Concept Note for MAR Fund's Reef Rescue Initiative

Opportunities for the Mesoamerican Reef countries to include coral reefs into asset valuation and climate related risk assessments, and the economic rationale for using financial instruments to insure coral reefs against hurricanes and damage from ship groundings.

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Prepared on behalf of MAR Fund

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Introduction

The Mesoamerican Reef (MAR) is a marine ecosystem stretching more than 1,000 kilometers along the coastline of four countries—Mexico, Belize, Guatemala, and Honduras. MAR is the largest barrier reef in the Western Hemisphere and the second largest in the world. MAR is biologically diverse, species-rich, and home to numerous species that are endangered or under some degree of protection. Indeed, the ecologic and economic importance of MAR has been recognized by the establishment of multiple protected areas and parks, including the Belize Reef, Arrecifes de Cozumel National Park, Hol Chan Marine Reserve, Punta de Manabique Wildlife Refuge, Sian Ka'an Biosphere Reserve and the Cayos Cochinos Marine Park.

The Mesoamerican Reef Fund (MAR Fund) is a regional environmental fund established in 2004, whose mission is to drive regional funding and partnerships for the conservation, restoration, and sustainable use of the Mesoamerican Reef. To further this goal, the German Cooperation through the KfW capitalized an $8.5 million permanent endowment to support MAR Fund's Reef Rescue Initiative (RRI). The annual revenues from the endowment ($350,000 per year on average) have allowed the RRI to start key ground work and will guarantee long term sustainability for the RRI.

Four ***key strategies*** guide the RRI:

1. Ensure sustainable long-term funding for continuous and emergency restoration through the establishment of an Emergency Fund and other innovative mechanisms such as for example, creating insurance mechanisms for reefs;
2. Support and develop reef restoration and rehabilitation in the region;
3. Develop alternative sources of income and new employment opportunities for local communities, based on resource conservation; and
4. Promote the commitment of governments from all four countries in the region through the development of policies and regulations aimed at facilitating the restoration and continued guardianship of the reefs.

The RRI's initial implementation period is planned for five years, with the four countries the participation of the four countries of the MAR region. The geographic focus would be in selected pilot sites located in the marine protected areas in the four countries, with selection based on several criteria, including ecological importance and availability of committed government counterparts. For more information on the RRI, its goals and ongoing work please visit http://marfund.org/en/mar-rescue-initiative/# .

The aim of this paper is to explore the economic rationale and policy considerations for including coral reefs into asset valuation and climate change-related risk assessments and investing in innovative financial instruments to support coral reef conservation and restoration following damage from hurricanes and ship groundings. The paper also aims to provide the conceptual tools to convince governments, sectoral planners, and other

interested parties to sustain the implementation and financing of the RRI activities beyond the five-year start-up period.

Why the Focus on Coral Reefs?

Coral reef ecosystems are among the most biologically diverse and economically valuable on the planet, providing significant goods and services and contributing to food security, livelihoods, and safety for millions of people. Specifically, coral reefs are spawning and nursery grounds for important fish populations. They provide numerous jobs for local people in tourism, recreational activities, and fishing. Coral reefs also protect coastal communities from storm surges, beach erosion, and wave-induced damage from tropical cyclones. At the first annual Ocean Risk Summit held in May 2018 in Bermuda, many of the speakers highlighted the key role of coral reefs in maintaining a sustainable ocean environment, critical for underpinning biodiversity and a healthy global climate, thus underscoring the "global public good" aspect of coral reefs.

But how does one value a coral reef's ecosystem services?[1] The values attributed to ecosystem services can only be understood in the context of the stakeholders who benefit from these services. We consider each of the above services in turn, starting with those most tied to specific individuals and moving onward to those services which benefit the broadest array of stakeholders.[2]

- On ***fishery*** services, stakeholders would include local fishers, boat builders, fishing net makers, fish market employees, tourist fishers, and, importantly, consumers of seafood (both locally and internationally, to the degree that seafood is exported). The category of consumers is likely to include many subsistence fishers, and, hence, members of the community most vulnerable to any changes in fish/ crustacean stocks. The last category also indicates the important role of coral reefs in food security for the local community.[3]

- On ***tourism*** services, stakeholders would include hotels, snorkel and dive shops, coastal restaurants, other miscellaneous tourism services (local craft-makers, tour guiding services, car rental agencies, etc.), and a large labor force providing the associated services, many of whom might be relatively low-skilled, low-income workers particularly vulnerable to any slowdown in tourism.

[1] While this note only considers reefs' ecosystem services related to fisheries, tourism, coastal protection, biodiversity, and carbon sequestration, reefs provide other services as well, such as cross-ecosystem nutrient transfer, sediment retention, aesthetic and cultural values, etc.

[2] While most papers, including this one, consider each of these categories of ecosystem services independently when valuing them, they are all closely interlinked. For example, healthy fisheries are a core part of biodiversity, and carbon sequestration is dependent on the coastal protection of the broader seascape.

[3] According to UN (2014), coral reefs are responsible for 17 percent of all globally-consumed protein, rising to as much as 70 percent or more in island and coastal countries.

- On ***shoreline and coastal protection***, all of the above stakeholders would be beneficiaries in addition to other coastal residents, businesses, and government (in light of public infrastructure, such as roads, bridges, etc., that might be located near the coast). Indeed, various studies have indicated that coral reefs provide more cost-efficient shoreline protection than man-made structures.

- As for ***global public goods*** associated with coral reefs, these could be broadly categorized in terms of biodiversity and carbon sequestration/mitigation. Stakeholders, by the very definition of such goods, would extend to all countries, people, and even generations. But there are also some specific stakeholders as well:

    - On ***biodiversity***, coral reefs are sometimes viewed as the planet's "rainforests of the sea" and "medicine cabinet," with as yet unknown potential uses and many drugs having already been derived from coral reef organisms. Stakeholders, in this regard, could include researchers, academics, pharmaceutical companies, as well as potential human beneficiaries of medical advances, among others.

    - On ***carbon sequestration/mitigation***, the government could be a specific stakeholder if the preservation of reefs would be considered as part of a country's contribution to global efforts on carbon mitigation (see below for further discussion).

