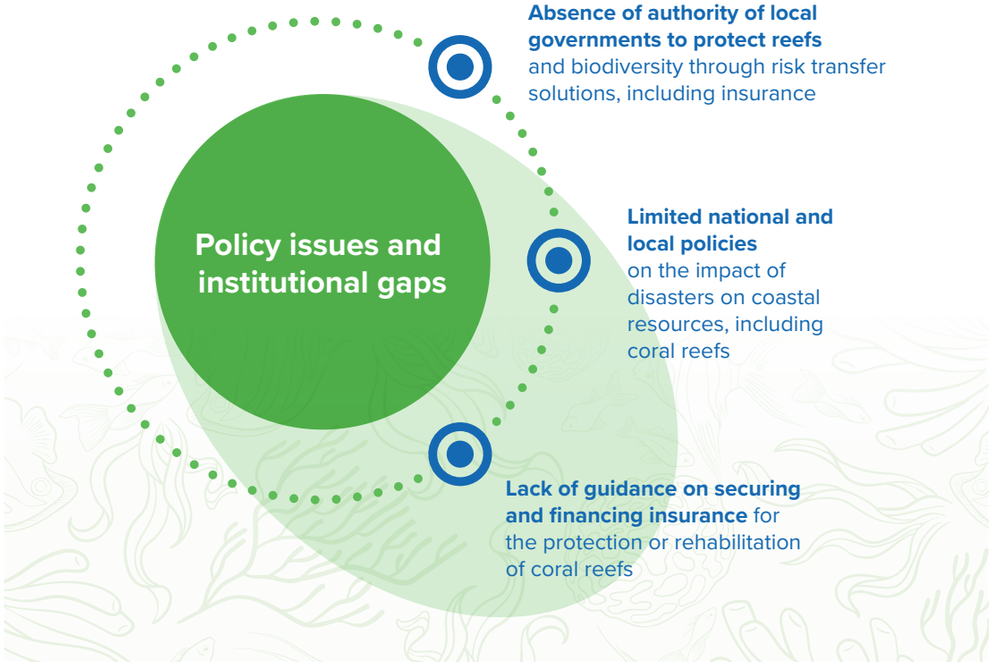
114 UNEP 2019

To build a strong enabling environment for reef insurance and risk transfer solutions, there must be a clear understanding of location-specific policies, regulations, and the role of legal authorities about coral reef management. This can be done by creating a stakeholders' and policy mapping, and assessing these three dimensions:

Figure 6: Developing institutional policies and structure

The following provides a high-level overview of the gaps and issues in the policy frameworks in countries with reef insurance potential and the recommended solutions.

Figure 7: Common gaps within country frameworks



6.1 Institutional and regulatory arrangements

In this research, we have found that no country explicitly prohibits any public or private entities to derive benefits from the existence of coral reefs, financially or otherwise, and from legally purchasing insurance for protecting such benefits. This extends to all stakeholders such as local governments and businesses, such as hotels and tourism operators.

Insurable interest to purchase insurance

Coral reefs are generally considered as public/natural assets, with the ownership title resting with the state. However, as private-sector stakeholders have an inherent insurable interest due to intrinsic financial or economic benefits or loss connected with reef, these stakeholders should be able to purchase an insurance cover linked to reef.

It is imperative to assess the enabling provisions and gaps in the institutional and regulatory framework of the countries where reef risk solutions are needed. Common themes in this respect are as follows:

- ***The policy and institutional frameworks in general already provide for the importance of coastal resources, including coral reefs,*** through established policy steering and enforcement structures. However, the level of complexity varies. For example, in some of the Pacific island states, the co-existence of contemporary laws and traditional customs pose challenges in enforcement.
- ***The governance for the protection and management of reefs is generally shared between the central and local governments.*** Local authorities tend to be entrusted with powers for policy enforcement, resource mobilization and community engagement, through various mechanisms including marine protected areas (MPAs).[115] The regulation and governance of insurance and financial products, however, remains at the national level. Also, there is a significant variation between the levels of responsibility assigned to the local government and the national government, respectively, in terms of insuring public resources.

Fiji: Legal provisions and limitations for reef insurance

The protection of Fiji's fisheries and coral reefs is embedded in a complex legal and governance system that combines a modern legal framework based on English common law and a traditional iTaukei system grounded in the country's customs and history. Currently, there is no comprehensive ocean or MPA policy in Fiji, but there are several regulations that are tangentially relevant to MPAs.

Locally Managed Marines Areas (LMMAs) have been established through the main law on Environment Management, although it has no specific provision on MPA establishment and only a blanket provision for the protection of the country's environment. The Fisheries Act 1942, modified in 1991, provides the scope for implementing fishing restrictions through regulations. The Offshore Fisheries Management Decree 2012 designates MPAs and requires the creation of fishery management plans.

- ***The interface between coastal resource management (CRM) and insurance as a risk management solution is generally not articulated in the policy frameworks.*** Making the connection will require close engagement at both the national and the local government levels.
- ***There does not seem to be wide experience in shaping funding mechanisms that integrate insurance,*** although current frameworks do enable local governments to mobilize resources for coastal resource management (CRM) to some extent, including for coral reef protection.

115 A "protected area" in this context was defined in 1994 by the IUCN and the World Conservation Monitoring Centre as "an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means."

The Philippines: Policy and institutional arrangements

In the Philippines, several multi-sectoral national and local laws and policies provide for the management of the country's natural resources, focusing on fisheries and coastal resource management (CRM), and emphasizing their importance for food security and local economy. Local governments units (LGUs) have been assigned the lead role of planning and implementing integrated coastal management (ICM) programmes, involving communities and civil society in the process.

The Republic Act (RA) 8550 Philippine Fisheries Code 1998 explicitly bans coral exploitation and exports, as well as the destruction of coral reefs and marine habitats. It authorizes LGUs and the Department of Agriculture to declare portions of municipal waters as fishery reserves and to establish fish refuges and sanctuaries.

The Act 7160 Local Government Code 1991 establishes the jurisdiction of LGUs in management of municipal waters where some coral reefs are found and sets out the functions of the LGUs in the legislation and enforcement of local ordinances on reef conservation, and to generate own revenues for the execution of reef protection. It empowers LGUs to establish marine protected areas (MPAs) within their respective jurisdictions. It also mandates LGUs to develop medium-term CRM plans, though it is not clear if such plans exist.

When it comes to insurance, LGUs are not explicitly mandated to purchase reef insurance. This lack of authority to protect reefs and biodiversity through insurance is an area of gap that requires policy advocacy to enable LGUs to procure risk transfer solutions, including insurance, for protecting reefs.

The LGUs, through ICM programmes, are required to promote private-sector involvement for the protection and rehabilitation of coral reefs and incorporate the coastal and marine resource accounting in the national and regional accounts.

Interestingly, the Republic Act 10121 Philippine Disaster Risk Reduction and Management Act 2010 and the National DRF and Insurance Strategy 2015 have also been issued. These instruments deal with disaster risk finance (DRF), with a focus on insurance. The LGUs have the mandate to plan, budget for, and implement projects for disaster response and recovery. However, the impact of disasters on coastal resources, including coral reefs, has not been considered in these policies, which is another missing link.

Additionally, it is not clear whether it is allowed to use local funds for calamity insurance related to the protection and rehabilitation of coral reefs. Most insurance purchased by governments around the world has been for catastrophe coverage of public assets, while some governments have also provided subsidized crop insurance to farmers.

The DRFI portfolio in the Philippines mostly relies on risk reduction, i.e., the National Disaster Risk Reduction and Management Fund (NDRRMF) and the Local Disaster Risk Reduction and Management Funds (LDRRMF). Around five percent of estimated public revenue from regular sources are allocated for risks related to hazards with high frequency and low severity. Often there are contingent credit lines for risks with medium frequency and severity. For risk transfer, the government relies on the state-owned Government Service Insurance System (GSIS) indemnity-based insurance instruments for risks related to hazards with low frequency and high severity. The LDRRMF specifies the possible DRM activities for which it can be used, including pre-disaster preparedness programmes and payment on calamity insurance. However, there is no explicit guidance on securing insurance for the protection or rehabilitation of coral reefs, which a major limitation in the framework.

The LGUs are allowed to raise revenues and secure funds to implement ICM through taxes; allocation of funds from internal revenue; securing loans and grants; adopting user-fee schemes for waste management, leisure purposes, and other environmental services; arranging credit financing schemes; and other options.

In the Philippines, the LGUs are members of the NIPAS Protected Area Management Board. The Department of Agriculture through the Bureau of Fisheries and Aquatic Resources has a general responsibility for the management of fishery management areas. The Department of Environment nd Natural Resources (DENR) has the overall jurisdiction over the entire natural resources and environment sector.

6.2 Common institutional issues

Generally, the insurance regulatory frameworks in different countries describe the principles governing the insurability of assets. Since coral reefs are public assets, the framework must allow for public authorities to have an insurable interest in the reefs, so that they can legally buy insurance for them.

