A landscape review of nature-based solutions as an incentivization for insurance policy

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Introduction

Sea-level rise, coastal flooding and climate change induced coastal erosion all threaten coastal communities and ecosystems in California; by 2100, approximately 500,000 Californians will be negatively impacted by the resulting loss of ecosystem services, water supply disruptions, and damage to agricultural land (Climate Change Impacts in California, 2011). However, maintaining healthy coastal and marine ecosystems can help minimize the impact. Investments in coastal infrastructure and ecosystem restoration are crucial in preventing major, long term expenses and protecting vulnerable communities. Both the federal and the California state budgets include funding that is specifically marked to advance nature-based climate solutions. Most recently, the California State Budget 2022-2023 allocated $768 million in a General Fund over two years for nature based solutions.

An estimate on the global level done by the UN Environment Program reveals that 0.1% of global GDP is invested in nature-based solutions, or $113 billion per year[1]. The report suggests that to meet future climate, biodiversity and ecosystem degradation targets, this number should increase four-fold by 2050. Currently, the ratio public-to-private funding is 6-1. The outlook poses opportunities for private sector investment to increase significantly.

As a major financial player, insurance can significantly contribute to scale up climate-adaptation measures. Leveraging the expansion of nature-based solutions (NbS) through the insurance sector is a promising area of growth in climate adaptation and resilience. Globally, demonstration projects using NbS incentivization in insurance policies or products are increasing in popularity. With over 840 miles of coastline, California promises to be an excellent candidate for implementation of such initiatives. This paper generates an overview of existing academic literature and case studies to provide best practices and specific recommendations for implementing NbS insurance schemes in a California context.

[1] Such estimates are indicative, as capital flows into NbS are not tracked or reported consistently.

Analysis Framework

Implementing NbS through insurance partnerships is a complex and multifaceted process that requires holistic analysis of stakeholders, mechanisms, and best practices in establishing a common basis of comparison. A standardized set of criteria allows for evaluation of the existing cases on a comparable level. We analyzed the issue from both academic and practical perspectives and divided the evaluation criteria. The following questions were examined to create this framework and inform the recommendations of this study:

- *What is the current standpoint of academia towards NbS and its usability in insurance practices?*
- *How do existing projects for NbS in insurance work?*
- *Are there synergies between the theoretical and the practical use of NbS in insurance and how does it fit together?*
- *Are there gaps between the academic and the practical literature and how can they be closed?*

I. Examination criteria for academic literature:

Our objective in reviewing the academic landscape of NbS in insurance is to provide a concise overview of the current status of research. Major questions[1] answered were:

- *How effective are NbS with regards to climate adaptation in coastal areas?*
- *Is there a consensus among researchers on the efficacy of NbS for climate adaptation?*
- *What models are presented by academia to implement NbS in insurance schemes and how do they work?*
- *What are the major constraints of these models with regards to implementation?*
- *Is social and environmental equity prioritized in these models?*
- *Are there major knowledge gaps about NbS in insurance and in which segment is the highest need for further research?*

II. Examination criteria for existing projects:

The following table provides an overview of the criteria and guiding questions that were used to evaluate existing cases. The first four criteria summarize the context of the case study. The last three analytical criteria were used to identify bottlenecks and constraints, potential social equity and environmental justice concerns, and applicability to California as a model system[2].

[2] The questions to determine injustices are derived from the IUCN's framework of social justice in marine conservation, aiming to identify recognitional, procedural, distributional and contextual equity (*Re-Imagining Marine Conservation through Centering Social Equity*, n.d.).

Criteria	Metrics/Evaluation
Location	o Country / State / City o Size of affected area
Ecosystem	o What kind of ecosystem is considered for the NbS? o How does the ecosystem improve climate resiliency?
Stakeholders	o Insurance company o Insurance Holder (private/public/commercial) o Organizations regarding the NbS o Government
Financing Mechanisms	o How is the NbS funded? o Are there financial incentives for stakeholders to promote NbS? o How does the case impact the insurance premium?
Constraints	Which factors are currently constraining the outcome of the case? o Political o Ecological o Financial o Social
Social Equity	o To what extent was equity defined and recognized for the local context? o To what extent were local communities engaged throughout project development and implementation? o To what extent were/are benefits and impacts distributed among local populations and groups? o To what extent do broader contextual factors impact local populations and groups?
Applicability to California	o Does the ecosystem exist in California? o Would the program positively impact California's resiliency towards sea-level rise? o Are there regulatory constraints in California that would burden the implementation? o Is the program financially feasible for California?