The argument for coral reefs' carbon sequestration/mitigation services, however, is more complex than for other ecosystem services. Admittedly, while the data are very limited, many scientists believe that coral reefs are very minor emitters of carbon (due to the living nature of the reef). However, carbon sequestration and other biochemical services could be considered in the context of ecologically-linked habitats such as mangroves, seagrass beds, and salt marshes. As discussed in Barbier et al. (2011) and Moberg and Rönnbäck (2003), coral reefs, mangroves, salt marshes, and seagrass beds create interconnected, single "seascapes" with a synergistic relationship between them. Thus, the coastal protection services provided by reefs through dissipating the force of waves and currents are instrumental for the evolution of suitable environments for mangroves, sea grasses, and salt marshes—all of which provide substantial carbon sequestration services. This implies that reefs should, in the aggregate, be counted as contributing to carbon mitigation efforts.

For each of the ecosystem services discussed above, the government could be seen as an indirect stakeholder. Governments obtain revenues from the fisheries and tourism services of coral reefs and expend revenue to protect employment in the event of a loss of such services. For coastal protection, in addition to the direct service of protecting public infrastructure, the government could face implicit liabilities from damages incurred to privately-owned infrastructure and resources, such as when housing is badly damaged in the aftermath of a natural disaster.

Quantifying the value of coral reefs in monetary terms helps to raise awareness of the economic importance of such green infrastructure and the implications of policymakers' decisions, including allocation of budgetary resources for reef conservation. But measuring the value of marine ecosystem services is particularly challenging and is still a relatively underdeveloped field.

There are various methods to estimate the economic value of natural resources like coral reefs. One such approach is a "willingness to pay" survey that attempts to assess the value that individuals would place on, say, visiting coral reefs. Some studies attempt to estimate the total economic value of an ecosystem, including both use values (such as fishery services (consumptive) and tourism (non-consumptive)), indirect services such as coastal protection, and non-use values (such as the value placed on a natural resource just knowing it exists).[4] A more basic approach is to estimate the economic activity generated by an ecosystem for the local economy—jobs, taxes, revenues, etc. Services which have a market value such as fishing and tourism are, therefore, easier to value than those for which no clearly defined market exists (coastal protection, biodiversity, for example). In any event, all such estimates are subject to a high degree of uncertainty but can still serve to inform policymakers about the potential losses due to ecosystem degradation.

Despite the challenges, there have been numerous efforts to value ecosystem services, with studies on global, regional, and local bases. The Global Ocean Commission (2014) estimates that the global economic value of carbon sequestration associated with marine ecosystems (including coral reefs) could reach as high as US$222 billion per year. De Groot et al. (2012) provides **global estimates** of the value of a number of marine ecosystem services, including those for open oceans, coral reefs, mangroves, and others. They estimate, for example, that the value of ecosystem services ranges from a low of US$ 490/year per hectare of "average" open ocean to US$ 350,000/year for the services provided by an "average" hectare of coral reefs using 2007 dollars. As noted in this review, as well as in Spalding et al. (2017), the range of estimates of marine services in the limited literature is quite variable; Spalding et al. find that the mean estimate in their study is 10 times larger than the median.

Cesar, Burke, and Pet-Soede (2003) present estimates of the value of reef services for the **Caribbean region.** They note $1.8B annual services at the time of their study and net present value for reefs of $49.5B. Another study for the region[5] estimated annual net benefits provided by coral reefs through fisheries, dive tourism, and shoreline protection services between $3.1 billion and $4.6 billion in 2000 (Burke and Maidens, 2004). The largest share of this total derived from the net benefits from dive tourism, at $2.1 billion, followed by shoreline protection services at $700 million to $2.2 billion, and fisheries at $300 million. Moreover, the degradation of Caribbean coral reefs was estimated to result in annual losses of $95 to $140 million in net revenues from coral reef-associated fisheries and $100 to $300

[4] TEEB (2011) provides a useful review of the challenges of valuing ecosystem services as part of the Millennium Ecosystem Assessment and the Economics of Ecosystems and Biodiversity exercise.

[5] In this study, the Mesoamerican Reef is included in the category, "Western Caribbean."

million in reduced tourism revenue by 2015. An even more localized study in 2001 suggested that reef fisheries of the **Mesoamerican Reef** of Belize, Honduras and Mexico were potentially worth $15,000–$150,000 per km² a year (Talbot and Wilkinson, 2001 cited in UNEP-WCMC, 2006).

At the local level, a 2009 study (Cooper, Burke, and Bood, 2009) estimated the value of coral reefs and mangroves to the **Belize economy**.[6] Among the key findings from the study was an estimated value of reef and mangrove-related fisheries, tourism, and coastal protection services at US$395-559 million per year, compared with Belize's GDP of US$1.3 billion in 2007 (i.e., roughly 30-43% of GDP). More specifically, the study estimates that economic benefits from fisheries were about US$15 million, while reef-associated tourists spent an estimated US$150-196 million (about 12-15% of GDP). The authors note that, by comparison, the cruise industry contributed only US$5.3-6.4 million in reef and mangrove-related taxes and revenues, and that the coastal areas reap very little economic benefit relative to the negative economic impact of the cruise industry. Finally, the study estimates that coastal protection services from coral reefs are on the order of US$120 – 180 million per year in avoided damages, with reefs able to mitigate more than three-quarters of wave energy.[7]

These vitally important goods and services of coral reefs are at risk from local and global human activity, and the Mesoamerican Reef is no exception.[8] Perhaps the most severe and growing threat is at the global level in the form of climate change (Intergovernmental Panel on Climate Change, 2018). The threats from climate change include both trend and shock components. The trend components include increases in ocean temperatures and acidity due to rising concentrations of carbon dioxide and other greenhouse gases. Thermal stress from warming oceans can result in mass coral bleaching, while acidification undermines coral growth rates (and corals are already among the slowest growing animals on earth).

