

Outcome-Based Performance Measures for Coastal Systems

Bibliography

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NCRL subject guide 2019-05

<https://doi.org/10.25923/x40m-h954>

June 2019



U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Office of Oceanic and Atmospheric Research
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Background & Scope

The goal of this bibliography is to gather two related sets of resources: one on coastal community resilience and vulnerability; and one on decision support systems, currently in use or being developed, that have integrated social and ecological factors. Both sets of resources will go towards a project to develop a decision support system that integrates social and ecological factors, to help understand coastal systems and assess whether our communities are safer or more prepared for natural disasters and the effects of climate change. The majority of literature included are peer-reviewed journal articles from a social science perspective.

Section I – Environment and Community Assessment

This section focuses on articles that analyze the relationship between the environment and communities in coastal areas. These articles focus on coastal system dynamics, social vulnerability indicators, and integrating local GIS data into their analyses. The articles included are about products developed to assess the land-sea interface, the methodologies used to create these products, and the products' actual and projected outcomes.

Section II – Decision Support Systems Integrating Social and Ecological Factors

This section explores what decision support systems have been created that integrate social and ecological factors, with a focus on coastal areas across the world.

Sources Reviewed

The following databases were used to identify sources: Clarivate Analytics' Web of Science: Science Citation Index Expanded and Social Science Index, BioOne Complete, JSTOR, Google Scholar, and ScienceDirect. Only English language materials published since 2013 were included.

Section I: Environment and Community Assessment: Applications and Outcomes

Abelshausen, B., Vanwing, T., & Jacquet, W. (2015). Participatory integrated coastal zone management in Vietnam: Theory versus practice case study: Thua Thien Hue province. *Journal of Marine and Island Cultures*, 4(1), 42-53 <https://doi.org/10.1016/j.imic.2015.06.004>.

Sustainable management processes have undergone a shift from a top-down approach to a bottom-up approach. This bottom-up approach allows for a more apprehensive inclusion of stakeholders. In traditional hierarchical societies a combination of both is considered more desirable. This combination is described as a participatory approach that allows for bi-directional knowledge sharing. The question asked is whether this theoretical approach is viable in practice, taking into account different social, political and cultural influences. Qualitative research in bi-directional knowledge sharing and stakeholder participation in Integrated Coastal Zone Management (ICZM) was conducted in the provinces of Thua Thien Hue in Vietnam. Qualitative research was conducted using coding analysis. This analysis showed that in practice a great reluctance for change affects the implementation of ICZM. This reluctance is directly related to the level of power of stakeholders and the level to which stakeholders are embedded in the top-down tradition. Two contradicting results emerged. On the one hand the theoretical understanding of participatory ICZM is highest when reluctance for change is highest and vice versa. On the other hand a decrease in power results in an increase of the sustainability of the implementation of participatory ICZM. This research concluded that a 'platform or structure' is essential to achieve sustainability. In the Vietnamese context the tradition of power results in a platform which is both formal and non-formal. A non-formal platform is needed to create social capital, whereas a formal platform will limit the risk for arbitrariness and allow for institutionalisation.

Ahmed, B., Kelman, I., Fehr, H. K., & Saha, M. (2016). Community Resilience to Cyclone Disasters in Coastal Bangladesh. *Sustainability*, 8(8), 29 <https://doi.org/10.3390/su8080805>.

Bangladesh is one of the poorest and most disaster-prone countries in the world. To address both problems simultaneously, sustainable livelihoods (SL) could be better connected with disaster risk reduction (DRR). For this purpose, one initiative implemented in Bangladesh is called the Vulnerability to Resilience (V2R) programme which ran from 2013 to 2016. This programme was primarily initiated and funded by the British Red Cross in a consortium with the Swedish Red Cross and the German Red Cross. This article presents the first evaluation of the V2R programme with three objectives. The first objective was to measure whether the selected communities have achieved community resilience characteristics as defined by the programme. The second objective was to conduct a cost-benefit analysis for the intervention. The third objective was to analyse V2R's impact on the communities in terms of DRR and SL. Community-based focus group discussions and household-based surveys were conducted before and after the intervention (2013-2016) in two coastal communities in Patuakhali district, Nowapara and Pashurbunia. The analysis found that community members are now engaged with many hazard-resilient and vulnerability-reducing livelihood activities, using SL to implement DRR, yet these approaches were almost absent prior to V2R. Consequently, the communities have achieved resilience characteristics, being more well-organized and better connected; having better access to infrastructure, services, and economic opportunities; are more knowledgeable and healthier; and are better managing their available resources. Critiques of the concepts are discussed, although in this case, DRR based on SL has shown positive results, exactly as development theory suggests.

Alin, S. R., Brainard, R. E., Price, N. N., Newton, J. A., Cohen, A., Peterson, W. T., . . . Bednarsek, N. (2015). Characterizing the Natural System: Toward Sustained, Integrated Coastal Ocean Acidification Observing Networks to Facilitate Resource Management and Decision Support. *Oceanography*, 28(2), 92-107 <https://doi.org/10.5670/oceanog.2015.34>.