Literature Review: Examining Current Academic Knowledge of Coastal Nature Based Solutions

Landscape Synthesis of Scientific NbS Research[3]

Recent research suggests that NbS for sea-level rise and coastal erosion mitigation (shoreline/beach nourishment) holds potential for more effective coastal resilience outcomes when compared to engineered solutions. Positive co-benefits are often associated with NbS systems, with many systems conferring multiple environmental and social benefits simultaneously. Within the context of healthy coastal and marine ecosystems, co-benefits of NbS may include wave attenuation, sea level adaptation via managed inland retreat, habitat creation and restoration for rare and endangered species, infrastructure and property protection and buffering, and increased public education, recreation, and access. Multiple studies examining NbS implementation have found more success in interventions in natural systems as opposed to the creation of novel ecosystems, suggesting that the restoration of existing ecosystems may be a more effective strategy for maximizing NbS benefits. Similarly, larger, older, and more established ecosystems are more effective in provisioning ecosystem services than their younger counterparts; these benefits include climate adaptive services, which may suggest increasing returns on investment over long time scales. Established ecosystems are also more stable and are able to recover more effectively from disturbance, which may be of importance as climate change leads to increased frequency of natural disasters.

NbS in the Field

Emerging NbS projects in California are gaining traction as interest in "living shorelines" increases[4]. A majority of California case studies use Olympic Oysters (*Ostrea lurida,* the state's only native oyster species) as the center of project design, with others incorporating eelgrass meadow planting, sediment deposition, sand dune creation and reinforcement, and upland salt marsh restoration. Many of these projects are created using a co-benefits approach, with primary interest in creating and/or restoring native habitat and peripheral interest in their significant benefits in wave attenuation and sea-level rise adaptation capacity.

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[3] This review only examines case study (field) data, and does not reflect the dearth of information contained in the many theoretical models of NbS implementation.

[4] For the purpose of this report, living shorelines are considered synonymous with coastal nature based solutions. In academic study, there are distinctions between these terms along a spectrum of "softness" (i.e. what percentage of the coastal intervention is nature based versus built infrastructure); this subcategorization was not explored to avoid unnecessary complication.

Success stories include the San Francisco Living Shorelines Site at San Rafael, Surfer's Point Beach in Ventura, and Upper Newport Bay in Orange County (see Appendix 1 for further information on the cases). From these and other national studies, both salt marshes and oyster reefs have emerged as appropriate NbS systems and have been found to be effective barriers against erosion and wave energy. Combining multiple methods of climate adaptive NbS has been found highly effective as is the case in using marshes and shell sills in tandem. Studies from the Gulf of Mexico and the Southeastern US have shown salt marshes and oyster reefs to be significant tools in buffering storm surges, even in hurricane conditions. NbS installations are more stable and establish more successfully in protected areas (e.g. bays, inlets, etc.) and are therefore more likely to successfully reduce wave height and energy and require less maintenance, replanting, and continued restoration.

Box 1: Do Nature-Based Solutions Work?

Is there a consensus on the efficacy and value of NbS?

Across hundreds of studies of nature-based interventions, NbS have been found to be effective in provisioning ecosystem services that protect habitat and help ecosystems. Globally, coastal ecosystems protect over 13 million people from flooding and are often equally as effective as "grey" infrastructure. In a 2020 survey of NbS literature, no studies reported negative social outcomes and found more synergies than trade-offs in establishing nature based solutions in coastal systems. Natural coastal ecosystems have been found to be highly effective in attenuating wave height and certain types of ecosystems have even been found to mitigate extreme waves in category I hurricanes.

Current Foci in NbS Insurance Literature

NbS have become increasingly popular in research and practice, a large portion of which centers on frameworks, guidelines, success markers, and criteria for evaluation. These theoretical studies tend to focus on the socioeconomic and policy considerations of implementation, but few are compared against existing systems or their application to insurance programs, limiting their usability for practitioners. Most economic analyses of engineering solutions and NbS are common, while comparative analyses between grey and green infrastructure are lacking. While economic insights are harder to address, research is progressing in preference toward NbS as more cost-effective, lower maintenance, and having higher co-benefits than attainable with engineered solutions (higher overall NPV).

Box 2: Where is Social Equity in Insurance Frameworks?