The shock component includes hurricanes and the attendant wave action as well as the debris load and sedimentation from flooding. The severe hurricane season in 2017, with six major hurricanes causing widespread socioeconomic damage over the Gulf Coast and the Caribbean, intensified public debate on the role of climate change in altering storm intensity and distribution. Indeed, a recent NOAA study (Murakami et al., 2018) indicated that the temperature differential between the tropical Atlantic and the rest of the global oceans can create conditions for large numbers of high-intensity storms. The authors predict that, in the future, the region will be subject to even higher numbers of fiercer storms.

[6] The Belize government, influenced by this study, decided to sue for damages after a container ship, Westerhaven, ran aground on a coral reef in January 2009. The suit was based on the forgone economic contribution of the damaged reef's ecosystem services. In April 2010, the Belize Supreme Court ruled that the ship's owners must pay the government about US$6 million.

[7] Schumann and Mahon, 2015 present an extensive bibliography of localized studies from the Caribbean and the methodologies employed but no additional estimates.

[8] Among the local sources of threat are overfishing, destructive fishing, unchecked coastal development, watershed-based pollution, marine-based pollution, pressures from tourism, and damage from ships.

A 2011 study (Burke et al., World Resources Institute) warned that, unless action is taken now, 90 percent of coral reefs will be threatened by 2030 and nearly all of the earth's reefs could be in serious danger from climate-change induced impacts by 2050 (Intergovernmental Panel on Climate Change, 2018; Beye et al. 2018). Such projections underscore the importance of protecting the health of the Mesoamerican Reef now to serve as blue shoots for regeneration of other reef systems in more dire shape.

Laying the Groundwork

Despite their importance, coral reefs are often overlooked or underappreciated in policy decisions and government investment. The amount currently invested in the MAR region in protecting coral reefs and coastal ecosystems is small relative to their contribution to the national economy and social welfare. Such protection could address various threats to the integrity of the reef ecosystem - both those which are slowly developing including warming temperatures, acidification, and sedimentation as well as rapid onset events such as storms and damage due to shipping. Some of these damages are potentially insurable and can be specifically addressed with instruments discussed in this note.

The MAR has had a history of moderate to severe hurricanes impacting it, and recovery from the storms has been variable. This section considers how these countries could lay the groundwork to make financing for protection and restoration of coral reefs sustainable. In particular, it looks at two key elements for addressing disaster risks: a disaster risk management strategy and a disaster risk financing strategy.

The four countries in the MAR region have all had ample experience in dealing with natural disasters and thus have relatively well-developed physical emergency planning and systems in place to respond to disasters. Each of the countries has policies to build resilience and reduce vulnerability, but a full-fledged **disaster risk management strategy** should also fully recognize natural resource assets in the same light as other public assets.

Steps to protect coral reefs and maintain their health should be embedded in countries' broader risk management strategies. A healthy coral reef is the first line of defense against damage from climate change and other stressors, as healthy reefs are much better able to withstand the impact of warming oceans and ocean acidification. Additionally, any strategy to protect coral reefs needs to prepare for the increased frequency and intensity of tropical storms and hurricanes. As countries cannot predict precisely when a hurricane will strike but do know that severe weather events will occur, they have to draw up plans in advance to ensure rapid response and recovery.

The second key element is a comprehensive **disaster risk financing strategy** that includes a comprehensive analysis for the management of fiscal risks associated with natural disasters, together with a strategic vision to build resilience. For the MAR region, disaster risk financing strategies are not yet in development or else are in the early stages of adoption

and generally not comprehensive in recognizing natural assets as public assets.[9] However, such strategies are fundamental for effective public financial management of disaster risk. Moreover, a strategy could and should specifically integrate climate change and climate finance into national planning and budgeting processes and be aligned to other national priorities. A more systematic, integrated approach would make climate finance more sustainable.

Performing a **disaster risk financing diagnostic** is key to underpinning a robust disaster risk financing strategy (Alton, Mahul, and Benson (2017)). The primary audience of such a diagnostic is government officials, particularly those from finance ministries. Both the World Bank and the IMF have effectively done such diagnostics for some of the MAR countries. In the case of the IMF, the institution is currently engaged in a pilot project to produce Climate Change Policy Assessments (CCPAs) for small states, which provides a thorough evaluation of fiscal planning to cope with natural disasters.[10]

The first step in conducting a diagnostic is to assess the impacts of past disasters, explicitly including the impact arising from damage to coral reefs and marine ecosystems. Three types of impact should be considered: economic, fiscal, and social.

- ***Economic***—the impact on growth, unemployment, and other disruptions to the economy resulting from a natural disaster, as evidenced in IMF Article IV reports, Post-Disaster Needs Assessments (PDNAs), etc. In the case of coral reef damage, this could include a slowdown in the tourism sector, loss of jobs in tourism and fishing, among other impacts.

- ***Fiscal***—the impact on contingent liabilities and foregone revenues, as evidenced in budget outcome reports, IMF Article IV reports, PDNAs, etc. Contingent liabilities can be either explicit (i.e., obligations based on law or clear policy commitments) or implicit (i.e., non-legally binding obligations based on public expectations or political pressure). In the case of damage to coral reefs, implicit liabilities could include support to poorer households who have lost jobs in tourism or fishing, and measures to help the tourism sector to recover, such as tax breaks. In addition, losses to the tourism sector would likely imply losses in revenues.

- ***Social***—the impact on the poor and vulnerable, including job losses and numbers that have fallen into poverty as a result of the disaster. Again, damage to coral reefs could result in job losses among fishers and low-skilled, low-income workers in the tourism sector, together with food insecurity among those that depend on local fish for much of their protein.

[9] Mexico is most advanced in this regard (see discussion on FONDEN below). Guatemala's Ministry of Finance has recently adopted a disaster risk financing strategy (Guatemala, 2018), and Belize is receiving assistance from the World Bank and the IMF toward developing such as strategy (World Bank, 2018; IMF, 2018).

[10] Belize has been the beneficiary of a preliminary CCPA, as it is categorized as a small state in the IMF (IMF, 2018).

The second step is to review the existing legal and institutional framework for disaster risk financing. This would include the budget process and current practice, budget execution post-disaster, and the institutional setup for resource mobilization and execution in the aftermath of disasters. The institutional setup should include the nature of the relationship and responsibilities between the ministry of finance and other ministries and departments involved in disaster response and related financing. This review would also examine whether an appropriate legal framework exists for *public-private-partnerships* (PPP) and for *trust funds* and the approach to cost-sharing among various stakeholders, both within government and outside of government. This latter consideration could be particularly relevant for coral reef disaster financing, since stakeholders could include the tourism sector or commercial fishing industry, among others.