Coastal ocean ecosystems have always served human populations they provide food security, livelihoods, coastal protection, and defense. Ocean acidification is a global threat to these ecosystem services, particularly when other local and regional stressors combine with it to jeopardize coastal health. Monitoring efforts call for a coordinated global approach toward sustained, integrated coastal ocean health observing networks to address the region-specific mix of factors while also adhering to global ocean acidification observing network principles to facilitate comparison among regions for increased utility and understanding. Here, we generalize guidelines for scoping and designing regional coastal ocean acidification observing networks and provide examples of existing efforts. While challenging in the early stages of coordinating the design and prioritizing the implementation Of these observing networks, it is essential to actively engage all of the relevant stakeholder groups from the outset, including private industries, public agencies, regulatory bodies, decision makers, and the general public. The long-term sustainability of these critical observing networks will rely on leveraging of resources and the strength of partnerships across the consortium of stakeholders and those implementing coastal ocean health observing networks.

Aswani, S., Howard, J. A. E., Gasalla, M. A., Jennings, S., Malherbe, W., Martins, I. M., . . . Watmough, G. R. (2019). An integrated framework for assessing coastal community vulnerability across cultures, oceans and scales. *Climate and Development*, 11(4), 365-382 <https://doi.org/10.1080/17565529.2018.1442795>.

Coastal communities are some of the most at-risk populations with respect to climate change impacts. It is therefore important to determine the vulnerability of such communities to co-develop viable adaptation options. Global efforts to address this issue include international scientific projects, such as Global Learning for Local Solutions (GULLS), which focuses on five fast warming regions of the southern hemisphere and aims to provide an understanding of the local scale processes influencing community vulnerability that can then be up-scaled to regional, country and global levels. This paper describes the development of a new social and ecological vulnerability framework which integrates exposure, sensitivity and adaptive capacity with the social livelihoods and food security approaches. It also measures community flexibility to understand better the adaptive capacity of different levels of community organization. The translation of the conceptual framework to an implementable method is described and its application in a number of "hotspot" countries, where ocean waters are warming faster than the rest of the world, is presented. Opportunities for cross-cultural comparisons to uncover similarities and differences in vulnerability and adaptation patterns among the study's coastal communities, which can provide accelerated learning mechanisms to other coastal regions, are highlighted. The social and ecological framework and the associated survey approach allow for future integration of local-level vulnerability data with ecological and oceanographic models.

Atkins, J. P., Burdon, D., Elliott, M., & Gregory, A. J. (2011). Management of the marine environment: Integrating ecosystem services and societal benefits with the DPSIR framework in a systems approach. *Marine Pollution Bulletin*, 62(2), 215-226
<https://doi.org/10.1016/j.marpolbul.2010.12.012>.

Ever increasing and diverse use of the marine environment is leading to human-induced changes in marine life, habitats and landscapes, making necessary the development of marine policy that considers all members of the user community and addresses current, multiple, interacting uses. Taking a systems approach incorporating an understanding of The Ecosystem Approach, we integrate the DPSIR framework with ecosystem services and societal benefits, and the focus this gives allows us to create a specific framework for supporting decision making in the marine environment. Based on a linking of these three concepts, we present a set of basic postulates for the management of the marine environment and emphasise that these postulates should hold for marine management to be achieved. We illustrate these concepts using two case studies: the management of marine aggregates extraction in UK waters and the management of marine biodiversity at Flamborough Head, UK.

Awuor, C. B., Orindi, V. A., & Adwera, A. O. (2008). Climate change and coastal cities: the case of Mombasa, Kenya. *Environment and Urbanization*, 20(1), 231-242
<https://doi.org/10.1177/0956247808089158>.

This paper discusses the risks that the city of Mombasa faces from the direct and indirect impacts of climate change. Mombasa is Kenya's second largest city and has more than 700,000 inhabitants. It is the largest seaport in East Africa, serving not only Kenya but also many landlocked countries and the north of Tanzania. The city has a history of disasters related to climate extremes including floods, which cause serious damage nearly every year and, often, loss of life. The floods in October 2006 were particularly serious, affecting some 60,000 people in the city and the wider province. In addition, around 17 per cent of Mombasa's area could be submerged by a sea-level rise of 0.3 metres, with a larger area rendered uninhabitable or unusable for agriculture because of water logging and salt stress. Tourism is an important part of the city's economy. Thus, sandy beaches, historic and cultural monuments and several hotels, industries and port facilities would be negatively affected. This paper also discusses the measures needed to reduce the vulnerability of Mombasa's population and economic base to climate change.

Ayyub, B. M. (2014). Systems Resilience for Multihazard Environments: Definition, Metrics, and Valuation for Decision Making. *Risk Analysis*, 34(2), 340-355 <https://doi.org/10.1111/risa.12093>.

The United Nations Office for Disaster Risk Reduction reported that the 2011 natural disasters, including the earthquake and tsunami that struck Japan, resulted in \$366billion in direct damages and 29,782 fatalities worldwide. Storms and floods accounted for up to 70% of the 302 natural disasters worldwide in 2011, with earthquakes producing the greatest number of fatalities. Average annual losses in the United States amount to about \$55billion. Enhancing community and system resilience could lead to massive savings through risk reduction and expeditious recovery. The rational management of such reduction and recovery is facilitated by an appropriate definition of resilience and associated metrics. In this article, a resilience definition is provided that meets a set of requirements with clear relationships to the metrics of the relevant abstract notions of reliability and risk. Those metrics also meet logically

consistent requirements drawn from measure theory, and provide a sound basis for the development of effective decision-making tools for multihazard environments. Improving the resiliency of a system to meet target levels requires the examination of system enhancement alternatives in economic terms, within a decision-making framework. Relevant decision analysis methods would typically require the examination of resilience based on its valuation by society at large. The article provides methods for valuation and benefit-cost analysis based on concepts from risk analysis and management.