Social equity considerations present in NbS Frameworks:

- Consensus regarding NbS as a critical element in building resilience in high-risk communities, while insurance scheme motive can be questionable
- NbS is likely to play a role in keeping risk insurance affordable in vulnerable communities due to lowering long-term risk
- Economic analyses suggest that lower income and subsistence lifestyles complicate the tradeoffs with monetary payments, so stated preference studies often shift to time payments as an alternative to standard monetary payments to avoid an underestimation of willingness to pay (WTP).
- Acknowledgment of the climate impacts already suffered by vulnerable coastal communities and the resulting economic impacts.
- A push for innovative, collaborative programs for co-production of knowledge among diverse affected stakeholders exists, but incentives are needed

Nature Based Insurance Case Studies

There are a limited number of case studies demonstrating the usage of insurance as an incentive for NbS as represented in the subsequent case study examination. Nevertheless, there are examples of successful implementation of programs, which have been expanded following initial success. Examples of this include coral reef insurance in Hawai‘i modeled after a similar program in Quintana Roo, Mexico. Constraints to expansion remain and are case dependent, however, there is evidence to suggest this model may be an effective management tool to protect climate-vulnerable communities.

Eight case studies have been selected to demonstrate how insurance may play a role in incentivizing NbS, with a focus on cases that may be relevant to the Northern California context. These eight case studies are communicated through the table format outlined in the methodology section. Footnotes are numbered to be correlated with the case study number, which provide additional literature expanding on the information outlined in the table. Additional case studies were reviewed but ultimately not included for further examination. This is due to the scope of this report aiming to identify projects related to coastal NbS and an applicability to Northern California. It should, however, be noted that any future development of a program would benefit from examining the design of other unique insurance mechanisms for potential frameworks, so below we include notable case studies for further research when considering the application of incentivizing NbS through insurance:

1) African Risk Capacity (ARC) - United Nations World Food Programme - Mali
2) Caribbean Oceans and Aquaculture Sustainability FaciliTy (COAST) - Grenada & St. Lucia
3) IBC Agriculture and Wetlands Insurance - Windsor, Ontario

4) Terrafirma Risk Retention Group - United States
5) Wildfire Resilience Insurance - United States

Case Study	Location	Ecosystem	Stakeholders	Financing Mechanisms	Constraints	Social Equity	Applicability to California
1 Mesoamerican Reef Insurance	Quintana Roo, Mexico (167 km of coastline)	Coral Reef (coastal storm buffer)	Swiss Re*, The Nature Conservancy§, Mexican Government§, Local Businesses§, Restoration Teams†	Parametric insurance policy dependent on wind speed (100+ knots)	Lag time between receiving payout and distribution for restoration efforts.	Restoration team created by local community; payout funds support local community.	Low
2 Hawai'i Reef Insurance	Coastlines of O'ahu, Maui, Lanai, Moloka'i, Hawai'i	Coral Reef (coastal storm buffer)	Munich Re*, The Nature Conservancy and donors§, Division of Aquatic Resources, Restoration Teams†	Parametric insurance policy dependent on wind speed (50+ knots)	Pilot program for one storm season; supported primarily by donors.	Equitable fund application noted in design; use community partners for restoration and fund allocations.	Low
3 NFIP Community Rating System (CRS)	United States (23,000 participating communities)	Qualifying Activities (flood risk reduction)	FEMA*, Environmental Protection Agency, Participating Communities†	Point-Based System: implemented activities earn points to receive insurance discounts	Activities may have high costs associated with implementation.	Information encompassing social equity criteria not found.	High

Stakeholder Key (based on primary role, which is a simplification): * demotes insurer/administerer, † denotes policy owner, § denotes funder

Footnotes correlate with case study number to provide additional program information:

1. MAR Fund: Mesoamerican Reef: Insuring a natural asset in the name of conservation
1. Swiss Re: Designing a new type of insurance to protect the coral reefs, economies and the planet
2. TNC: The Nature Conservancy Announces First-Ever Coral Reef Insurance Policy in the U.S.
3. US EPA: Get Flood Insurance Discounts with Low Impact Development, Open Space Protection Plans, and Stormwater Management Regulations
3. FEMA: Flood Insurance

Case Study	Location	Ecosystem	Stakeholders	Financing Mechanisms	Constraints	Social Equity	Applicability to California
4 Mangrove Insurance Program	Philippines (3 sites, conserving 3,400ha and restoring 600ha)	Mangroves (flood reduction benefits)	RISCO[§], Conservation International[§], Swiss Re*, Coastal Communities/Asset Owners[†]	Blend of grants, loans, blue carbon credits, and insurance	Complex financing and monitoring systems requiring intensive implementation.	Community engagement outlined in design; prioritized sites based on vulnerability.	Moderate
5 Prins Hendrikzanddijk Heritage Site (Prince Hendrik Sand Dyke)	Texel, Netherlands (3km/200ha of habitat restoration)	Sand Dyke (sea level rise resiliency)	Swiss Re*, Jan De Nul Group, The Waterboard 'Hollands Noorderkwartier'[§], Local Residents	Construction all risks (CAR) policy	Intensive construction development phase and high initial costs.	Information encompassing social equity criteria not found.	High
6 Mangrove Restoration and Insurance	The Caribbean (7 countries, 3,000km of coastline)	Mangroves (flood and erosion risk reduction)	The Nature Conservancy[§], Multiple Universities, National/Local Governments[†]	Combination of insurance (parametric or indemnity) and trust funds.	Inadequate flood modeling reduces the effectiveness of project site selection.	Program design emphasizes community benefits; local residents involved in restoration.	Moderate