The third step in conducting a diagnostic is to review the existing portfolio of disaster financing mechanisms and instruments. This would include all financing mechanisms explicitly designed to mitigate disaster-related financial risk. Governments can then prepare a fiscal risk statement which costs out the government's likely contingent liabilities deriving from natural disasters and climate change.

Ideally, the MAR region countries would apply a risk layering approach to finance, along the lines recommended by both the World Bank and the IMF in their work on strategies for Belize to cope with natural disasters (WB (2018), IMF (2018)). Risk layering is comprised of two components: risk retention and risk transfer:

- ***Risk retention***—retained risks rely heavily on budgetary resources or debt and should be used mostly for low impact, more frequent events. This is the primary approach used by MAR countries;

- ***Risk transfer***—transferred risks use insurance or capital markets or rely on international donors to cover costs from natural disasters and should be used mostly for high impact, infrequent events. Risk transfer has been used to only a limited extent in the MAR region.

Another important distinction in disaster risk financing is whether the financing is ex ante or ex post:

- ***Ex ante***: such financing would include contingency budgets, reserve funds, contingent credit lines, and sovereign risk transfer.

- ***Ex post***: this would include budget reallocations (typically heavy reliance), tax increases, post-disaster borrowing, and donor assistance.

Ex ante financing is clearly preferred to mitigate the fiscal damages associated with natural disasters. However, most countries tend to rely heavily on ex post financing, such as budget reallocations, post-disaster borrowing, and donor assistance. Particularly in the face of climate change with potentially more frequent and severe disasters, reallocating the budget could derail development plans. Clearly, debt financing of disaster response is generally

unsustainable. Relying on donor assistance is highly uncertain; the possibility of donor fatigue against a background of more frequent disasters makes this approach particularly risky.[11] If a government relies almost entirely on ex post financing for disasters, it is unlikely that it would allocate any funding to coral reef restoration in the aftermath of a disaster.

Ex ante financing is regarded as international best practice to prepare for the impact of natural disasters. This approach ensures that financing is readily available for relief and recovery after a disaster, and perhaps even some reconstruction. In addition to setting up contingency budgets or reserve funds explicitly dedicated to natural disaster losses, governments could tap contingent credit lines and/or funds directly related to addressing climate change or natural disasters. These could include the World Bank's Catastrophe Deferred Drawdown Option and the IMF's Rapid Credit Facility and Rapid Financing Instrument as well as any similar facilities through multilateral banks, the UN system or bilateral donors.[12]

Finally, sovereign risk transfer could include purchasing parametric or indemnity insurance or instruments like catastrophe bonds. For most of the MAR region countries, insurance coverage of public and private assets is typically very limited, even for physical infrastructure. A clearly articulated disaster risk financing strategy could help to convince policymakers of the importance of insurance coverage to mitigate financial risks. An important example of parametric insurance already in place in the region is the Caribbean Catastrophe Risk Insurance Facility (CCRIF), which to date, only Belize has tapped to some extent (Annex 1 discusses further the CCRIF). As discussed in the following section, parametric insurance for coral reef restoration would be an innovative approach for ex ante disaster risk financing.

Mexico provides an excellent example of an ex ante budgetary allocation, coupled with some sovereign risk transfer for natural disasters. The Government of Mexico established a Fund for Natural Disasters (FONDEN) in 1996 to ensure that it had financial resources following natural disasters. FONDEN has continued to evolve, leveraging its resources with market-based risk transfer instruments such as cat bonds.

Table 1 bellow illustrates the **most cost-effective approach to financing** for managing disaster risks.[13] The proposed MAR Fund approach to financing would be included in the upper right-hand corner, as indicated below.

[11] Donor assistance can also give rise to the Samaritan's Dilemma, in which humanitarian assistance lessens the incentives for beneficiary governments to take the steps to avert the problem in the first place.

[12] IMF (2017).

[13] Based on Ghesquiere, F., and Mahul, O., World Bank, 2010.

TABLE 1.

	Disaster Risk	Financial Instruments
Risk Transfer	**High Risk, Low Probability**: e.g., hurricanes, tropical storms, major earthquakes	**Disaster Risk Insurance**: e.g., catastrophe bonds, parametric insurance (Including for **coral reefs)**
Risk Retention	**Medium Risk, Medium Probability**: e.g., floods, minor earthquakes	**Contingent Lines of Credit**
	Low Risk, High Probability: e.g., local floods, landslides	**Contingent Budgets, Reserves, Annual Budget Allocations**

Embedding Coral Reefs into a Disaster Risk Financing Strategy

Reef insurance could be viewed as a self-contained component of a larger strategy of disaster risk management. It is important to note that as envisioned, the insurance policy/contract is not likely to be based on the value of the reef – with all the methodological ranges that implies - but on the cost of the restoration project. Parametric, or index, insurance has advantages over the more commonly used indemnity insurance. It addresses a range of well-known obstacles to insurance provision such as adverse selection and moral hazard.[14] In addition, it reduces the cost of claim verification and assessment of damages and losses since parametric insurance is based on pre-defined indexes linked to natural events; when the parametric index is reached or exceeded, the policy is activated, and a pre-defined payout is made by the insurer. Thus, parametric insurance is capable of being much more quickly – and cheaply - disbursed compared to indemnity insurance.

Table 2 summarizes the **advantages of parametric insurance policies compared to indemnity insurance policies**.[15] The basic difference in the two approaches to insurance stems from the fact that indemnity insurance needs a tangible asset to be indemnified and a clear owner of that asset which takes out the insurance. These are both problematic for reefs; parametric insurance avoids both of these problems. However, in the process of

[14] Adverse selection reflects the fact that the client has more information on their own risk than does the insurer. This implies that insurance is more likely to be purchased when the client has greater-than-average risk. Moral hazard refers to the incentive to reduce protective actions when an individual is covered by insurance.