Bevacqua, A., Yu, D. L., & Zhang, Y. J. (2018). Coastal vulnerability: Evolving concepts in understanding vulnerable people and places. *Environmental Science & Policy*, 82, 19-29
<https://doi.org/10.1016/j.envsci.2018.01.006>.

Coastal vulnerability is a spatial concept that identifies people and places that are susceptible to disturbances resulting from coastal hazards. Hazards in the coastal environment, such as coastal storms and erosion, pose significant threats to coastal physical, economic, and social systems. The theory of vulnerability has been an evolving idea over the past hundred years. In recent decades, improved technology and high-profile disaster events, has caused an increase in publications in the coastal hazards field. Modern approaches to understanding coastal vulnerability examine the complex systems that determine the spatial distribution of hazards, risks, and exposure. Consensus among today's researchers shows that coastal vulnerability is geographically dependent and requires place based investigations. This review examines over 200 coastal vulnerability related works. Through this extensive literature review, this research describes the evolution of vulnerability concepts, and the modern definition of vulnerability with the goal of providing a well-informed body of knowledge to be used in the advancement of resilience and increased sustainability in coastal areas.

Campuzano, F. J., Mateus, M. D., Leitão, P. C., Leitão, P. C., Marín, V. H., Delgado, L. E., . . . Neves, R. J. (2013). Integrated coastal zone management in South America: A look at three contrasting systems. *Ocean & Coastal Management*, 72, 22-35
<https://doi.org/10.1016/j.ocecoaman.2011.08.002>.

The management of coastal systems where overlapping economic interests compete for the same resources make the use of integrated approaches indispensable. The Integrated Coastal Zone Management (ICZM) focuses mainly on three major goals: (1) overcoming the conflicts associated with the sectorial management, (2) preserving the productivity and biological diversity of coastal systems, and (3) promoting and equitable and sustainable allocation of coastal resources. The DPSIR (Drivers-Pressures-State-Impact-Responses) framework is a common tool that allows the description of environmental problems by defining the relationships between anthropogenic activities and the environment. In this context, the use of numerical models as integrative tools in ICZM has grown significantly over the years. This work focused on three estuarine systems in South America: Santos estuary (Brazil, 24° S) and Bahía Blanca estuary (Argentina, 39° S) in the Atlantic coast and Aysén fjord (Chile, 45°S) in the Pacific coast. These estuaries differ significantly in their physical, chemical and biological conditions, as well as on their socio-economic settings and human-related problems. Numerical models have been used to study the relation between the pressures derived from human activities and their impact on the state of each system. The results presents a contribute to increase the scientific knowledge needed to support the implementation of local legislations and policies, to assess

different scenarios of coastal activities and sources use, to support management decisions and, ultimately, to promote sustainable of coastal resources.

Canters, F., Vanderhaegen, S., Khan, A. Z., Engelen, G., & Uljee, I. (2014). Land-use simulation as a supporting tool for flood risk assessment and coastal safety planning: The case of the Belgian coast. *Ocean & Coastal Management*, 101, 102-113
<https://doi.org/10.1016/j.ocecoaman.2014.07.018>.

Given the volatility of both natural and man-made coastal processes, coastal safety has become a prime concern worldwide. In many countries, governments have developed integrated coastal safety plans whose implementation poses complex governance issues, involving multi-level negotiations, consensus building and the reconciliation of conflicting views on coastal development. Communicating these plans is a complex issue. It involves building tools for assessment of flood hazard and for effectively articulating potential risks of flooding to decision makers, stakeholders and the public at large. This paper presents a simulation-based approach that couples the outcome of a GIS based flood hazard model with a cellular automata based land-use change model, to produce risk maps linking areas under different land uses to potential flood depth. The method allows spatially explicit analysis of population at risk given a certain storm event and is applied to the case of a 1 000-year and a 4 000-year storm occurring along the Belgian coast, corresponding to the risk levels included in the Flanders Integrated Master Plan for Coastal Safety. The study shows the importance of taking land-use dynamics into account when assessing potential flood hazard impacts in coastal areas characterized by a strong pressure on land resources.

Ceskavich, R., & Sasani, M. (2018). Methodology for Evaluating Community Resilience. *Natural Hazards Review*, 19(1), 13 [https://doi.org/10.1061/\(asce\)nh.1527-6996.0000272](https://doi.org/10.1061/(asce)nh.1527-6996.0000272).

Community resilience is dependent on the functionality of building clusters and supporting infrastructure systems because these facilitate social and economic activities in a community. This paper seeks to help communities improve their resilience to natural hazards by developing a methodology, starting with estimation of a community's current level of resilience and directly comparing it to the target level, allowing for the identification and mitigation of performance gaps by the community. Assuming that communities are working under limited resources available to improve their resilience, an important focus of this paper is on prioritizing performance gaps such that those with the greatest negative effect on the current level of resilience may be addressed with mitigation first. Finally, a cost-benefit analysis is conducted on alternative mitigation actions for each priority performance gap. The result is a set of cost-effective mitigation actions to be implemented that will address prioritized performance gaps between the community's target and current levels of resilience, thus improving community resilience. The resilience evaluation methodology is demonstrated on a case study of the City of Boston using scenario hazard events simulated.