Stakeholder Key (based on primary role, which is a simplification): * demotes insurer/administerer, † denotes policy owner, § denotes funder

Footnotes correlate with case study number to provide additional program information:
4. Restoration Insurance Service Company (RISCO): Instrument Overview
4. Restoration Insurance Service Company (RISCO): Instrument Analysis
5. Jan De Nul Group: Prins Hendrik Sand Dyke, The Netherlands
5. Swiss Re: World Heritage Site nature-based solution leads the way in reducing the risk of rising sea levels
6. TNC: Reducing Caribbean Risk: Opportunities for Cost-Effective Mangrove Restoration and Insurance

Case Study	Location	Ecosystem	Stakeholders	Financing Mechanisms	Constraints	Social Equity	Applicability to California
7 IBC Coastal Flooding Insurance (Making Room for Wetlands Project)	Bay of Fundy, Canada (75ha of coastal habitat)	Marshes and Sand Dunes (coastal flood protection)	Insurance Bureau of Canada (IBC)*, Saint Mary's University, Department of Fisheries and Ocean Coastal Restoration§	Combination of government funding and insurance policy.	Requires significant government funding to restore degraded habitat.	Identify equitable approach in program design; involvement and collaboration with Indigenous communities; government grants for funding.	High
8 Missouri River Community Flood Resilience Insurance	Missouri, Atchison and Holt Counties (5 miles/400 acres of wetlands)	Levee setback and wetland restoration (flood risk reduction)	The Nature Conservancy§, Munich Re*, FEMA, USACE, Missouri DNR§, Landowners†, Farmers†	Government and non-profit funding coupled with insurance incentives.	Real estate requirements, upfront funding and construction contracts/permits for levee setback projects.	Community engagement and involvement outlined in design; landowners receive benefits.	Moderate

Stakeholder Key (based on primary role, which is a simplification): * demotes insurer/administerer, † denotes policy owner, § denotes funder

Footnotes correlate with case study number to provide additional program information:
7. The Geneva Association: Flood Risk Management in Canada: Building flood resilience in a changing climate
7. IBC: Insuring and Restoring the Natural Assets that Protect Coastal Communities
7. Swiss Re: Protecting and Enabling Nature-Based Solutions
8. TNC: Improving Flood Resilience Through Community Insurance and Nature-Based Solutions
8. TNC: Large-Scale Levee Setback Playbook
8. TNC: Reconnecting the Missouri River Floodplain

Recommendations to practitioners, researchers, and communities

Research Needs: Opportunities and Knowledge Gaps

1. **Environmental equity, traditional ecological knowledge, and community co-created science is lacking in current literature, marking a critical need for socioeconomic research in NbS framework creation and case study analysis.** Studies examining NbS case studies are often written from an ecological perspective, with few examining the social, economic, and policy considerations of these cases. While this does constrain the depth and breadth of knowledge available for policy makers and climate adaptation practitioners, it also signals opportunities in both policy-science collaboration and interdisciplinary research within academia. The larger socioeconomic consequences of NbS should be more thoroughly examined. Considerations of environmental justice, equity, displacement, and benefit distribution are often overlooked or marginalized in existing studies but merit further research and investigation. Permutations of NbS systems have shown varied results depending on design and location, suggesting opportunities for engineering research and optimization, especially as it pertains to erosion control.
2. **Many opportunities exist for increased reflective case study examinations**; those studies that do follow NbS systems through implementation are limited in scope to physical or habitat measurements and would benefit from a social ecological systems approach to analysis. In recent years, there has been a rapid increase in NbS research and clear knowledge gaps within literature that examines implementation success. As of 2020, only 13% of NbS studies included coastal ecosystems, and only 10% focus on climate impacts in coastal ecosystems. Gaps in current research span a wide range of disciplines and offer opportunities for inter and transdisciplinary research. There are opportunities for specialists across policy, ecology, engineering, and environmental fields to contribute to discussions of NbS in coastal areas. Urban and hybrid living shorelines (those using both living and grey infrastructure in tandem) are both poorly studied. There are limited case study comparisons of grey infrastructure and NbS efficacy available. Case studies examining NbS insurance for marine ecosystems including seagrass meadows and kelp forests are also limited. A large percentage of the current corpus of literature consists of frameworks and modeling, but little investigation has been done into the application or retrospective analysis of implemented NbS systems. Further research is needed to bridge gaps between the current understanding of climate change impacts and the viability, efficacy, and health of NbS systems.