[15] Based on "The Caribbean Catastrophe Risk Insurance Facility: Celebrating 10 Years, 2007-2017", *10th Anniversary Commemorative Magazine*, CCRIF SPC.

avoiding the challenge of ascribing ownership parametric insurance does have the disadvantage that it can be subject to basis risk (see below).

TABLE 2.

Advantages	Parametric insurance	Indemnity insurance
Lower premiums	Transaction and admin costs lower	Assessing claims is costly; added to premium
Faster payouts	Based on pre-defined trigger	Need on-the-ground assessment of losses; could take months
Objective and transparent	Calculation of payout totally objective and based on widely-published info	Assessment of loss depends on loss adjustor; exclusions and limitations
Reduction in moral hazard	Payout independent of any actions taken after policy is issued	Policyholders may engage in riskier behavior after policy is issued
Simplified claims	No need for detailed asset values and other info	Requires lots of information about insured asset

Over the last decade, enthusiasm for of the use of index insurance to help protect livelihoods from weather risk in low and middle-income settings has been tempered by mixed results from a number of innovations and pilot projects. One key challenge has been "risk ownership" – low income populations traditionally look to their government or international donors for assistance after disasters, and taking financial ownership of that risk, through purchasing insurance, is often not workable for most such individuals. Even with subsidies, individual farmers and herders have proven wary of index insurance due to issues of trust, limited liquidity, and basis risk—the latter stemming from a mismatch of the spatially covariate risk that corresponds to the index trigger and idiosyncratic drivers of individual loss. Stated differently, this refers to the risk that a client faces a loss even though the trigger is not reached and, thus, the client does not receive a payout[16]. Various solutions have been proposed, some of which require obtaining more information on individual clients, thus,

[16] Basis risk goes both ways and can produce pay-outs in excess of immediate needs.

reducing—albeit not necessarily negating—one of the advantages of index insurance. Many more recent initiatives use a group or aggregator model, where risk-sharing across many individuals mitigates some basis risk as well as addressing other barriers to insurance uptake.

Reef insurance, however, aims to fund reconstruction programs rather than reimburse individual loss (similar to the FONDEN program in Mexico). Thus, the obstacles noted in marketing insurance to individuals are less likely to prove impediments. For example, basis risk (i.e., a potential mismatch between payout and losses) may be less overt when the purpose of the payout is not to cover discreet damage or loss (e.g. of crops), but rather to begin restoration work.

As discussed below, an insurance contract is likely to be between a collective entity in keeping with the local legal framework and a private provider using an agreed-upon trigger. In the case of reef insurance, a relatively simple form of parametric insurance is likely to be appropriate; two criteria are jointly potential triggers: i) the location of the hurricane within a specific geographic zone (box), and ii) its category. Hence, this is often referred to as a "cat in a box" trigger. If these two criteria are met, it triggers a payout.

For reef protection, **the trigger is likely to be based on peak wind speed (which, for ease of understanding, is converted to hurricane category)**. Rainfall during a storm *may* be more damaging overall (as in Hurricane Mitch in 1998 or Hurricane Florence in 2018), but this may not necessarily be the preferred trigger for reef restoration, given that intensity of wave action (closely correlated with wind speed for a given reef segment) has the best proxy relationship to reef damage (Puotinen et al., 2016).

Hurricanes are monitored internationally, and data on the storms are not proprietary; therefore, the trigger does not require appreciable monitoring costs. Further, Atlantic Basin tropical cyclones are very well researched, and both academic and risk-taking communities have relatively high confidence in their probabilistic projections of frequency/intensity relationships, enabling pricing of parametric triggers based on wind speed to be relatively straightforward and well-constrained. However, given climate change, there is a concern for ambiguity risk stemming from the uncertainty of the probability of the occurrence and strength of storms. While there are extensive data for probability of wind speeds in the Atlantic Basin there is residual uncertainty about the impact of changing climate on the odds of a disaster occurring. This uncertainty may add a premium over current actuarial calculations of insurance costs.

A **key feature of the approach is the timeliness of a payment**; there is no need for an additional on-the ground—or in this case, in the water—assessment of damage. Payments can be made more promptly than is generally the case with governmental domestic self-insurance or international disaster response. This has a particular advantage in the case of reef protection, as the value of restoration projects is highly time dependent. Damage to the reef continues well after a storm has cleared since rubble underwater continues to batter the reef in the course of normal tides and currents. Removal of such debris, then, not only limits the extent of reef destruction; it also sets the foundation for seeding of new coral while

providing temporary employment for individuals working in the tourism sector and fishing industries.

Another important aspect of reef insurance is that **a prompt restoration payout can finance both the protection and growth of a living reef as well as mitigate the interruption of livelihoods of those dependent on reef services.** To state this somewhat differently, it addresses the damage to assets from a storm, the economic loss from a suspension of the normal flow of services from the reef, and the related social costs of loss of livelihoods among a vulnerable population.

Who Benefits and Who Pays for Reef Insurance?

As discussed previously, a diverse set of ecosystem benefits derive from coral reefs. This implies **diverse actors are at risk and thus would benefit from insurance** (see Table 3 below). The institutional framework for reef insurance thus requires a means to accommodate multiple ultimate beneficiaries of an insurance contract and, most likely, multiple premium payers, not all of whom are direct beneficiaries.

Table 3. Prospective Stakeholders in Parametric Insurance for Coral Reefs

Ecosystem service	Strength of evidence	Reef or coastal ecosystem?	Direct stakeholders	Potential insurance purchasers
Fisheries	+++	Reef mainly, but mangrove as nursery	Fishers, fishing industry workers	Government, fishing industry
Tourism	+++	Reef mainly	Hotels, dive shops, other tourism-related businesses, tourism-sector employees	Government, hotels, other tourism industry
Coastal protection	+++	Reef mainly, but coastal system to smaller degree	Tourist infrastructure owners, coastal home owners, government	Government, hotels, coastal businesses and homeowners
Biodiversity	+++	Coastal system, but reef largest contributor	All countries and people; academics, researchers, pharmaceuticals	International NGOs, multilateral development banks, other countries
Carbon sequestration	++	Coastal system, but reefs fundamental to protection of coastal system	All countries and people	Government, international NGOs, multilateral

				development banks

Governments might finance a portion of the total premium as: a) part of its global disaster risk management[17] and climate change adaptation commitments; and b) as a means of reducing post-disaster unemployment and loss of tourist tax revenue.