Chen, S. L., & Ganapin, D. (2016). Polycentric coastal and ocean management in the Caribbean Sea Large Marine Ecosystem: harnessing community-based actions to implement regional frameworks. *Environmental Development*, 17, 264-276 <https://doi.org/10.1016/j.envdev.2015.07.010>.

Over the past several decades, Small Island Developing States (SIDS) have successfully forged a coalition among themselves, and make a strong case for special considerations for their development needs at global level. The unique characteristics of SIDS require environmental protection actions to be local, contextual and small scale under the coordination of regional strategic frameworks, if the overall effort is to be relevant and effective. The article examines the environmental challenges in the Caribbean islands, and discusses the regional inter-governmental approach vis-a-vis community-based local solutions. The paper considers either of these two approaches alone as inadequate, and advocates a polycentric governance approach that focuses on a nested, coordinated and linked set of local actions in the implementation of coherent regional frameworks. The paper draws its findings from community-based experiences of projects in the Caribbean islands supported by the GEF Small Grants Program (SGP) which is implemented by UNDP as a mechanism to undertake a "local action, global impact" approach to achieve sustainable development. The paper presents three examples of local actions in the Caribbean Sea LME region that should be replicated to achieve high local ownership and sustain ability, and through linkages with other partners and entities, to generate scaled-up impacts. To ensure the coherence of local actions and their effectiveness in addressing regional issues, the paper advocates strengthened collaboration between programs such as that of the GEF SGP with those that develop and implement regional initiatives and frameworks.

Erikson, L., Barnard, P., O'Neill, A., Wood, N., Jones, J., Hart, J. F., . . . Foxgrover, A. (2018). Projected 21st Century Coastal Flooding in the Southern California Bight. Part 2: Tools for Assessing Climate Change-Driven Coastal Hazards and Socio-Economic Impacts. *Journal of Marine Science and Engineering*, 6(3), 19 <https://doi.org/10.3390/jmse6030076>.

This paper is the second of two that describes the Coastal Storm Modeling System (CoSMoS) approach for quantifying physical hazards and socio-economic hazard exposure in coastal zones affected by sea-level rise and changing coastal storms. The modelling approach, presented in Part 1, downscales atmospheric global-scale projections to local scale coastal flood impacts by deterministically computing the combined hazards of sea-level rise, waves, storm surges, astronomic tides, fluvial discharges, and changes in shoreline positions. The method is demonstrated through an application to Southern California, United States, where the shoreline is a mix of bluffs, beaches, highly managed coastal communities, and infrastructure of high economic value. Results show that inclusion of 100-year projected coastal storms will increase flooding by 9-350% (an additional average 53.0 +/- 16.0 km²) in addition to a 25-500 cm sea-level rise. The greater flooding extents translate to a 55-110% increase in residential impact and a 40-90% increase in building replacement costs. To communicate hazards and ranges in socio-economic exposures to these hazards, a set of tools were collaboratively designed and tested with stakeholders and policy makers; these tools consist of two web-based mapping and analytic applications as well as virtual reality visualizations. To reach a larger audience and enhance usability of the data, outreach and engagement included workshop-style trainings for targeted end-users and innovative applications of the virtual reality visualizations.

Ferro-Azcona, H., Espinoza-Tenorio, A., Calderón-Contreras, R., Ramenzoni, V. C., Gómez País, M. d. I. M., & Mesa-Jurado, M. A. (2019). Adaptive capacity and social-ecological resilience of coastal areas: A systematic review. *Ocean & Coastal Management*, 173, 36-51
<https://doi.org/10.1016/j.ocecoaman.2019.01.005>.

Establishing protected areas constitutes one of the main strategies for the conservation of marine and coastal ecosystems. Increasing risks associated with environmental change along with highly degraded coastal ecosystems encompass complex management challenges for the long-term sustainability of these landscapes. This article aims to explore the role of protected areas in past and ongoing community adaptation to the compounded effects of climatic and anthropogenic change. A literature review of published articles is conducted through systematic queries of the bibliographic database Web of Sciences, and by comparing adaptation and social-ecological resilience processes within and out of coastal protected areas. Findings underscore the absence of specific studies that target these topics inside protected areas, highlighting a geographic bias towards research largely carried out in developed countries. Results also indicate the current need for management practices within protected areas to adopt more participatory, comprehensive, and flexible approaches. Protected areas not only promote the conservation and provision of ecosystem services but are also key in building coastal communities' adaptive capacity and resilience in face of future scenarios.

Garcia-Ayllon, S. (2018). Long-Term GIS Analysis of Seaside Impacts Associated to Infrastructures and Urbanization and Spatial Correlation with Coastal Vulnerability in a Mediterranean Area. *Water*, 10(11), 29 <https://doi.org/10.3390/w10111642>.