The damage to coral reefs by disaster events can be minimized by prompt clean-up and restoration activities. However, the financial and technical resources for this are often scarce among stakeholders including coastal communities, businesses, and the local governments, for a variety of reasons:

- **There is an absence of precise, evidence-based models** quantifying the economic and resilience benefits of coral reefs and the financial impact of the loss of such benefits. Such models are essential to make the business case for investing in the maintenance and restoration of reefs, along with a complete analysis of funding, demand, and supply.
- **Stakeholders, including governments, coastal communities, and businesses, are unaware** of the importance of reefs in supporting economic activities, protecting property and people.
- **Stakeholders are also unfamiliar with *ex-ante* risk transfer solutions,** including insurance and nature-based strategies, and its potential to protect coral reefs.
- **There is a shortage or even absence of socio-economic data on vulnerable communities and infrastructure** that directly or indirectly benefit from the economic and protective services provided by reefs. This includes data related to non-monotonic economic impact on micro and small businesses, and most vulnerable segments of the population, including low-income women-led households.
- **There is an absence of adequate and enabling policy and legal frameworks,** and institutional structures for the governments and policymakers to recognize reefs as assets and therefore qualify their insurable interest. This significantly reduces the possibility of risk takers, such as insurers and reinsurers, to offer robust insurance products.
- **There is limited insurance penetration and density among remote islands and coastal communities.** This is a two-way problem: There are no suitable insurance products on offer from the supply side, mostly due to insurers' limited understanding of the need for and potential of nature-based solutions, and the awareness and interest from the demand side is also scarce.
- **There is limited knowledge and technical capacity of local stakeholders**, such as governments and coastal communities, to carry out maintenance and *ex-post* restoration on coral reefs.

Ex-ante arrangements and investments in risk transfer solutions are necessary to ensure that when the need arises, sufficient and timely resources are readily available for reef restoration and conservation.

Also, the classes of insurance and the type of assets in which insurers are allowed to invest vary significantly from jurisdiction to jurisdiction. The local solvency regulations also have an impact on insurers' capability to insure or invest in reefs, since the non-recognition of investments as admissible assets or uncertainty in projected claims can have a huge impact on underwriting capacity or profitability.

Another potential problem is that the money paid out in compensation directly to the government. The reef owner may be preoccupied with spending on other disaster relief efforts rather than investing into the reef restoration.

6.3 Improving the enabling environment

To pave the way for reef insurance and other risk sharing solutions, the enabling environment must be improved in terms of: (i) strengthened legislation; (ii) improved institutional policy, regulatory framework, and capacity; (iii) financing mechanisms; and (iv) piloting product innovations. These interconnected steps can be carried out simultaneously in many cases.

Strengthened legislation

Due to the overlapping laws and governance frameworks in some of the jurisdictions, modern reef management and protection techniques are not effectively implemented. In some cases, locally managed marine areas (LMMAs) are not formally recognized. There is a need to harmonize existing laws and policies relevant to MPAs.

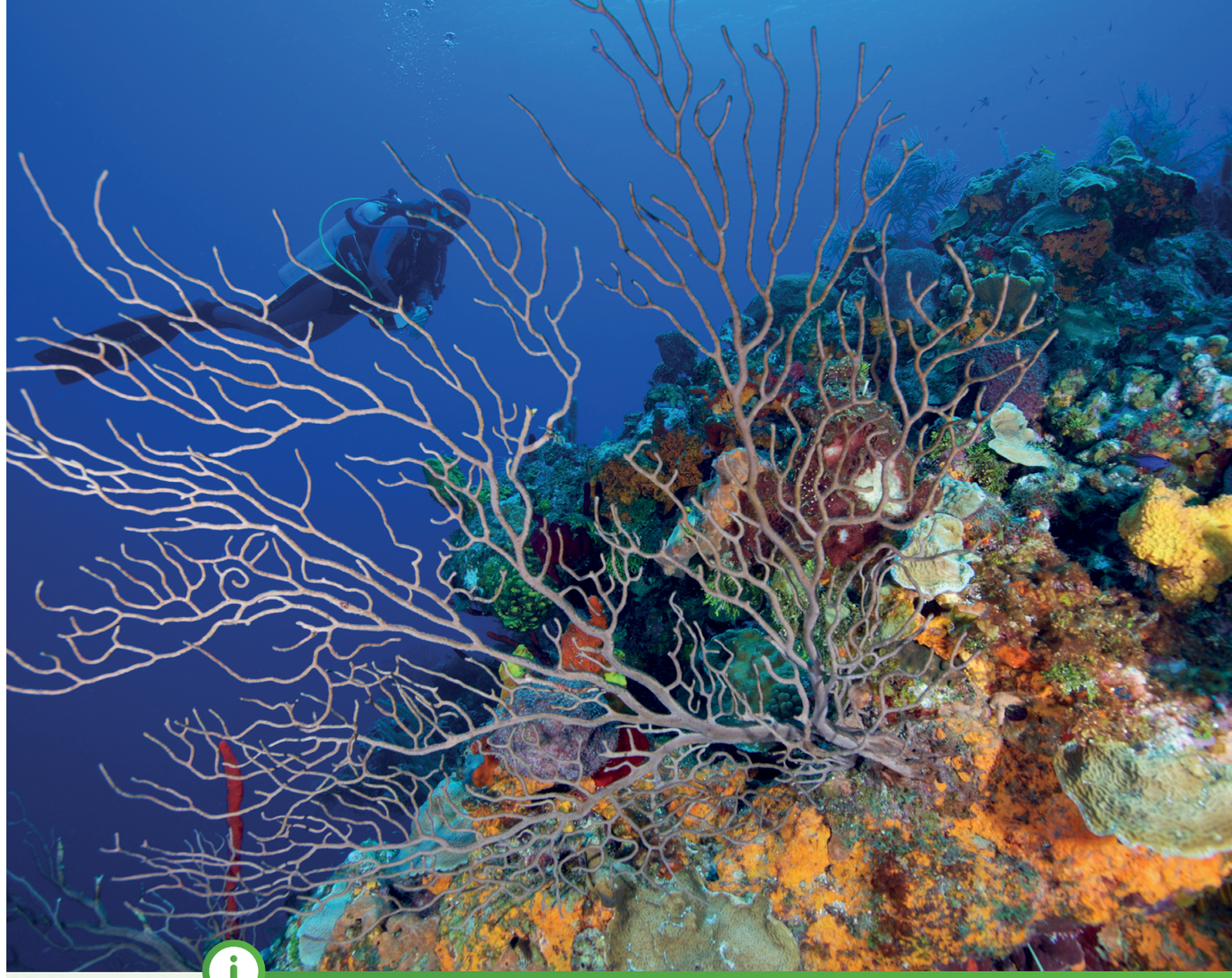
There is no consistent enforcement of licensing for fishing activities that put unreasonable pressure on biodiversity conservation needs. There is a lack of coherence in the coastal resource management plans, including unclear direction on fishery licensing, and inadequate systems of coastal monitoring and surveillance.

In some countries, national environmental councils exist but they have not been functioning smoothly. Such bodies should include representation from ministries responsible for land, mineral resources, agricultural, fisheries, forests, tourism, non-government organizations (NGOs), and the business community.

In some of the jurisdictions, there are LMMAs that promote the preservation, protection, and sustainable use of marine resources. However, such LMMAs are often informal in nature, existing outside the legislation, and/or are under rules that conflict with the main legislation. Some of these LMMAs that operate outside the legal frameworks however have formalized an effective management practice. This disconnect highlights the inadequacy of many existing legal instruments which are needed for effective marine resource management.

In some countries, fees and fines are paid into funds[116] for the conservation of natural resources and initiatives related to climate change. However, risk transfer instruments such as insurance are not mentioned in the laws governing these funds, so those resources cannot be easily streamlined and used for instruments like insurance.

116 An example of these the Conservation Trust Funds (CTFs), legally independent institutions providing sustainable financing for nature conservation. CTFs mobilize resources from international donors, national governments, and the private sector, and provide grants to projects. For more details see the comprehensive analysis of CTFs by the Conservation Finance Alliance.



Fiji: Insurance or no insurance?

In Fiji, there is the Natural Disaster Relief and Rehabilitation Fund (Prime Minister's Fund) which only funds post-disaster response, relief, or rehabilitation efforts. Insurance for public assets has only been held for a few asset classes and has often been insufficient when disasters strike. The country does not participate in the parametric cover policy offered by the Pacific Catastrophe Risk Insurance Company (PCRIC) as it appears that the risk attachment point does not meet the specific needs of the country for the severity of events to be covered.

However, the government, in collaboration with a private insurer, has started to provide microinsurance coverage for certain groups, which demonstrates the government's interest in risk transfer solutions. This experience could be leveraged to promote the value of insurance for marine conservation, and reef protection.

Solomon Islands: Limited enforcement and understanding mismatch of stakeholders

The protection of coral reefs in the Solomon Islands is embedded in general government policy frameworks that address marine resources. The responsibility has been devolved at provincial government levels, which have enacted laws to conserve coral reefs in provincial waters and collect annual fees from commercial entities, which are meant to be used for conservation efforts. However, in practice these fees are seldom or only partially collected. Efficient enforcement is needed so that the fees and levies can be collected and channelled for procuring risk transfer solutions for reefs, such as insurance.

In the Solomon Islands, the National Biodiversity Strategy and Action Plan 2008 identified sustainable financing as one of its priorities for biodiversity management, in addition to the Protected Areas Act 2010 which includes a provision for the establishment of a trust fund. However, the institutional arrangements for the implementation of these laws are still non-existent. This means that despite the policy and legal emphasis on the importance of coral reefs for food security, rural livelihoods, and coastal protection, there are only limited financial resources available to carry out any meaningful work for reef protection.