Direct beneficiaries of such insurance include fishers and employees in the tourism sector. Individuals might seek to purchase hurricane risk insurance that gives a direct cash payout for lost earnings. Global experience, however, indicates that it is unlikely that many individuals, particularly low-skilled, low-income workers, would pursue this option. Nor would a direct cash payout to individuals likely have benefits for reef restoration. Thus, an insurance policy would be envisioned to provide, not a direct payout, but would nonetheless provide benefits to workers from the demand for their services during a restoration effort and, more importantly, would benefit from long-term environmental services (specially food security) maintained by reef restoration.

Hotels and other tourist dependent businesses, another set of stakeholders who could benefit from insurance may seek coverage for interruption of business that provides cash payouts in case of hurricanes that negatively affect their business. But again, these payments are not likely to be invested in reef restoration. Moreover, while firms and individuals employed in reef-dependent occupations might recognize the benefits from restoration, they likely anticipate these benefits whether or not they actually contribute to the cost of insurance. This is a standard and well known 'free-rider' problem.

Thus, this is where a private/public partnership would ideally be in place. To the degree that there are collective associations within the tourist industry, membership fees could be partially devoted to a share of the premiums. A surcharge to tourists could also serve this purpose. This could be a dedicated tax, where such fit the legal framework, or it can be an optional per stay or per night contribution, ideally one that the visitor can opt out of rather than opt into. However, it is unlikely that a payout into general government revenue, for example, will lead to direct and commensurate funding of reef restoration. Thus, it will be necessary to set up a dedicated/segregated fund to both reassure contributors that their monies are being used for the purpose for which they were collected, and to provide transparent management of the funds.

Additionally, as the reef and coastal ecosystem is a global public good, the larger international community might be willing to defray a share of the costs of such a program. Clearly, neither annual nor ex post fund-raising would serve the function of sustainable insurance. However, paying for the pilot phase of a reef insurance program would be a reasonable approach for donors, provided that there is a reasonably good chance that if proven to be effective, governments and local businesses would continue to fund the policy premiums for reef insurance.

Finally, a trust fund similar to various debt-for nature swaps that have been successful in financing recurring costs of park protection can provide a sustainable stream of funding.

[17] Under the Sendai Framework for disaster risk reduction (UNISDR, 2105), for example

MAR Fund's Role

For reef insurance to be an effective tool, upfront protocols and logistic arrangements for in-situ response must be in place – having money quickly is an enabler, putting it to work is what really matters. To this end, MAR Fund has been working for many years to put in place the multiple elements required for reef insurance to work.

Beyond the issue of "who should pay for reef insurance?" (discussed above) there needs to be a designated entity that holds the insurance contract and can allocate funds according to pre-agreed and transparent rules once a policy pay-out is triggered. This is an area where MAR Fund brings over 15 years of experience, and a well-recognized track record of effective financial and project management in the region - currently, MAR Fund manages a $25 million endowment fund and has mobilized $22.4 million of project funding.

Another consideration is that reefs are under the management of national governments, so restoration has to take place in close coordination, and with prior approval, of the pertinent authorities in each country. For this, it is vital to understand the legal and administrative structure in each country, a task already completed by MAR Fund. Given its prior work, MAR Fund is well positioned to negotiate Memorandums of Understanding and other agreements with national and local authorities to allow access to reef sites to rapid response teams following a hurricane or ship grounding.

Finally, rapid response teams need to be trained and equipped in advance, and logistics need to be pre-arranged for quick deployment to the restoration site and teams need to be supported and funded while working. To a large degree, this is 'soft' infrastructure, comprised of a set of experts in reef restoration that have the experience to train fishers and staff from tourist industry in the immediate tasks for reef protection. Immediate response for the first phase of reef protection is largely a matter of staffing and coordination; expensive equipment is not required. Creating these core skills from scratch after a storm risks a delay that compounds the damage to the reef. If, however, this soft infrastructure is already in place prior to any natural disaster, reef restoration would be effectively a so-called "shovel-ready" project, that is, one that can take place almost immediately in the aftermath of a storm.

Challenges and Opportunities for Sustainability

Ultimately, **the success of MAR Fund's RRI depends on whether the program can become sustainable on its own after the 5-year start-up phase**. The key challenge will be to persuade governments to fully recognize reefs as a public asset—similar to other types of public assets like roads, bridges, hospitals—in light of the substantial economic and ecosystem services provided by coral reefs. Indeed, green infrastructure can be the first line of defense against climate change and natural disasters (e.g., various studies have found coral reefs more effective than man-made seawalls in coastal and shoreline protection).

Encouraging the MAR region governments to have a full-fledged disaster risk financing strategy which incorporates coral reef insurance is an important first step. Governments

should also be encouraged to pursue other International initiatives that may be appropriate to further MAR Fund's and the RRI's goals for promoting and financing reef restoration and conservation as well as broader international agreements and frameworks – e.g. Paris agreement, SDGs, Sendai Framework, InsuResilience, G7 Oceans initiative, Year of the Reef, etc.

Nevertheless, given the low insurance coverage of other public assets and in the face of competing priorities, it could be difficult for governments to justify earmarking funds for reefs[18] when other competing priorities might seem more urgent in the aftermath of a disaster. A key difference, however, could be the involvement of both the private sector and international NGOs and donors in co-financing. On the private sector side, the most obvious candidates would be the local tourist industry including hotels, dive shops, boat rental and similar marine activities. This sector is a major beneficiary of healthy reef systems, but at the same time, may place major stresses on the ecosystem. An economic valuation of reef services can help support efforts to require hotels to compensate for some of the stressors. With private sector involvement comes the issue of free riders and how to enforce contributions to the trust fund or PPP. Again, a robust legislative framework can be helpful in this regard.