The relationship between the impacts of coastal perimeter transformations derived from human activity and coastal vulnerability is not easy to assess. The impacts associated with coastal dynamics are phenomena that usually develop very extensively over a considerable time. These are transformations that cause significant environmental damage in vulnerable coastal areas, but whose results are very often not really visible until 10, 20, or even 40 years have elapsed. In addition, the analysis and quantification of the current context in complex territories is particularly difficult, since the spatial feedback of various issues and its consequences can generate an uncertain scenario with many interrelated variables. In this field, the use of GIS tools can be of great help to objectively analyze the relationship between coastal anthropization and its impact on its vulnerability in order to correct wrong inertias in vulnerable coastal areas. To this end, a long-term GIS analysis has been carried out of the impacts from urbanization and seaside infrastructures suffered by a complex Mediterranean coastal area in Spain. This territory, with singular elements such as dune ridges, beaches located in protected areas, and a coastal lagoon, will be evaluated using GIS spatio-temporal indicators over the last 90 years and geostatistical correlation methods. This approach will allow us to better understand the relationship between territorial transformations on the coast and the current coastal vulnerability of this area.

Gari, S. R., Newton, A., & Icely, J. D. (2015). A review of the application and evolution of the DPSIR framework with an emphasis on coastal social-ecological systems. *Ocean & Coastal Management*, 103, 63-77 <https://doi.org/10.1016/j.ocecoaman.2014.11.013>.

The applications of the Driver-Pressure-State-Impact-Response (DPSIR) framework were reviewed for several Social-Ecological Systems (SES), with an emphasis on the coastal environment. The evolution of

DPSIR was traced from the Stress-Response framework to its present form. Discrepancies in the definitions of the DPSIR's information categories are presented. The application of the framework was explored both as a discrete tool and combined with other methods for different coastal and estuarine systems and biodiversity. The overall merits and limitations of the DPSIR framework are discussed in a critique. Several recommendations are suggested for refining the framework to overcome its limitations. Finally it is concluded that an updated DPSIR framework is a useful adaptive management tool for analyzing and identifying solutions to environmental problems.

Guimarães, M. H., Sousa, C., Dentinho, T., & Boski, T. (2014). Economic base model for the Guadiana estuary, Portugal an application for Integrated Coastal Zone Management. *Marine Policy*, 43, 63-70 <https://doi.org/10.1016/j.marpol.2013.03.010>.

The concept of base-multiplier analysis is that export activities constitute the economic base of a region, whereas the other economic activities that sell their goods and services to the local residents grow or shrink depending on the performance of the base activities. These concepts, with origins extending at least as far back as the early 1900s, have reached maturity and are widely applied. The attractiveness of an economic base model (EBM) draws in its simplicity in expressing the power of demand in regional income determination. Extensive literature has grown up around the economic base theory, however, systematic publications concerning empirical application are scarce and focus mostly on the socio-economic dimension of the analyzed system. Such territorially oriented economic models are useful in a variety of decision making procedures; preparation of annual budgets, short-run market demand forecasting, longer-term growth strategies. The purpose of this article is to present a practical application of EBM to the geographical area of the Guadiana Estuary, on the south coast of Portugal. The interest of the EBM application in this case study includes its integration in a broader project that applies a Systems Approach Framework (SAF) towards Integrated Coastal Zone Management (ICZM). There are three pillars of sustainability considered here: social, ecological and economic, hence, the article not only describes EBM application but also how it has been use to demonstrate a chain of events resulting from the interaction between the ecological and the socio-economic sub systems of the area. The results obtained will probably raise the usual criticism to which the economic base model has been exposed previously; however it provides unequivocal evidence that a truly interdisciplinary approach to a given territorial target can be successfully shared with end users and the research community.

Hategekimana, Y., Yu, L. J., Nie, Y. P., Zhu, J. F., Liu, F., & Guo, F. (2018). Integration of multi-parametric fuzzy analytic hierarchy process and GIS along the UNESCO World Heritage: a flood hazard index, Mombasa County, Kenya. *Natural Hazards*, 92(2), 1137-1153 <https://doi.org/10.1007/s11069-018-3244-9>.

Flood is a natural hazard affecting human life and ecosystem globally causing catastrophic disasters. Most flood-induced socioeconomic losses are exacerbated by unabated urban development, population upsurge, unregulated municipal systems, and indiscriminate land use. Therefore, implementation of a flood prediction system can potentially help mitigate flood-induced consequences. In this study, a framework of multi-criteria analysis incorporating geographic information system, fuzzy analytic hierarchy process, and bivariate statistics-based methods was developed for flood hazard index determination. Flood-prone areas were identified based on six factors (hydrological aspects and land

cover): elevation, aspect, slope, flow accumulation, rainfall, and land cover map. To generate a flood hazard index, each one of the factors was classified into five categories: very low, low, moderate, high, and very high; the factors were then combined and processed using the proposed methodology. Obtained overall maps have been adjusted with socioeconomic data such as gross domestic product to relate the flood exposure to economic and demographic factors in Mombasa County, Kenya. Results suggest that the County is largely dominated by areas with a high flood hazard index due to its location and shoreline. Fort Jesus, the UNESCO World Heritage site, is currently under high risk of flood as shown by the flood hazard index, while most of the shoreline is at very high risk of flooding.

Kantamaneni, K., Phillips, M., Thomas, T., & Jenkins, R. (2018). Assessing coastal vulnerability: Development of a combined physical and economic index. *Ocean & Coastal Management*, 158, 164-175 <https://doi.org/10.1016/j.ocecoaman.2018.03.039>.