The Solomon Islands was a participant in the first two seasons of the Pacific Catastrophe Risk Insurance pilot. But the government opted out in the third season after learning that the Santa Cruz earthquake and flash floods in 2014 were not eligible for payouts under the insurance terms as per its expectations.

Improved institutional policy, regulatory framework, and capacity

As the data gaps are filled, more scope for reef insurance and risk transfer solutions is expected to emerge. This will lead to insurance-for-nature solutions, requiring financial mechanisms to protect and restore coastal ecosystem. It will also call for more adequate provisions in the regulatory framework, especially in terms of data management, claims, and consumer protection.

Public authorities can receive training and knowledge to collect and monitor data to be able to fill the gaps which includes the valuation of ecosystem benefits (protection from floods and storms, tourism, fisheries, etc.), exposure details of the asset (or income) losses correlated with the reefs, capacity and costing to carry out regular reef ecosystem maintenance and restoration.

Financing mechanisms

Most international commitment instruments are not linked to financial mechanisms to help fund the reef-risk mitigation or risk transfer costs. This presents a challenge for the many low- and lower-middle-income countries with reef-related commitments.[117] Of the 591 reef-related commitments, only about 25 percent refer to financing provisions or mechanisms, including general calls for developed countries and development finance institutions to support

117 Burke et al 2012

developing countries. There is a need to expand the financing mechanism specifically for coral reef ecosystems and provide grants or concessional financing to low- and lower-middle-income countries with coral reefs, to help those fill their capacity gaps.

Piloting product innovation

Facilitation is needed to innovate and offer contemporary insurance and risk transfer products, directly protecting the reef system. Designs for potential innovative solutions are discussed in the chapter SOLUTIONS THROUGH RISK TRANSFER. This must be combined with incentives for disaster risk reduction (DRR), and pre-disaster activities to strengthen the reefs, and offer risk transfer capacity for the residual risk.

Linking the level of property cover with the DRR and resilience measures on nearby reefs should incentivize the insured to invest in reef resilience to lower their premiums. This would also benefit insurers in terms of lower payouts.

Policy advocacy with local policymakers, public authorities and fiscal management agency can facilitate these incentives, example, tax rebates for investors and buyers of reef insurance.

Reef insurance in Mexico: Policy support and ownership

The reef insurance in Mexico would not have been possible without the commitment of the Quintana Roo Government, which purchased insurance policies over the years. The funds for the insurance came from the Coastal Zone Management Trust, established in 2018 by the government with the support from partners.

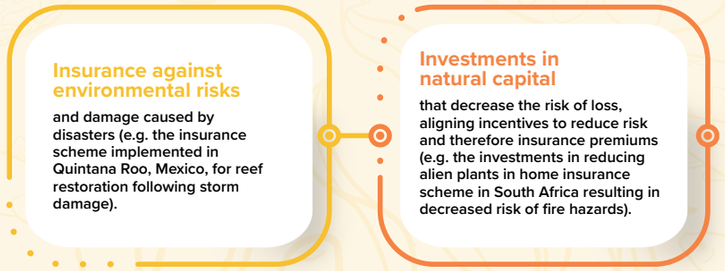
Covering 160 km of coast, the reef benefited from an insurance payout in 2020 to repair hurricane damage. Together with the insurance, the National Commission of Natural Protected Areas launched the post-storm response plan involving nearly 80 trained volunteers to repair the reef. Their work involved stabilizing displaced coral colonies as well as rescuing and transplanting broken coral fragments.

While the public-funding approach to reef management suffers from insufficient resources and falls short of international targets, new and innovative sources of private finance can help. The UN Environment Assembly resolution 2/12 of 2016 has also emphasized the business case for both private and public sectors to invest in the protection, preservation, and enhancement of reefs.

7. SOLUTIONS THROUGH RISK TRANSFER

Risk transfer solutions for natural capital, including insurance, can be divided into two major categories: *insuring the risk*, i.e., preparing when a hazard occurs; and *investing in natural capital*, i.e., taking steps to reduce the frequency, severity, or impact of hazards. Reducing risks results in further advantages like reduction of insurance premiums.

Figure 8: Ways of risk transfer



The overall cost of reef restoration activities varies significantly depending on many factors, such as the degree of damage and restoration needs, local cost of labour, and the required density of transplanted corals. Despite progress towards cost-effective reef restoration schemes, reef repair and restoration is still expensive. Moreover, for lost coral colonies to regenerate it takes a significant number of years. This recovery also depends on the extent of the damage and the scope of the repair.

This snapshot captures only immediate needs as the long-term response tends to be costly and calls for a business case for insurance and other risk transfer solutions. It is key to address immediate needs to avoid future expenses regarding reef repair activities. The economic potential, livelihood, and coastal protective capacity gets compromised without investing in ongoing restoration.

7.1 The necessary conditions for insurance solutions

Insurance is a risk management tool used to transfer risk from the owner or manager of an asset to the insurance provider at the cost of a premium. The insurance buyer pays the premium to seek access to funds in case the insured asset suffers damage specified in the insurance policy. A dedicated insurance solution to cover the restoration cost for the reef is an essential step if the full protective value of the reef is to be reinstated.[118] Insurance for reefs is suitable when the following criteria are met:

118 Reefs for resilience

- ***Adequate reef risk information is available*** to make risk pricing and underwriting possible, enabling insurers to calculate potential losses and, the cost of insurance premium.
- ***The cost of the expected damage is more than the premium*** paid by the insurance buyer. If it is not so, then again it is cheaper to pay the repair costs.
- ***Unpredictable events are the cause of reef damage***: If the reef losses are due to foreseeable reasons such as human pollution, etc., then buying insurance wouldn't be cheaper than the full cost to repair the reef.
- ***The damages to the reef should be repairable,*** otherwise the insurance claim proceeds cannot be used to repair the reef. If the reef is damaged beyond repair, insurance cannot be applied.
- ***Risk is diversifiable.*** Insurers need a large enough pool of insurance buyers to diversify their own risks. And, together with the support of reinsurers who tend to have much bigger risk absorption capacities.

Reef insurance is usually a suitable solution in case of the ***high-severity, low-frequency hazards***. The risks associated with less frequent hazards can be passed on by the local authorities to insurers and reinsurers when it is affordable to do so. Severe climate disaster risks are best mitigated through insurance as these risks are financially burdensome for local authorities to absorb and can cause losses beyond their financial capacity.

The nature and level of insurance against more frequent hazards, such as seasonal floods and cyclones, depends on the priorities of the local authorities and stakeholders. For example, at one location there may be a higher concentration of vulnerable businesses, while at another location there may be more vulnerable households. Also, these risks may not remain the same forever and show variable behaviour over the medium to long term, i.e., with the changing return-period of different hazards the intensities also change, and often these risks are sporadic, which makes it hard for local governments to allocate budget.

Some of the categories where insurance can be developed are as follows:

- **Business protection**: To protect business assets, compensate for business interruption, etc.
- **Aquaculture/mariculture protection**: To protect fisheries and productive assets in coastal areas
- **Household protection**: To protect private coastal dwellings and properties
- **Low-income population**: To protect lives and livelihoods of the low-income population

The pure risk premium for reef insurance depends on the perils and the type of insurance cover. For example, the insurance payout for reef restoration will also include cover for the beach clean-up costs and may also include the coverage for onshore losses. A reef restored in a timely manner means continued protection of the coastal built-up capital, and the prompt resumption of business and tourism activities. To cover these costs a sustainable source of insurance premium funding should be established together with a long-term financial plan that considers cost fluctuations over time. The cost of protecting a reef via insurance is small and therefore worth investing in. Insurance ensures maintenance of a reef's health and ensures that reefs can continually yield economic and financial benefits.

In sync with plans of various developing countries, reef-related insurance is seen to increase the overall insurance outreach. For example, the government of the Philippines aims to make insurance available to an additional 50 million people by 2022.[119] This aims to protect people living in disaster-prone areas, one of the potential ways of which could be by insuring reefs to maintain reefs' protective barrier, thus protecting the communities that depend in them.

The reef-insurance solutions may use different models to calculate the criteria and the claim amounts. These include the following:

- **Parametric insurance** is defined by a set event threshold. For example, payouts are triggered by an agreed level of rainfall or storm intensity. It is easy to set up, and claims can be settled rapidly, following a mutually acceptable definition of loss. Such type of insurance does not need a lengthy loss assessment or adjustment process. It is a relatively new format for insurance, with pioneering applications in natural capital insurance, including the coral reefs in Mexico's Quintana Roo. However, the model carries a very high basis risk[120] compared to other options.
- **Indexed parametric insurance** is based on the above but has different claim levels set for different hazard trigger levels. The payouts are still set in advance and determined by the hazard model, rather than a case-by-case assessment. The model therefore retains some of the expediency advantages of the pure parametric approach but allows for differentiation of payout in a variety of more severe scenarios.
- **Loss modelling** involves using computer simulations of likely scenarios to build natural catastrophe or *nat cat* models, to help estimate potential losses, and payouts. The approach carries a lower basis risk but is expensive in terms of the resources required to build and run the model. Also, this model is reliable when similar risk exposures are in effect.
- **Indemnity-based insurance** undertakes to pay out to the insured based on the actual, verified loss. The process carries very little basis risk but can involve a lengthy and costly process between a claim being submitted and the benefits being paid out to the insured party.

See below for a table of the principal comparative features of the different insurance types.