Some **prospective approaches to both lower the costs (directly and indirectly) of parametric insurance policies and make the RRI sustainable** could include:

- Engaging with credit rating agencies to encourage them to provide better credit rating if coastal infrastructure were "insured" via healthy coral reefs;

- Working with domestic insurance companies to reduce the price of policies for coastal properties where coral reefs are healthy;

- Incorporating the costs of protection of coastal ecosystems as part of the Intended National Defined Contribution in the Paris Climate Accord for carbon mitigation, as is currently done with rainforests;

- Scaling up the program over time to other countries to achieve diversification and lower costs; and

- Encouraging the IMF as well as other international financial institutions to formally incorporate climate change into its policy dialogue with countries and to expand its CCPAs to countries particularly vulnerable to the impacts of climate change.

Some of these issues will require further investigation and new opportunities will likely materialize as experience is gained during the start-up phase. The RRI program features learning-by-doing, supported through data collection and thorough "after-action" reports in

[18] This has both an ex ante and ex post dimension. Ex ante earmarking means that the government is willing to contribute its share of financing for purchasing parametric insurance policies aimed solely at reef restoration. Ex Post earmarking means that any payout would be used only for reef restoration and preservation and would **not** find its way into general budget resources, even if those were being used for other recovery efforts after a disaster.

the event of a payout (or lack thereof) after a natural disaster occurs; experience gained will be crucial to inform not only the long-term resilience planning for the MAR but also for reef conservation globally.

Suggested Next Steps for MAR Fund and the RRI

Based on the discussion of challenges and opportunities presented above, we suggest that MAR Fund and the RRI:

1. Identify and lobby key government decision makers in the MAR Region and IMF, IADB and World Bank to:
    a. Promote the concept that coral reefs are public and global assets given the substantial economic and ecosystem services they provide.
    b. Persuade them to include coral reefs into disaster risk planning and financing strategies, and to incorporate reef insurance as a way to finance the risk to this important green asset.

2. Partner with MAR Region governments to pursue financing opportunities for reef restoration and conservation (e.g. the GEF, IADB, World Bank, InsuResilience), and persuade governments to include reef restoration into broader international agreements and financing frameworks – e.g. Paris agreement, SDGs, Sendai Framework, GEF, G7 Oceans initiative, Year of the Reef, etc.

3. Increase MAR Fund's and the RRI's presence and recognition in the international arena as a significant player in reef restoration, climate risk policy and planning, and innovative financing. This entails intensifying the current level of contact with high level government and regional officials, and with international donors and multilateral organizations. Also, MAR Fund may want to be a more proactive presenter/voice at important international conferences, both dealing with global frameworks and scientific underpinnings, in order to broadly convey its message to decision makers.

4. Seek opportunities to engage the tourist industry associations (hotels, dive shops, boat rental and similar marine activities) to discuss their economic dependency on healthy reef systems, and how the work of the RRI aligns with their own financial wellbeing. Economic valuation of reef services can help support efforts to persuade these stakeholders to invest in measures (such as help pay for reef insurance) to mitigate some of the stressors they place on the reefs.

5. Explore the willingness of each country to levy tourist or hotel-stay contributions (both voluntary or mandatory) to support insurance premiums, and under what legal arrangements this would be feasible.

Annex 1. The Caribbean Catastrophe Risk Insurance Facility

The Caribbean Catastrophe Risk Insurance Facility (CCRIF) was launched in 2007, based on a request by the Caribbean Community (CARICOM) to the World Bank for assistance in improving access to catastrophe insurance after the severe devastation caused by hurricanes, particularly Hurricane Ivan, in the Caribbean in 2004. As the result of a collaboration between the region's governments and key donor partners,[19] It became the world's first multi-country risk pool based on parametric insurance.

The CCRIF allows countries to pool their natural disaster risks[20] and collectively purchase catastrophe risk insurance at a substantial discount relative to what they would pay if they had to approach the insurance market individually. The CCRIF's use of parametric insurance allows it to offer immediate liquidity in the aftermath of a disaster, with the policy activated on the basis of exceeding a pre-established trigger and the payout increasing up to an agreed limit as the intensity of the event increases. For tropical cyclones and earthquakes, a modeled loss approach is used, in which the event characteristics, independently reported, are used as input to a locked catastrophe risk model, which estimates an expected loss to a fixed portfolio of assets. The excess rainfall product uses a simpler approach in which the accumulation of rainfall during a pre-agreed time window, weighted based on exposure, dictates the payout amount.

In its first 10 years, the CCRIF made 22 payouts totaling over US$69 million to 10 member governments. These payouts have lessened the burdens on state finances and have been used almost immediately for post-disaster clean up, rehabilitating infrastructure, and assisting local communities in their recovery. During the 2017/18 policy year, CCRIF made further payouts totaling more than $60 million, most during the very active hurricane season.

In 2015, the CCRIF expanded beyond the Caribbean to allow Central American countries to join. 20 countries are members of CCRIF at present. Currently, the only one of the four MAR region countries to participate in the CCRIF is Belize. However, Belize reduced its coverage under the CCRIF, declining to renew its hurricane and earthquake policies and investing only minimally in excess rainfall coverage. This was due to disappointment with the payouts after Hurricanes Richard and Earl.

[19] It was developed with a grant from Japan and capitalized through contributions to a Multi-Donor Trust Fund from the governments of Bermuda, Canada, the European Union, France, Ireland, and the United Kingdom, the Caribbean Development Bank the World Bank, and membership fees paid by participating Caribbean governments. The United States, Mexican and German governments also contributed to a second MDTF, which supported the expansion of the facility to Central America and the development of an expanded range of parametric insurance products.

[20] Initially, the CCRIF only included tropical cyclone and earthquake products, but it was expanded in 2013 to include excess rainfall, based on stakeholder demands. The facility is currently working on expanding its products to include drought, agriculture, and fisheries.

References

Alton, Martin Luis, Olivier Mahul, and Charlotte Benson. "Assessing Financial Protection against Disasters: A Guidance Note on Conducting a Disaster Risk Finance Diagnostic," World Bank and Asian Development Bank (2017).

Brander, Luke, and Pieter van Beukering. "The total economic value of US coral reefs: a review of the literature." (2013).