As a consequence of climate change, coastal communities worldwide are subject to increased risk from sea-level rise and more intense storms. Therefore, it is important for coastal managers to have focused site specific data on present and predicted climate change impacts in order to determine shoreline vulnerability. There are few UK studies that characterise coastal vulnerability, while nearly all global work has concentrated on geomorphological and to a lesser extent, socio-economic aspects. In response, the present study developed a new Physical Coastal Vulnerability Index (PCVI) and applied it to eleven UK sites, seven in England, three in Wales and one in Scotland. PCVI results were then compared and contrasted with a new Fiscal Coastal Vulnerability Index (FCVI), which enabled coastal areas to be visually classified in one of four categories to inform relative risk. Both indices were subsequently Integrated into a Combined Coastal Vulnerability Index (CCVI). Results showed that Great Yarmouth and Aberystwyth were highly vulnerable, while Llanelli and Lynmouth were least vulnerable, and the importance of integrating both indices is demonstrated by modified overall vulnerability assessments. Therefore, CCVI provides a simple to use shoreline monitoring tool which is particularly suitable for assessment of risk. The indices support coastal planning, including intervention or no active intervention policies, and thereby benefitting a range of stakeholders. CCVI works at local, regional and international scales, and identifies vulnerable locations. Consequently, these indices will inform management strategies to improve coastal resilience under various sea level rise and climate change scenarios.

Karrasch, L., Klenke, T., & Woltjer, J. (2014). Linking the ecosystem services approach to social preferences and needs in integrated coastal land use management – A planning approach. *Land Use Policy*, 38, 522-532 <https://doi.org/10.1016/j.landusepol.2013.12.010>.

Coastal zones with their natural and societal sub-systems are exposed to rapid changes and pressures on resources. Scarcity of space and impacts of climate change are prominent drivers of land use and adaptation management today. Necessary modifications to present land use management strategies and schemes influence both the structures of coastal communities and the ecosystems involved. Approaches to identify the impacts and account for (i) the linkages between social preferences and needs and (ii) ecosystem services in coastal zones have been largely absent. The presented method focuses on improving the inclusion of ecosystem services in planning processes and clarifies the linkages with social impacts. In this study, fourteen stakeholders in decision-making on land use planning in the

region of Krummhörn (northwestern Germany, southern North Sea coastal region) conducted a regional participative and informal process for local planning capable to adapt to climate driven changes. It is argued that scientific and practical implications of this integrated assessment focus on multi-functional options and contribute to more sustainable practices in future land use planning. The method operationalizes the ecosystem service approach and social impact analysis and demonstrates that social demands and provision of ecosystem services are inherently connected.

Khakzad, S., Pieters, M., & Van Balen, K. (2015). Coastal cultural heritage: A resource to be included in integrated coastal zone management. *Ocean & Coastal Management*, 118, 110-128
<https://doi.org/10.1016/j.ocecoaman.2015.07.032>.

Maritime and coastal cultural landscape, encompassing land and sea, and underwater is an important part of our cultural resources in the coastal areas. Although, integrated coastal zone management (ICZM) has theoretically addressed the importance of cultural ecosystems, cultural resources have mostly been overlooked in holistic coastal management plans. Overlooking cultural resources results in loss of cultural identity associated with certain habitats; loss of tourism, recreational and educational opportunities; decline in local ecological knowledge, skills and technology pertaining to habitat management; and loss of opportunities for social and cultural capital. Literature and practice show that there is no proper definition and evaluation of coastal cultural heritage is available and coastal cultural heritage has not been considered as a resource with high level of benefit for development and people. Acknowledging the importance of coastal cultural heritage as a resource in ICZM, and the role that ICZM can play in linking land and sea management approaches highlights the necessity of new methods for defining and evaluation of coastal cultural heritage. This paper proposes models and guidelines for defining and evaluating coastal cultural heritage to be included in Marine Spatial Planning (MSP) and ICZM as a resource through application of the integrative complexity theory and learning from the experiences in management of other coastal resources. The results will be an integrative evaluation method and a guideline for delineating coastal cultural areas. The method and tool will be examined through the case of Ostend in Belgium.

Kratzer, S., Therese Harvey, E., & Philipson, P. (2014). The use of ocean color remote sensing in integrated coastal zone management—A case study from Himmerfjärden, Sweden. *Marine Policy*, 43, 29-39 <https://doi.org/10.1016/j.marpol.2013.03.023>.

In this study the use of ocean color data as a diagnostic tool in integrated coastal zone management was investigated as part of the Science Policy Integration for Coastal Systems Assessment (SPICOSA) project. Parallel to this, an operational coastal monitoring system has been set up in close collaboration with end-users. The core work of the bio-optical part in the project was to develop Secchi depth and attenuation of light as indicators for coastal zone management, by linking remote sensing with the socio-economic and ecological model developed in SPICOSA. The article emphasizes the benefits of stakeholder involvement and end-user feedback for efficient and improved system development. Furthermore, conceptual models were developed on how to integrate remote sensing data into coastal zone management and into a physical-biological model of the Baltic Sea. One of the work packages in the SPICOSA project was academic training. In this work package, on-line teaching material in the field of

remote sensing and bio-optics was developed and disseminated on the SETnet web page. The article presented here may act as supportive material for training in bio-optics and remote sensing.

Lee, Y. J. (2018). Relationships among Environmental Attitudes, Risk Perceptions, and Coping Behavior: A Case Study of Four Environmentally Sensitive Townships in Yunlin County, Taiwan. *Sustainability*, 10(8), 22 <https://doi.org/10.3390/su10082663>.