Table 5: Comparative of insurance product options

Insurance type	Features					
	Complexity	High data requirements	Need for loss adjustment	Payout speed	Basis risk	Moral hazard
Pure parametric				✓	✓	
Indexed parametric				✓	✓	
Modelled loss	✓	✓	✓			✓
Indemnity	✓	✓	✓			✓

119 Inquirer.net

120 *Basis risk* arises when the index measurements do not match an individual insured's actual losses. The basis risk can be minimized through robust product design with adequate testing of contract parameters and ensuring that the area covered by the index is homogeneous both in terms of weather and in terms of coral coverage.

However, any of these formats require creating an enabling environment if the local regulatory framework does not facilitate reefs insurance. The issues and solutions around the regulatory environment are discussed in Section 6.1 on Institutional and regulatory arrangements.

7.2 Workable solution: Parametric insurance

Looking at the pros and cons of different insurance products, a workable solution could be a parametric product that is developed for reef insurance. This would allow rapid access to post-disaster funds, which can help reef recovery in a timely and cost-effective manner. It would also ensure a balance between the local developmental and post-disaster needs and supporting the development of an efficient insurance market.

Parametric products are also simpler to develop based on climate risk indicators such as the cyclone category, wind speed, rainfall level, etc. Also, there is no need for loss adjusters or claims handlers to evaluate actual damage.

The following figure shows the benefits of parametric insurance[121].

Figure 9: Benefits of recommended parametric solution

It is recommended that the parametric insurance is combined with a hybrid distribution model, where the policy (and any payouts) is issued to a macro-level (government) or meso-level (association, trust) entity, which then passes on the benefits to the underlying population or its members. This lowers the costs of managing distribution and claims. The benefits of the coverage at the micro level, is channelled through grass root-level distribution channels such as business associations, cooperatives, and trusts.

This model of insurance needs to be based on the parameters that are most closely correlated to actual losses at the locations. To decide payouts, parameters would be verified against data from independent agencies, allowing transparent and swift claim payments.

The parametric solution is dependent on three criterions. These are - the trigger threshold[122] (e.g., cyclone category or wind speed); a defined geographical area; and the payout structure. The parametric insurance can also have an indexed structure, where the payout may vary in steps as per the intensity of the event trigger.

121 A moral hazard is when an actor becomes more likely to engage in dangerous behaviour after taking steps to protect themselves from the consequences. In the case of insurance this can mean investing less to protect the value of an asset once it is insured.

122 A multi-trigger parameter arrangement, with thresholds for two or more factors e.g. wind and rain, is also possible. .

7.3 Structure of the recommended solution

Ideally, this parametric cover should be offered through a multi-location[123] risk pooling arrangement, wherein all risks are consolidated for all locations at a common level. It recommended that this insurance arrangement is carried out in conjunction with any existing disaster risk reduction and management (DRRM) funds that already is established at the local level. This ensures sustainability in the long term through a common structure. By streamlining the insurance solution with the existing DRRM arrangements, the local authorities can consolidate the reef risks in their jurisdiction, and provide greater economies of scale. This then serves as a risk consolidation mechanism, allowing scale and collective bargaining power to the local authorities to procure cost-effective insurance for the reef risks in their jurisdictions.

A pooling arrangement that helps layer the risks can be done by creating two layers. One for the insurable risks, and another for the risks that cannot be insured or are financially unviable to be insured. This is discussed in detail in the chapter ASSESSING THE RISKS.

Figure 10: Flow of the risk transfer solution

Example: Tropical cyclone reef insurance product

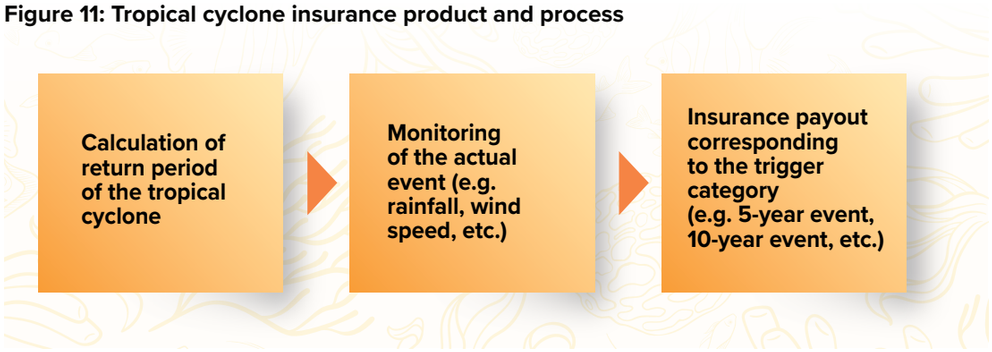
The frequency and intensity of tropical cyclones are on the rise due to climate change, and they are among the most damaging natural hazards for coral reefs. A parametric solution to manage this risk can be designed to pay out if the cyclone track enters a defined geographical area. This method can be further enhanced by dividing the areas into sub-units and recording different intensities in each of these sub-units. If the insurance is using stepped, indexed parameters then those locations experiencing higher-intensity cyclones can be given higher payouts than those experiencing lower intensity cyclones, as losses will presumably be lower. Setting the thresholds and corresponding payouts requires data on levels of population, businesses, households, wind speed, financial values of assets, etc., as well as long-term historical estimated values for wind speed and rainfall in each location, and the calculated return period.

The more reliable the local-event data, the lower will be the basis risk. Moreover, to ensure greater accuracy and less basis risk, recent data can be mapped with historical data.

123 Depending on the span of reef area, a multi-location or multi-country solution can be devised.

Monitoring of the actual event – both for rainfall and wind speed – is calculated after the tropical cyclone's return period has been estimated for the reef location. If the trigger event occurs, the insurance would pay out according to the trigger category, for instance a five-year, 10-year or 20-year event. The return period is key to determine the levels of the payout and the premium.

Figure 11: Tropical cyclone insurance product and process



It is not difficult for policyholders to understand this type of insurance coverage as it is simple and accessible. However, educating policyholders about different levels of risk triggers and varying levels of insurance payouts is still important.

Insurance for the Mesoamerican Barrier Reef System

This insurance product is supported by the InsuResilience Solutions Fund, and co-funded and implemented by Willis Towers Watson (WTW) and the Mesoamerican Reef Fund (MAR Fund)[124] through a unique shared governance framework. The policy covers key reef sites in Belize, Honduras, Guatemala, and Mexico, and is expected to improve the climate resilience of almost two million beneficiaries in the region, protecting ecosystems that is home to 65 species of coral and more than 500 species of fish, as well as many other protected marine species.

The MAR Fund will be the insurance policyholder, with the policy providing a payout in line with the cost of response at varied damage levels. The insurance claim will be triggered by the intensity of a hurricane, with damage estimation through a reef risk model.

With the increasing effects of climate change exerting pressure on the reef, the risk of a hurricane impact leading to irreversible coral degradation and mortality will be reduced by having insurance payout for timely restoration activities. This will help to clean up the reef and jump-start regeneration and recovery and reducing the overall impact of lost ecosystem's social and economic services. What will surely help is the quick payouts to help remove debris after storms occur and sticking the broken corals back together.

124 The Insurance Journal.

7.4 Alternative risk transfer

Developing new and effective solutions to manage and share the risks to natural resources requires imagination and knowledge. It is important to look beyond insurance *per se* and seek a combination of solutions through alternative risk transfer. With careful design, insurance and alternative risk investments can be mutually reinforcing, as increased resilience reduces the risks, translates to lower insurance premiums, and provides a strong financial incentive to keep making investments.[125]

This then improves reef resilience and benefits, as alternative forms of risk transfer, helps in eliminating the reef financing gaps, and supports interventions to enhance the ecosystem services that reefs provide. This approach results in stronger livelihoods and improved economic security of the most vulnerable communities, resulting in better social and ecological resilience in face of climate change.

Scaling bond investments

Debt financing can be used to invest in preventive measures to reduce risks. With the recently increasing global pledges on climate finance, there has been a growing interest in the alternative risk transfer and investment instruments, such as debt-for-nature swaps. Such instruments are key to increase coastal resilience, and present an untapped potential. For example, the $22 million Seychelles debt-restructuring model shows scope for replication and scalability in other jurisdictions.