Barbier, E., Hacker, S., Kennedy, C., Koch, E., Stier, A., and Silliman, B., "The Value of Estuarine and Coastal Ecosystem Services," *Ecological Monographs* 81(2), 2011, 169-193.

Barnett, Barry J., and Olivier Mahul. "Weather index insurance for agriculture and rural areas in lower-income countries." *American Journal of Agricultural Economics* 89, no. 5 (2007): 1241-1247.

Beyer, Hawthorne L., Emma V. Kennedy, Maria Beger, Chaolun Allen Chen, Joshua E. Cinner, Emily S. Darling, C. Mark Eakin et al. "Risk-sensitive planning for conserving coral reefs under rapid climate change." *Conservation Letters* (2018): e12587.

Burke, Lauretta and Jonathan Maidens, *Reefs at Risk in the Caribbean*, World Resources Institute, Washington, DC (2004)

Burke, L., K. Reytar, M Spalding, and A. Perry, *Reefs at Risk Revisited*, World Resources Institute, Washington, DC (2011)

CCRIF SPC, "The Caribbean Catastrophe Risk Insurance Facility: Celebrating 10 Years, 2007-2017, 10th Anniversary Commemorative Magazine

Cesar, H., L. Burke, and L. Pet-Soede, "The economics of worldwide coral reef degradation, "Cesar Environmental Economic Consulting, Arnhem, Netherlands (2003)

Cole, S., Giné, X., Tobacman, J., Topalova, P., Townsend, R. and Vickery, J., 2013. "Barriers to household risk management: Evidence from India." *American Economic Journal: Applied Economics*, *5*(1), pp.104-35.

Conservation International, *Economic Values of Coral Reefs, Mangroves, and Seagrasses: A Global Compilation*, Conservation International, Arlington, VA (2008)

Cooper, E., Burke, L., and Bood, N., *Coastal Capital: Belize. The Economic Contribution of Belize's Coral Reefs and Mangroves*, WRI Working Paper, World Resources Institute, Washington, DC (2009)

De Groot, R., et al, "Global estimates of the value of ecosystems and their services in monetary units," Ecosystem Services, Vol. 1, No. 1, pp. 50-61 (2012)

Ghesquiere, F., and O. Mahul, *Financial Protection of the State Against Natural Disasters: A Primer*, Washington, DC, World Bank (2010)

Global Ocean Commission, “From decline to recovery, rescue package for the global ocean,” Oxford, United Kingdom (2014)

Guatemala, Ministry of Public Finance, “Disaster Risk Financing Strategy,” April 2018

Intergovernmental Panel on Climate Change. Special report. Global Warming of 1.5C. October 2018.

International Monetary Fund, “Small States’ Resilience to Natural Disasters and Climate Change—Role for the IMF,” IMF Policy Paper, December 2016

International Monetary Fund, “ Large Natural Disasters—Enhancing the Financial Safety Net for Developing Countries,” IMF Policy Paper, May 2017

International Monetary Fund/World Bank Group, “Belize: Climate Change Policy Assessment—Pilot,” draft, 2018

Jensen, Nathaniel D., Andrew G. Mude, and Christopher B. Barrett. "How basis risk and spatiotemporal adverse selection influence demand for index insurance: Evidence from northern Kenya." *Food Policy* 74 (2018): 172-198.

Jensen, Nathaniel, and Christopher Barrett. "Agricultural index insurance for development." *Applied Economic Perspectives and Policy* 39, no. 2 (2017): 199-219.

Moberg, F. and P. Rönnbäck, “Ecosystem services of the tropical seascape: interactions, substitutions and restoration,” *Ocean and Coastal Management* 46: 27-46 (2003).

Murakami, H., E. Levin, T. Delworth, R. Gudgel, and P. Hsu, “Dominant effect of relative tropical Atlantic warming on major hurricane occurrence,” *Science*, September 2017

OECD, *The Ocean Economy in 2030*, OECD Publishing, Paris (2016)

Puotinen, Marji, Jeffrey A. Maynard, Roger Beeden, Ben Radford, and Gareth J. Williams. "A robust operational model for predicting where tropical cyclone waves damage coral reefs." *Scientific reports* 6 (2016): 26009.

Schuhmann, Peter W., and Robin Mahon. "The valuation of marine ecosystem goods and services in the Caribbean: A literature review and framework for future valuation efforts." *Ecosystem Services* 11 (2015): 56-66.

Spalding, M., McIvor, A., Beck, M., Koch, E., Moeller, I., Reed, D., Rubinoff, P., Spencer, T., Tolhurst, T., Wamsley, T., van Weesenbeek, B., Wolanski, E., and Woodroffe, C, “Coastal Ecosystems: A Critical Element of Risk Reduction,” *Conservation Letters*, May/June 2014 7(3), 293-301

Spalding, Mark, Lauretta Burke, Spencer A. Wood, Joscelyne Ashpole, James Hutchison, and Philine zu Ermgassen. "Mapping the global value and distribution of coral reef tourism." *Marine Policy* 82 (2017): 104-113.

TEEB, *The Economics of Ecosystems and Biodiversity in National and International Policy Making*, edited by Patrick ten Brink, Earthscan, London and Washington (2011)

Temmerman, S., Meire, P., Bouma, T., Herman, P., Ysebaert, T., and De Vriend, H., "Ecosystem-Based Coastal Defence in the Face of Global Change," *Nature* (December 2013).

UNEP-WCMC*. In the Front Line: Shoreline protection and Other Ecosystem Services from Mangroves and Coral Reefs*. United Nations Environment Programme (UNEP), World Conservation Monitoring Centre (WCMC), Cambridge, UK. 33pp. (2006)

UNISDR. "Sendai framework for disaster risk reduction 2015–2030." In *3rd United Nations World Conference on DRR*. Sendai, Japan: UNISDR, 2015.

United Nations, Food and Agriculture Organization, *The State of World Fisheries and Aquaculture: Opportunities and Challenges*, Rome, Italy, 2014

Wong, Y. C., Lemus, A., and Wagner, N., "Insuring Against Natural Disasters in the Caribbean," IMF Country Report No. 09/176, June 2009, 46-61

World Bank, "Advancing Disaster Risk Finance in Belize," February 2018