Climate change issues have attracted much attention in recent years. To date, the related research has focused mostly on the national and regional impacts of climate change. Taiwan, an island state, has relatively high vulnerability to the consequences of climate change, and its western coastal areas are particularly vulnerable. Yunlin County, with 13 townships that are all prone to flooding, will be highly affected by climate change. In this study, the 13 townships are grouped into four categories of synthesized vulnerability and ecological footprint (EF): "low synthesized vulnerability/low EF" (Linnei), "high synthesized vulnerability/low EF" (Sihu), "low synthesized vulnerability/high EF" (Mailiao), and "high synthesized vulnerability/high EF" (Huwei). Ecological footprint was used to measure the human demand for resources and ecological services, as well as a way to understand the relationships among human living habits, consumption patterns, and natural capital consumption. Then, the relationships among attitudes to climate change, risk perceptions, and coping behavioral intentions in these four categories were examined using structural equation models (SEM). A stratified random sampling method was used to collect 582 valid questionnaires. In addition to descriptive statistical analyses, the results of the SEMs for the four sensitivity categories indicate that different townships exhibit different causal relationships among attitudes to climate change, risk perceptions, and behavioral intentions. These findings can support appropriate strategies for governments, communities, and non-governmental organizations (NGOs) for ensuring that areas of various sensitivities can cope. However, more vulnerable townships exhibit no significant positive relationship between attitudes to and knowledge of climate change, place attachment, and their adaptation behavioral intentions in the face of disaster risk perceptions. Therefore, in areas with high vulnerability, special attention should be paid to making the residents improve their adaptive behavioral intentions in the face of disaster risk perceptions.

Levine, A. S., & Feinholz, C. L. (2015). Participatory GIS to inform coral reef ecosystem management: Mapping human coastal and ocean uses in Hawaii. *Applied Geography*, 59, 60-69 <https://doi.org/10.1016/j.apgeog.2014.12.004>.

Sociospatial information is critical to marine and coastal ecosystem management. The Hawaii Coastal Uses Mapping Project used a participatory geographic information systems (PGIS) methodology to gather local knowledge regarding the location and intensity of coastal human activities in Hawaii's priority sites for coral reef management. PGIS provided an efficient and effective means of obtaining information in a data-poor context, particularly at a scale and location where considerable local knowledge is held by community members and resource users. We detail the PGIS methods developed to collect sociospatial data on human uses in the project regions and discuss important considerations regarding the practice of PGIS that emerged from the mapping process, as well as implications for the production and documentation of spatial knowledge. Key themes include: issues of scale and appropriateness in using PGIS as a method for mapping human coastal and marine activities; data

validity, authority, and the nature of local knowledge; community trust, engagement, and collaboration; and utility for coral reef management. While several factors limit local agencies' ability to use this spatial information to date, natural resource managers found the participatory mapping process to be highly valuable for stakeholder identification and engagement, and the maps provide a resource to state and federal managers to better understand the human implications of future management scenarios.

Lins-de-Barros, F. M. (2017). Integrated coastal vulnerability assessment: A methodology for coastal cities management integrating socioeconomic, physical and environmental dimensions - Case study of Regido dos Lagos, Rio de Janeiro, Brazil. *Ocean & Coastal Management*, 149, 1-11
<https://doi.org/10.1016/j.ocecoaman.2017.09.007>.

Coastal zones can be considered inherently vulnerable because of sensitive ecosystems, geomorphological dynamics and complexity, and the clustering of many social, economic, and sometimes conflicting activities. In urban areas where tourism is highly treasured, this vulnerability is even worse. Intense demographic pressure may overload the carrying capacity limits of the sensitive coastal ecosystems. This process also exposes the population living in risky areas to physical vulnerability. This paper aims to present a methodology to integrate the physical, socioeconomic and ecosystem dimensions of coastal vulnerability through a useful tool for coastal zone management. It is propose a matrix that allows correlating the exposition degree and adaptive capacity of vulnerability. Based on this matrix it is possible to plot the integrated coastal vulnerability into a diagram of integrated coastal vulnerability assessment (DICVA). The case study of Regiao dos Lagos presented in this paper uses this integrated approach of coastal vulnerability. Between 2000 and 2010, the urban population grew significantly on the coast subject to erosion and tidal flood, as well as in flood-prone areas around the lagoons. In many cities, a massive influx of tourists surpasses the number of urban residents causing a deficiency in the water and sewage utilities systems. A resulting problem is the risk of groundwater contamination and lagoons pollution. These impacts can backfire and negatively impact the tourism industry as the environmental quality declines and the risk sensation increases. The proposed, integrated, and updated approach to coastal vulnerability may help to understand the complex effects of the relationship found in the different dimensions involved. Furthermore, this approach contributes to the effective use of the matrix and Diagram of Integrated Coastal Vulnerability Assessment, and may guide coastal management actions.

Liu, T.-K., Sheu, H.-Y., & Tseng, C.-N. (2013). Environmental impact assessment of seawater desalination plant under the framework of integrated coastal management. *Desalination*, 326, 10-18
<https://doi.org/10.1016/j.desal.2013.07.003>.