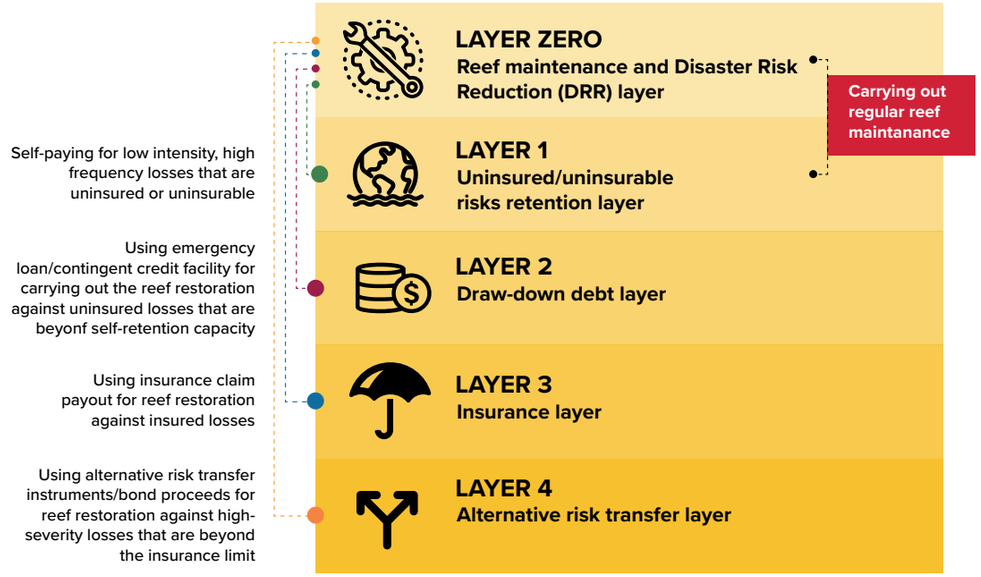
Such arrangements also provide an opportunity to bundle a series of transactions with an entity underwriting the issuance of the blue bond, the proceeds of which would then be used to finance the underlying debt transactions. A sizeable pool of funds could be achieved by bundling multiple transactions into a portfolio and blending that with public sector de-risking support. A preliminary analysis has identified the transaction potential of up to $2 billion across multiple SIDS.[126] More on financing options can be found mapped in the catalogue by BIOFIN.[127]

Insurers play a critical role in driving resilience investments towards sustainable and long-term projects, while incorporating climate-related risks in their underwriting and investment activities. This has been the view of the European Insurance and Operational Pension Authority (EIOPA), the key risk managers, and investors. [128]

125 Lloyds 2018
126 UNDP and TNC 2018
127 BIOFIN's catalogue
128 EIOPA 2019

7.5 Example of risk transfer solution: The Reef Disaster Risk Fund

Figure 12: The proposed reef disaster risk fund



Coastal businesses are often hard-hit when disasters strike. When long term community-wide solutions are in place not only do the coastal economies remain stable, but communities too benefit as reefs are protected. A multi-layer **Reef Disaster Risk (RDR) Fund** is thus a strong solution. This fund incorporates both insurance and alternative risk transfer in a layered structure. It can be created in a form chosen from a variety of locally applicable legal and structural options,[129] to provide an array of selected functionalities as demonstrated in the different layers of the Fund.

The key element of the financial strategy of the RDR will be to buy reef insurance to protect the reef that protects and adds value to local businesses and communities. Once the claim is triggered, the insurance would pay out for rebuilding and regenerating the reef and protecting it in the future. This portion of the proposed RDR Fund would be like the Mexico reef trust fund, contributed by municipal governments and the tourism industry on the Mexican Caribbean coast, and which also funds maintenance projects to protect the reef before and after storm surges.

A community wide RDR Fund ensures that adequate financial resources are also available to protect the reefs and communities before a loss event strikes. Further resources are then available for reef restoration and beneficiaries can continue business activities.

Participation in the RDR Fund can be made mandatory for specific types of businesses and community members. It is important that to avoid the risk of anti-selection[130] and moral hazard. This will not only reduce the financial vulnerability of the overall community but also support the Fund through regular risk weighted contributions from each participant. Participants operating in riskier locations must pay higher contributions than those who operate in far less risky locations and face same degree of potential losses. This model ensures that the safer participants are not ending up cross subsidizing for the riskier ones.

129 The 'one size fits all' approach cannot work here, since most of the countries have unique corporate and legal frameworks for the creation and operation of the Fund, ranging from trust structures to not-for-profit models. Hence, the term Fund is being used at this stage to represent the proposed risk transfer vehicle.

130 See footnote 51.

7.6 Layered structure of the fund

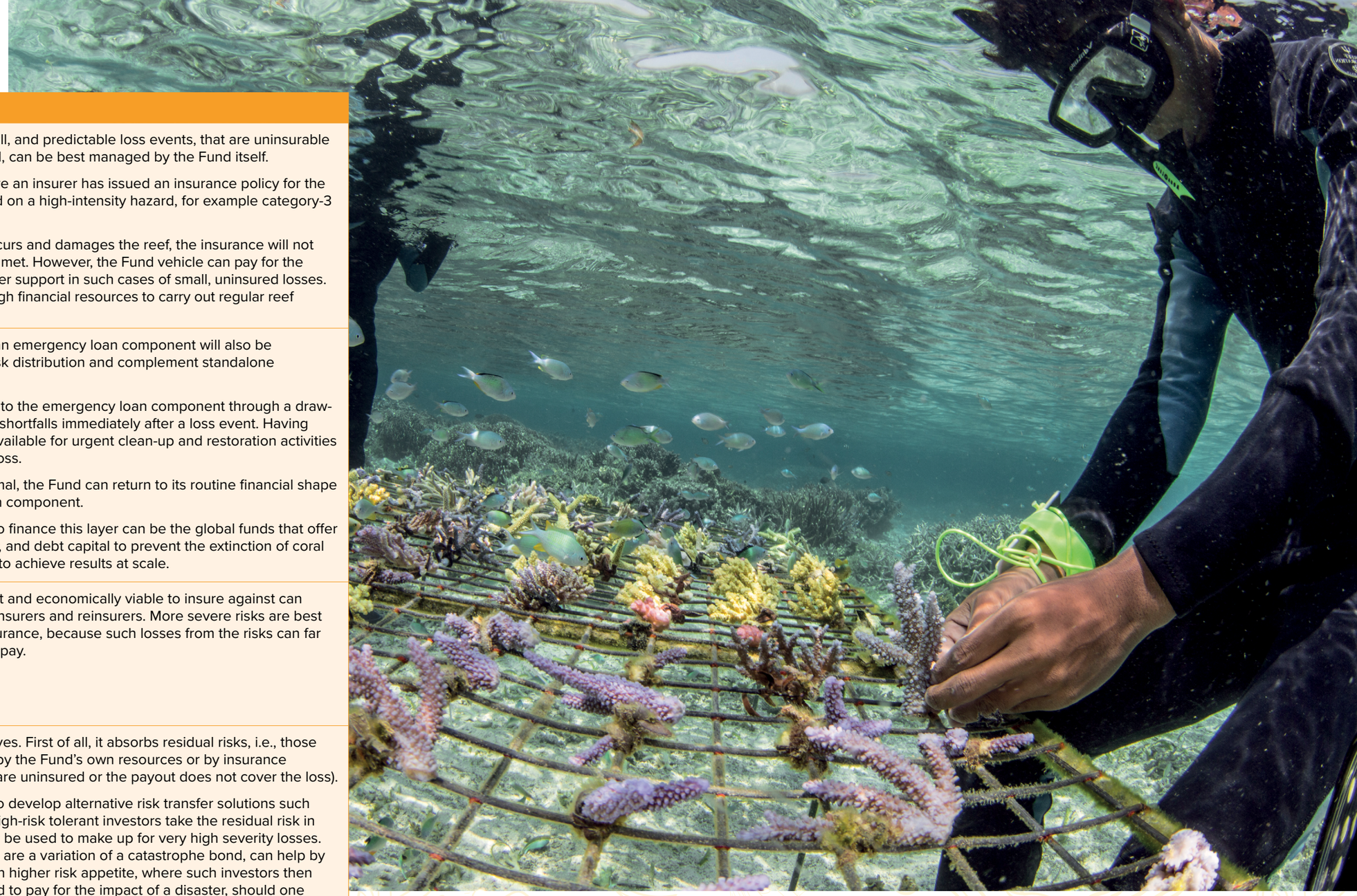
An RDR Fund would have a sophisticated structure to protect reefs against disasters of varied severities in different scenarios. At the base would be a fundamental layer, or **Layer zero**, consisting of regular reef maintenance function. **Layer 1** is a risk retention layer for protection against small, uninsurable risks from high-frequency, low-severity hazards, to be retained by the Fund. **Layer 2** consists of emergency loans. This draw-down debt component is to manage emergency disaster risk, and comes as continent credit facilities, or from internal resources of the Fund. **Layer 3** provides the risk transfer function, using insurance and reinsurance. This is suitable for insurable risks, i.e., where the hazards show medium to high frequency, and medium to high intensity. **Layer 4** is where alternative risk transfer comes in. This is appropriate for handling the residual risk, which can be transferred to investment bonds in a non-insurance solution for risk sharing. The different layers are mentioned in detail in the table below:

Layer Name	Description
Layer zero: **Regular layer for reef maintenance and Disaster Risk Reduction (DRR)**	There needs to be enough financial resources for regular reef maintenance. This layer would ensure fewer calls on insurance policies, thus reducing premiums in the long term and adding sustainability to the overall scheme. It would also reinforce the impact of investments through subsequent layers in relevant infrastructure and will improve the resilience of local government, enhance community capacity, and protect livelihoods. This layer will advocate for improving local and national policies on environment and reef protection. It will do so by working with a range of partners on financing mechanisms for subsequent layers, enhancing nature and livelihood solutions protected by a capital buffer, and investing in DRR activities. Post-disaster reef restoration is not just a one-off activity. Rather, reef managers may need to support recovery and regeneration for two to five years, involving several actions like reproduction and planting of coral colonies, consolidation of broken or degraded reef structures, and managing other stress factors.[131] This layer will also provide ongoing support for the continuous development and analysis of the reef location and investments in measures that reduce disaster losses while helping in evaluation of measurable impact, improving the sustainability of businesses and livelihood of people that depend on reefs. Such targeted investments in risk reduction activities will lower underwriting risks for insurers, and their costs of covering claims, resulting in lower premiums for policyholders, and thus creating a virtuous cycle of price incentives for investing in prevention and preparedness.[132] This layer will also provide technical assistance and training to local businesses on methodology to measure, monitor and manage the environmental impact of their business operations on reefs. Moreover, it will work with the government and policymakers to improve the regulatory framework for Blue Economy (reef insurance) and create a policy and financial environment that incentivizes private-sector engagement in reef conservation. The capitalization of this layer for reef risk assessment and maintenance can come from global funds and multilateral development banks through grant capital, which will then help local stakeholders to meet the coral reef commitments.