Recommendations for Policy Makers: Implementing NbS Systems

1. **Consider co-benefits to counter temporal constraints.** Because many NbS systems do not confer instant benefits, time and expertise in their planning, implementation, and maturation is essential. Site feasibility and careful consideration of design and ecosystem selection can also have large impacts on long- and short-term efficacy. Because of the time scale of implementing new built ecosystems, the conservation and restoration of existing ecosystems, even if impaired or incomplete, are valuable areas for NbS installation. Creating NbS green infrastructure alongside temporary or permanent grey infrastructure can create hybrid shorelines that amplify benefits and compensate for green infrastructure's establishment time.
2. **Ample opportunity exists for collaboration with the scientific and local communities throughout project visioning, planning, and implementation**. The intensity of the planning process allows for increased collaboration between community-driven researchers within the academic community and planning parties. In this scenario, both parties benefit from the exchange of information as well as lessening the gap in framework application research within the existing body of NbS literature.
3. **Equity and environmental justice considerations are equally as important in planning and site selection** as local communities are not only benefactors of coastal protection but also provide valuable insight as collaborative partners. Placement must also be taken into consideration; larger ecosystems confer more significant services, but in narrow coastal areas managed inland retreat may pose conflict with existing infrastructure and communities. Many areas of the California coast fall under the traditional jurisdiction of native tribal groups, and as such require collaboration and the elevation of Traditional Ecological Knowledge in any NbS project. Consideration should be given to the sustainability of program materials; oyster reefs are highly applicable NbS systems in much of California, but often are in short supply. Partnerships with communities and independent contractors to farm shells could induce economic growth in coastal areas, conferring future economic benefits.
4. **Consider private sector and community motivations.** Along with these considerations, it is important for policy makers to examine the motivation behind developing a program. For example, a private insurer may be interested in developing a policy for a NbS insurance scheme along the coastline where they insure coastal properties as a means to decrease the cost of expensive, recurring localized events. This brings about an ethical question, and should be examined closely in order to ensure the integrity of the social equity of the program rather than supporting private interests.

Recommendations for Insurance Practitioners: Creating NbS Insurance Schemes

1. **Create/ expand collaborative public-private partnerships around nature-based coastal adaptation planning.** The development and implementation of NbS insurance schemes typically require initial funding or lengthy legal/permitting procedures. In many cases, such financial constraints produce barriers to implementation of programs, or a lack of community support due to financial burden. Successful programs have demonstrated a collaborative effort among state and federal agencies alongside private businesses and non-profit organizations. Through these partnerships, nonprofits or other organizations often provide funding to support feasibility assessments, pilot projects and program implementation. With this support, governments are not burdened with financial constraints or a need to generate additional grants/funding. Additionally, partnerships may allow for more effective community outreach, which would otherwise not be possible due to a lack of resources. Following the initial investment of these programs, financial mechanisms through insurance policies may then support the long-term success and financial stability of NbS insurance schemes.
2. **Apply suitable valuation methods for NbS.** Gaining improved insight into the local economic landscape at the community level will facilitate the implementation of NbS. NbS are non-market goods and consequently do not have readily observable market prices. In order to estimate their economic value, suitable valuation methods such as revealed and stated preference, and adaptive data collection, should be applied.
3. **Compare and assess the effectiveness of parametric and indemnity insurance models based on the specific location and NbS.** Parametric and indemnity insurance are commonly utilized in the case studies for coastal protection. Parametric insurance has advantages such as quick payouts (reliance on specific triggers, such as wind speed, means payouts can be made relatively quickly without the need for lengthy claims investigations), high level of predictability (for both the policyholder and the insurer), and can be tailored to specific needs, such as the location and value of the coastal assets. However, these advantages may come with higher premiums compared to traditional insurance policies. A risk factor to consider is that the predetermined payout amount may not be enough to cover the actual losses incurred by the policyholder. Indemnity insurance addresses the two latter issues, but the payouts may be less predictable, as they may require more investigations and longer payout times. Generally with NbS schemes, indemnity insurance policy premiums are discounted following the usage of NbS, ultimately reducing risk.

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