131 One of the studies (BIOFIN 2016) assessed the cost options for coral reef restoration in Thailand and other countries with similar economic situations. It found costs for transplanting on concrete to be $543/ha, for providing artificial reef $38,596/ha, and floating nursery $95,575/ha. Important to note that the cheapest actions are not necessarily the most efficient or effective ones.

132 Carter 2020

Layer Name	Description
Layer 1: **Protecting uninsurable losses (from low-severity, high-frequency hazards)**	The risks due to frequent, small, and predictable loss events, that are uninsurable or too expensive to be insured, can be best managed by the Fund itself. There may be a scenario where an insurer has issued an insurance policy for the reef with a loss portfolio based on a high-intensity hazard, for example category-3 cyclones. If a lower-intensity cyclone occurs and damages the reef, the insurance will not pay out as the threshold is not met. However, the Fund vehicle can pay for the restoration of the reef, and other support in such cases of small, uninsured losses. Moreover, there must be enough financial resources to carry out regular reef maintenance.
Layer 2: **Draw-down debt component/ emergency loan layer**	As part of the overall design, an emergency loan component will also be developed. This can help in risk distribution and complement standalone insurance solutions. The Fund should have access to the emergency loan component through a draw-down facility to meet financial shortfalls immediately after a loss event. Having such resources immediately available for urgent clean-up and restoration activities helps to minimize the overall loss. As the situation becomes normal, the Fund can return to its routine financial shape and repay the emergency loan component. One of the potential sources to finance this layer can be the global funds that offer funding through grants, equity, and debt capital to prevent the extinction of coral reefs, providing opportunities to achieve results at scale.
Layer 3: **Insurance layer for risks associated with high-severity, low-frequency hazards**	The risks that are less frequent and economically viable to insure against can be passed on by the Fund to insurers and reinsurers. More severe risks are best protected against through insurance, because such losses from the risks can far exceed the insured's ability to pay.
Layer 4: **Alternative risk transfer/ investment layer**	This layer has multiple objectives. First of all, it absorbs residual risks, i.e., those losses that cannot be funded by the Fund's own resources or by insurance payouts (either because they are uninsured or the payout does not cover the loss). For such risks, it is important to develop alternative risk transfer solutions such as investment bonds, where high-risk tolerant investors take the residual risk in exchange for funds, which can be used to make up for very high severity losses. Here the resilience bonds that are a variation of a catastrophe bond, can help by spreading risk to investors with higher risk appetite, where such investors then provide funds that can be used to pay for the impact of a disaster, should one occur within the bond term. Such investments in the Fund can not only increase the resilience of the reef and its protective potential but can also positively impact the lives and livelihoods of coastal communities. This additional layer of risk capital can significantly improve the overall financial structure to protect reefs and provide ongoing capacity support tied to local needs through financial de-risking in cases of big, catastrophic losses that are not entirely recoverable through insurance payouts. The instrument is ideally issued by the entity that has the legal title on the reef, directly or through a legally appointed representative. Alternatively, legislative, and regulatory adjustments will have to be made to allow the insurable interest of a third party, which can then issue the instrument.



7.7 Focus and utility of the Fund

The layering of the Fund allows for the mobilization of financial resources for reefs that traditionally will not be considered available. This provides an opportunity for risk partners to acquaint themselves with a relatively new space, with potential for impact investment in reef conservation and economic development.

The Fund, specifically its Layer zero, will focus on channelling innovative and new private investment towards the development and management of MPAs, restoration of coral reefs and related ecosystems, education, and awareness on suppression of external pressure factors, and promoting sustainable ecotourism. The scope and utility of the proposed RDR Fund will include the following:[133]

- **Reinstatement of reefs and related biodiversity:** The degraded reefs can be restored with the help of innovative techniques. This restoration also protects other types of natural resources like mangroves and seagrasses -- all closely tied to the coral reef ecosystems, and often serving as nurseries for the fish and helping improve the overall water quality.
- **Development of marine protected areas:** By replenishing live coral cover, improving reef biodiversity, and protecting fish populations, there is an overall boost to coral reef conservation and climate change adaptation.
- **Naturally sustainable fisheries:** This helps reefs in retaining the right balance of biodiversity, thus promoting necessary bio resources for reefs.
- **Education and awareness on external pressure factors:** Raising awareness among stakeholders on reef degradation factors helps minimize the external pressure on reefs. In the long-term, positive activities to combat climate change reduces the vulnerability of reefs to destruction or damage.
- **Ecotourism:** Sustainable ecotourism eases the pressure on reefs, and provides financial returns. The increased revenue can in turn fund conservation activities.

The investments made in reefs should support foundational work in the target sectors and build a business case for revenue-generating streams, with a gradual shift of balance from grants to investments over time. This would also include activities around the strengthening of the policy, institutional and legal/regulatory frameworks, and capacity of participating authorities to stimulate the growth of coral-friendly economic development and support increased private-sector investment. See the chapter 6, CREATING THE ENABLING ENVIRONMENT.

The blending of technical assistance grants with investments would be ideal for site-specific baseline studies, capacity development, financial de-risking, and monitoring and evaluation. Building on these activities, further private investments can be identified and developed into portfolios of investment opportunities catalysed by reef development and protection. To encourage and reduce risks for investors in this relatively new market of coral natural capital, the need is to provide risk transfer solutions that offer opportunities for: co-financing of guarantees; concessional loans; and early equity investments, based on precise feasibility analysis of hazards, exposure, vulnerability, by engaging with local stakeholders with appropriate involvement to mobilize sustainable support for reef management and rescue.

133 This is also aligned with the objectives and terms of reference of the Global Fund for Coral Reefs (GFCR). The GFCR has been established to protect coral reefs and related biodiversity by facilitating the uptake of innovative financing mechanisms.

Investment case

One of the first projects by the Global Fund for Coral Reefs (GFCR) designed in the South Pacific on the small island developing state of Fiji is a collaborative programme with the GFCR, Joint SDG Fund, UN agencies, Mirova, Blue Finance, Government of Fiji, the World Wildlife Fund for Nature (WWF) and others. Applying grant financing to leverage private sector resources to benefit coral reef ecosystems and local Fijian communities, it demonstrates as a series of interventions such as co-management of a revenue-generating network of locally managed marine areas (LMMAs), sanitary landfill, oyster hatchery, and reef restoration.

Showcasing the GFCR's blended finance and collaborative approach, the proof-of-concept model in Fiji is expected to be replicated and scaled for coral reef regions throughout the world. The immediate expected outcomes include return on investment in at least 10 sustainable businesses, a co-management agreement for 10 LMMAs between the government of Fiji and a local Special Purpose Entity (SPE), and creation of at least 1,500 jobs for the local communities with gender participation. The expected outcomes in the following run include the mobilization of at least $75 million in investment towards natural resource and waste management, economic opportunities, and food security for at least 70,000 local people relying on coral reefs, and a measurable increase in fish biomass and coral cover.

7.8 Governance structure of the Fund

The overall Fund should be managed by an administrator, who should ideally be an independent entity or a representative consortium of stakeholders. There are various examples from around the world where the insurance schemes or risk pools are managed by independent administrators.[134] Inspiration can also be drawn from the Practice Standards for Conservation Trust Funds.[135] While each jurisdiction may have a different overarching legal and regulatory framework for the governance and structural design of the Fund, it is likely that some elements would remain common. For example, to manage the cash flow within the Fund, it must be an independent, preferably a locally domiciled vehicle (example the Seychelles Conservation and Climate Adaptation Trust or SeyCCAT). [136]

The manager of the vehicle would manage multiple cash flow streams, such as one to invest in risk reduction activities and improved management of reefs; another to procure and manage insurance and repay the investors; and another to work on the capitalization of the endowment, which can then support the future conservation and resilience work.

134 Examples may include the funds/schemes managed by administrators such as Turkish Catastrophe Insurance Pool, Japan Earthquake Pool, Indonesia State Asset Insurance Scheme, etc. Depending on the nature and size of the fund/ scheme, the Fund Administrator charges 1 to 2 percent of the net proceeds/revenue as the administration fees.

135 Conservation Finance Alliance

136 The term 'vehicle' is being used instead of a trust fund since some of the jurisdictions have restrictive laws for the creation and operations of a trust. Also, it is imperative that such a vehicle is made tax-efficient, which might not be the case in some countries if a trust structure is created.

It is important for the Fund to have a transparent governance structure, led by technical and advisory committees, which can decide on how to invest the pre- and post-event resources.

The functions and benefits of the Fund

The layered structure (including Layer zero) would not only pay the costs for carrying out the annual maintenance works at the reef but would also invest in measures that can help in reducing risks, thus bringing down the overall reef protection and restoration costs. It would also pay for regular beach clean-up and maintenance, and the purchase of insurance products (Layer 3). The proposed investment capitalization (Layer 4) would enhance the overall work significantly, and with a focus on maximizing impact and reducing risks, rather than just fund management. The key elements of an RDR are as follows:

- **Invest in risk reduction activities:** The RDR Fund should be able to invest in risk reduction activities through a variety of means, such as investing in *ex-ante* maintenance and clean-up activities which can help in maintaining reefs' health and making them less vulnerable to damage when a disaster occurs. Investments in risk reduction activities would mean lower potential losses and hence a significant reduction in insurance premiums.
- **Investing in resilient and better infrastructure:** The RDR Fund should be able to invest in resilient means and infrastructure, not only reducing the vulnerabilities of coastal communities and businesses to disaster losses but also contributing to reefs' health. For example, such infrastructure could include enhanced sanitation, waste-water treatment, or waste disposal. This may also include investments in sustainable mariculture practices, training activities, and improved land management.
- **Policy advocacy, education, and awareness:** The RDR Fund should play a considerable role in improving the environment for the collection of local taxes and levies, and policy reforms and enhancing the literacy and awareness of people about reef protection and insurance. This would include building the community's capacity and leadership ability on disaster preparedness, and consultations on resilience-building efforts. This may also include support for livelihood enhancement, such as improving the livelihoods of low-income local communities, in turn improving their capacity to pay for and benefit from reef insurance. This can include helping coastal fisheries and aquaculture-related small businesses, women involved in micro and small business activities in coastal areas.

Capital for such purposes would be a non-financial return-generating tranche, able to be drawn-down over a fixed life at an agreed-upon rate to provide predictability to both investors and the communities. Ensuring a drawdown rate also encourages dynamic engagement on innovation, ongoing capacity building, and project enhancements to continue active implementation. This would be an impact-measurable, value-added service, expanding the utility of reef financing through significant additional resources.

Beyond these impact-maximizing activities, the vehicle's role would be unique in its ability to provide a capital buffer to the coastal community in the event of disasters that do not trigger the parametric requirement.

7.9 Fund capitalization mechanisms

Through investments, the policymakers and community stakeholders would support business-driven solutions that strengthen and restore ecosystem services while building the climate resilience of coral reefs. The multiple mechanisms for capitalization of the Fund would help the reef sites and associated communities towards a climate-resilient and adapted ecosystem. This would include streams such as: sustainable fisheries and aquaculture; tourism user fees; blue carbon credits;[137] biodiversity offsets;[138] waste management businesses; sale of special use permits; and reef insurance premiums. One of the examples is in the Australian state of Queensland, where the local government together with HSBC bank is purchasing public and private reef credits, quantifying the value of conservation to improve the quality of water flowing into the Great Barrier Reef.[139]

In addition to the benefits of insurance, the financial structuring would also help in local capacity development needed for reef management and restoration activities, developing diversified and sustainable self-generating revenue flows to attract 'blue capital' investments.

In capitalizing on the proposed Fund, there is a need to create reserves within the vehicle, which would also provide a significant buffering capacity to the overall financing structure. A significant portion of funds would be used to purchase the insurance policy. However, it is imperative that a remainder, say 20 to 30 percent, is separated as a pool to fund the activities of Layers zero and 1, especially in cases of losses that are not insured or were uninsurable. This would also provide the needed financing for response to disasters that do not trigger the parameters of the insurance policy.

137 *Blue Carbon credit* is a term that refers to the carbon sequestered in coastal ecosystems – namely mangroves, seagrasses, salt marshes, corals, supporting fisheries, etc. for providing coastal protection to carbon sequestration.
138 *Biodiversity offsets* are generated from management actions that improve biodiversity values and are used to offset the loss of biodiversity values on the policy sites (biodiversity stewardship sites).
139 Financial Review 2020

The Joint SDG Fund

Founded in 2014, the UN Joint SDG Fund is intended to support countries to accelerate their progress towards the SDGs, by closing the financing gap for achieving the SDGs through systemic action in the international community.

The Fund's catalytic investments pipeline support initiatives that leverage public and private financing for nature conservation. One of its streams relates to the proposals in SIDS aimed to set up facilities for project identification, formulation, and financing of businesses and infrastructure to preserve critical coral reefs.[140]

There is additional scope for providing value-added services not directly linked to the reef, for example, providing ongoing capacity support to the local authorities and communities at risk, or working to support a response to crises, reef maintenance, regular beach clean-ups, and building reinforcement infrastructure. These accompanying measures through Layer zero would provide a significant benefit to the overall scheme and enhance the coverage of the financial product. Hence, setting aside a small cushion would help with *ex-ante* needs.

The Net-Zero Asset Owners Alliance[141]

To support the transition to a low-carbon economy, many of the world's largest insurers and reinsurers including Allianz, AXA, Aviva, CNP Assurance, Folksam, Generali, Nordea, Swiss Re, and Zurich, joined the UN-convened Net-Zero Asset Owners Alliance in 2019 and have committed to transition their investment portfolios to net-zero greenhouse gas emissions by 2050. This commitment paves the way for insurers to seek out green investment opportunities more actively across all asset classes, including infrastructure.

This is also in line with one of the recommendations in the report by UNEP on Analysis of Policies related to the Protection of Coral Reefs.[142] The financial resources would help in filling the capacity gaps through grants as well as concessional and/or investment financing, making progress towards international targets and commitments.

Tangible solutions demonstrating the possibilities to build the resilience of crucial ecosystems and the communities, livelihoods, and biodiversity using innovative financing in natural assets aid in countering the impacts of climate change.

140 Global Canopy 2020
141 Carter 2020; UNEP Finance Initiative
142 UNEP 2019

8. OUTLOOK AND RECOMMENDATIONS

While the resources and services that communities gain from healthy coral reef systems are estimated at $2.7 trillion a year,[143] there are only limited and fragmented active projects world-wide focusing on coral reef protection, and spending is only a fraction of what is needed. Smart interventions can have a positive impact on the health of coral reefs and reef-dependent economies with a potential to close to 70 percent of the gap between the estimated values derived from the degraded as compared to the healthy reefs.[144]

Now is the opportunity to bring the protection of coral reef systems in line with their required levels and to respond positively to global aspirations under the SDGs for equitable and environment-friendly policies. This involves defining a global standard for risk transfer for reef sustainability and requiring a collective approach that involves public authorities at all levels of governance (including cities, rural and coastal communities), private-sector actors across the reef value chain, NGOs, social partners, academics, and citizens.

143 GFCR 2020
144 UNEP 2018

Coordinated action will encourage reef custodians and the risk takers to participate in transforming and de-risking the reef systems, aligning with the biodiversity strategies and the planetary boundaries[145] of the SDG-related ambitions. Regular collation of reef data, and continued risk assessment of the value services provided by it, along with a cumulative socio-economic impact will drive the adaptation, risk mitigation, and risk transfer decisions.

There is interest around development of new insurance models and the instruments for investment in improving the resilience of coasts and communities. It is important that stakeholders join hands and work together to demonstrate the impact of new and innovative instruments and improve the capacity and awareness of local policymakers.

Reef insurance and alternative risk transfer products require substantial financial commitments, and an enabling environment to support informed policymaking. The steps needed are:

145 Scientists have identified nine key planetary boundaries in the Earth system. These nine systems and processes contribute to regulate the state and functioning of the Earth system. They are climate change; biodiversity integrity (genetic and functional diversity of ecosystems and their functions); ocean acidification; depletion of the ozone layer; atmospheric aerosol pollution; biogeochemical flows of nitrogen and phosphorus; freshwater use; land-system change; and release of novel chemicals.

- **Policy advocacy:** Continuous engagement is needed with local stakeholders to create the suitable policy and legal provisions and foster an enabling environment which facilitates reef insurance and investments. This should be done along with institutional capacity development. Some of the solutions to ensure that reef restoration is on track are - recognizing reefs as assets and accounting them in national accounts, creating legal provisions that allow insurable interest in reefs, and issuance of regulations around insurance for natural capital.
- **Systematic data models:** There is a critical need to develop suitable data collection systems that ease data gathering and enables the design of risk solutions. Quantitative and verified data can be related to not just location-specific risks but can also be interlinked with exposure data on local assets and livelihoods that are affected because of reef damage. This data also helps in developing parametric and hybrid insurance solutions. Moreover, continuously improving dataset results in precise risk models, and demonstrates how the coral reefs are changing because of the ongoing climate crisis. Increased collaboration on big data and field-ready technology for reef conservation will help design suitable insurance products.
- **Supporting the demand-side through innovative distribution channels:** Many countries depend on their coral reef capital for livelihood generation and economic progress. Tourism for some is the mainstay. Often, hotels and businesses, small-scale fishing community and medium, small, and micro enterprises are hard hit when reefs are damaged. The distribution channel for insurance and investments against reef losses depends on the type of stakeholders that need to be protected. In some cases, small-scale fishing communities and the MSMEs, network organizations or associations can play an intermediary role for insurance distribution.
- **Gender-balanced participation:**[146] Small coastal businesses that employ or are owned by women should also benefit from innovative insurance and investments. Research shows that women' participation enable climate-resilient initiatives, and contributes towards building resilient communities all while supporting long-term development.[147] A study of 20 coastal livelihood programmes across the Indonesian archipelago from 1998 to 2017 found that 40 percent of these programmes were completely gender-blind and only 10 percent had a focus on strengthening women's role in coastal resilience.[148]

Gender-discrimination in reef fishing

The state of reef resources is greatly influenced by gender roles[149], depending on cultural norms, social relationships, and the spatial scale of the markets. The assessment of gender roles in the potential of coral reef dependent fisheries, based on socio-economic status of 142 traders in 19 Kenyan coral reef fisheries landing sites, show a strong role of women in the sustainability of reef fisheries. Earlier this sector was primarily driven by profitability. Also overfished areas mostly retained women with low education levels. Women have been excluded from reef fishing in areas where there were high yields, profits, and sustainability.

146 Gender-disaggregated data is important. It helps in analysing how the climate change impact on coral reefs and fisheries affect both men and women across economic classes and by household headship, using locally defined criteria.
147 UNDP 2011
148 The Conversation
149 McClanahana and Abungeb 2017

- **Bringing inclusivity through national and local governments:** Both the national governments and the local governments have a role to play here, largely depending on the reef insurance model or type of solution offered. Due to global visibility and network, national governments are better when it comes to attracting international financing and support for coastal resilience. Often national governments have more public funding to protect people and property in coastal zones that are at risk. National governments can also initiate regional risk pools to improve both risk reduction before an event occurs and afterward. This is because countries often share oceanic boundaries and reefs are then considered a common resource. In some countries, there is a centralized ministry or a government department that is responsible for marine and coastal affairs. National governments also have a key role and a mandate in ensuring the implementation of necessary laws and enabling conditions to facilitate coastal resilience. The local governments play a significant role in proposing grassroots solutions, that can be supported by robust conditions for risk reduction measures and opportunities of private investment. One example is the Mexican state of Quintana Roo and its support towards the creation of a trust fund that redirects the tax money for purchasing insurance. Local governments have a better grasp of the issues on-ground and can partner with the right stakeholders to take collective action.

8.1 Potential impact assessment

There is currently no prominent framework specifically for impact assessment of reef insurance or other risk sharing mechanisms. However, some of the evolving natural capital impact frameworks provide nascent ideas on generating trusted, credible, and actionable information for making informed decisions. The Natural Capital Coalition[150] provides the protocol by offering a standardized but general framework to identify, measure and value impacts and dependencies on natural capital.[151]

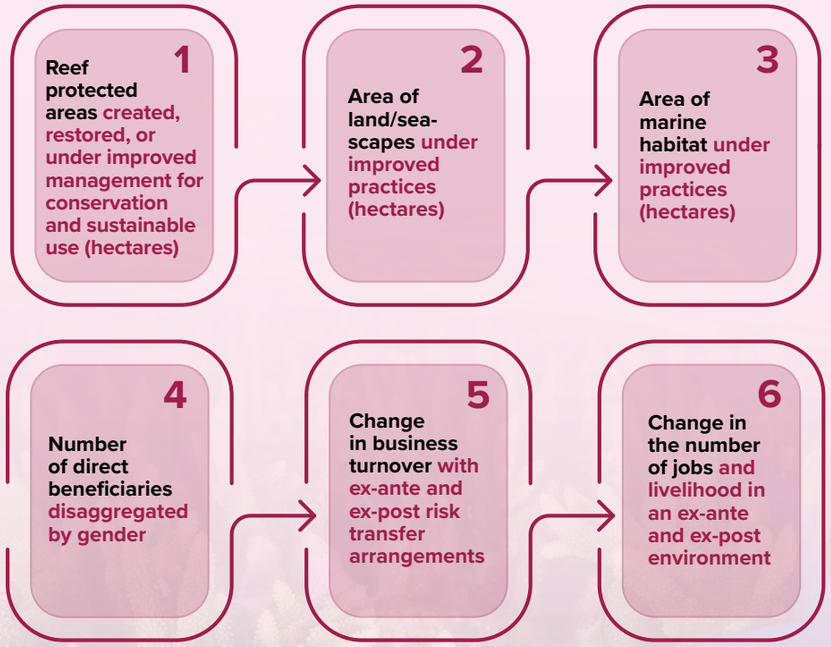
There is a need to, however, create a potential impact assessment and management framework that then can become integral to making reef risk transfer and investment decisions. Some of the actions can include:

Figure 13: Impact assessment actions [152]

150 The Natural Capital Coalition is a collaboration between leading organisations in research, science, academia, business, advisory, membership, accountancy, reporting, standard setting, finance, investment, policy, government, conservation and civil society, to promote that by 2030 the majority of businesses, financial institutions and governments include the value of all capitals in their decision-making, thus delivering a fairer, just and more sustainable world.
151 Natural Capital Protocosl, Principles and Framework
152 Adopted from IRIS+, managed by the Global Impact Investing Network (GIIN).

Some of the quantitative indicators to measure and assess the impact of reef insurance and other risk transfer mechanisms may include:

Figure 14: Suggested quantitative indicators to measure the impact of reef insurance



8.2 Looking forward

With efficient reef risk transfer solutions, the trajectory of declining coral reefs can be altered to a healthier outcome, unlocking potential economic value worth billions of dollars. Through strategic interventions using insurance and alternative risk transfer solutions, the gap between the forecasted benefits of a healthy reef and the current outlook of coral reef degradation can be closed.

Insurance can protect the scale of investments needed to manage and restore reef ecosystems and the services they provide. Despite challenges like climate change and the global pandemic, financing reef protection is seen as a sure-shot way to protect our natural capital. With this, there is an increasing interest of nature investors in the area of reefs conservation and insurance for coral reefs can support these financing initiatives by de-risking them and providing funds for repair and restoration works that otherwise might not be readily available because of competing ex-post priorities. Highlighting the issues and the opportunities in the global landscape for risk transfer solutions for protecting coral reefs and improving their resilience, this report helps policymakers and practitioners grasp how insurance and alternative risk transfer mechanisms can create a potential stream of financial resources for coral reef restoration.

Parametric insurance solutions can be very effective in protecting reefs against the impacts of extreme weather events when data relating to risks is limited. Such insurance solutions are also a good starting point to adequately protect against the risks and ensure efficient payouts. Hybrid solution can also be considered to combine the technical and operational efficiency of parametric insurance with the certainty of indemnity-based loss assessment. The proposed risk transfer solutions provide options of customization and scalability and supporting actions that result in reef restoration. The holistic reef disaster risk fund proposed in this report aims to help stakeholders understand as well as promote reef insurance models and other nature-based alternative risk transfer mechanisms.

Data to inform risk models is critical to support the development of insurance and risk transfer solutions, including the data on hazards, exposure (financial values of assets) and vulnerability that needs to be compiled. This calls for a greater partnership of stakeholders on data collection as it will inform the risk models by quantifying the level of risk faced by economic services, built-up capital, and the population in each location.

Creation of an integrated risk index would also help local stakeholders in tracking risks and deciding on the usage of suitable risk transfer solutions. The limited spatial capacity and scale of reef restoration, and scarce financial resources necessitate the integrated system of risk monitoring and restoration. This must be coupled with key steps of reef risk assessment aligned with the environmental and economic objectives. It is also important to assess where risks can be reduced and where they can be transferred to insurers, and where the adaptive capacity can be improved that may involve local communities and stakeholders; and lead to solutions for coral propagation and restoration, supported by insurance.

Risk awareness, reporting framework and capacity building is key to a solutions-based approach. The costs associated with the reef restoration activities are often assessed and

reported in an opaque manner, as most data sources have no standardization of identifying and reporting costs. Therefore, there is a need for a holistic and uniform assessment and reporting framework that can be used for restoration programs funded by insurance and risk transfer schemes. Most of the valuation of economic benefits derived from coral reefs and their restoration are complex and expensive. Further research is needed into the valuation of reef benefits, particularly assessing the benefits and economic efficiency of their restoration that can be funded by insurance. Since reefs take a certain amount of time to grow back into their pre-disaster form, the benefits that will accrue in the future will yield lower real economic value as compared to the present day after applying discounting. In addition, the development of a suitable impact assessment framework is also needed.

Stronger legislative policies and conducive environment for insurance mechanisms can greatly aid in the restoration and conservation of coral reefs and preserve the biodiversity of such ecosystems. This will help in bundling insurance solutions with improved reef management activities, thus reducing potentially damaging anthropogenic impact factors. Supported by stronger legislation, coordinated network of stakeholders and enabling policies, restoration benefits can be enhanced by identifying specific opportunity sites and focusing on reef restoration efforts. This starts with a country-specific mapping of stakeholders who have the authority and mandate for reef restoration, and who can play a critical role in deploying enabling policies so that insurance can bring more value to nature and communities together. In this way, not only the reefs will prosper but also the experts specializing in reef monitoring and restoration will be able to help the local communities whose businesses and livelihood are dependent on healthy reefs.

A range of risk transfer options, including insurance to support the reef restoration initiatives, have been presented in this report. Raising awareness on protecting hundreds of kilometres of critically at-risk coastline across multiple countries is imperative. Providing a global estimated value of $2.7 trillion per year through tourism and fisheries, or 2.2 percent of all ecosystem service values, reefs are home to more than one million diverse aquatic species.[153] Their contribution to the global net benefit of coastal protection alone is estimated at $9 billion per year, and their support to the pharmaceutical and food value chains is undeniable.

There is a powerful business case for the conservation and restoration of coral reefs, supporting nature and its socio-economic benefits with the help of insurance. Ensuring reef health will contribute to biodiversity resilience and the environment, whether it is through adaptation and risk reduction activities or through insurance and risk transfer solutions. ■

153 International Year of the Reef

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