This study aims to improve the current practice of EIA by introducing additional considerations for environmental impact assessment (EIA) under the framework of Integrated Coastal Management (ICM). Various EIA reports on the seawater desalination projects and the UNEP guidance for EIA of desalination were collected for document analysis. Along with in-depth interviews to obtain input from coastal stakeholders, an indicator framework for the impact of seawater desalination plants was thus developed by applying the concept of Integrated Coastal Management (ICM). Unlike the conventional EIA practice which mostly focuses on the direct impacts, the indicator framework under ICM includes direct and indirect impacts from three aspects: environment, economics and social, covering 14 criteria and 43

indicators. Our results showed that the social aspect criteria in our indicator system are mostly absent in the current EIA practice. This study includes recommendations for the improvement of the existing EIA of seawater desalination plants under the concept of ICM. The environmental impacts that are not well addressed or overlooked under conventional EIA regime are discussed herein.

Malone, T. C., DiGiacomo, P. M., Goncalves, E., Knap, A. H., Talaue-McManus, L., de Mora, S., & Muelbert, J. (2014). Enhancing the Global Ocean Observing System to meet evidence based needs for the ecosystem-based management of coastal ecosystem services. *Natural Resources Forum*, 38(3), 168-181 <https://doi.org/10.1111/1477-8947.12045>.

Ecosystem-based approaches (EBAs) to managing anthropogenic pressures on ecosystems, adapting to changes in ecosystem states (indicators of ecosystem health), and mitigating the impacts of state changes on ecosystem services are needed for sustainable development. EBAs are informed by integrated ecosystem assessments (IEAs) that must be compiled and updated frequently for EBAs to be effective. Frequently updated IEAs depend on the sustained provision of data and information on pressures, state changes, and impacts of state changes on services. Nowhere is this truer than in the coastal zone, where people and ecosystem services are concentrated and where anthropogenic pressures converge. This study identifies the essential indicator variables required for the sustained provision of frequently updated IEAs, and offers an approach to establishing a global network of coastal observations within the framework of the Global Ocean Observing System. The need for and challenges of capacity-building are highlighted, and examples are given of current programmes that could contribute to the implementation of a coastal ocean observing system of systems on a global scale. This illustrates the need for new approaches to ocean governance that can achieve coordinated integration of existing programmes and technologies as a first step towards this goal.

Marques, A. S., Ramos, T. B., Caeiro, S., & Costa, M. H. (2013). Adaptive-participative sustainability indicators in marine protected areas: Design and communication. *Ocean & Coastal Management*, 72, 36-45 <https://doi.org/10.1016/j.ocecoaman.2011.07.007>.

Recently there has been an effort to put in practice integrated management plans in Marine Protected Areas (MPA) not only because of their high natural and cultural importance but also due to usual conflicts related to local activities. These plans should include the use of adaptive sustainability indicators that reflect stakeholders concerns, and community interests, allowing a better assessment, management and reporting. An adequate set of indicators for the MPA should help their managers to improve management policies in order to achieve better decision making processes. This study aimed to develop a set of adaptive-participative sustainability indicators (SDI) for the assessment, management and reporting of MPAs that include, through the all process, the participation of local stakeholders at every levels, integrating the stakeholders knowledge and perceptions about the SDI meaning and a self-assessment of the SDI state produced also by the stakeholders. The proposed approach was tested in Luiz Saldanha's Marine Park, located in South East of Portugal between the municipalities of Sesimbra and Setúbal. The framework to design the SDI comprised four phases: i) an international analysis of SDI sets for coastal zones and MPAs; ii) a participatory process, where the stakeholders had the possibility to state their concerns through an online and face to face questionnaire surveys about the strengths and weaknesses of the MPA; iii) an analysis conducted by a team of experts to reach a set of indicators that

include the main relevant aspects of environmental, socioeconomic, and governance issues, taking into account the information from the first two phases and iv) a workshop and questionnaires held to assess the stakeholders' global views and perception about the selected set of indicators and each indicator's relative importance. This study showed the importance of a dynamic participative process involving the local stakeholders. It is concluded that this methodology allows a better understanding of each indicator by the local stakeholders and how it could respond to their concerns. It should also help the MPA managers, to define the most suitable management actions and monitor the management plan itself.

Matsuda, O., & Kokubu, H. (2016). Reprint of Recent coastal environmental management based on new concept of Satoumi which promotes land-ocean interaction: A case study in Japan. *Estuarine Coastal and Shelf Science*, 183, 422-429 <https://doi.org/10.1016/j.ecss.2016.11.021>.

Environmental conservation and management policy first emphasized on water pollution control in Japan. However, this kind of passive conservation policy is gradually being shifted to an active approach such as Satoumi, which includes the restoration of biodiversity, biological productivity, habitat and a well-balanced nutrient cycle between land and sea. Many Satoumi creation activities were also characterized by activities which promote interactions between land and sea. In this paper, a case study of Ago Bay in Shima City, Mie Prefecture, Japan, is introduced in which land-sea interaction at two sites was improved by promoting water exchange across dikes constructed for land development and land reclamation. Tidal flat restoration experiments conducted in Ago Bay clearly showed that the promotion of tidal exchange between the sea and wetland area on the inner side of dikes improved both deteriorated sediment quality and macro-benthos conditions. Along with the results of this case study, future tidal flat restoration in Japan is also discussed.

Mavromatidi, A., Briche, E., & Claeys, C. (2018). Mapping and analyzing socio-environmental vulnerability to coastal hazards induced by climate change: An application to coastal Mediterranean cities in France. *Cities*, 72, 189-200 <https://doi.org/10.1016/j.cities.2017.08.007>.

The densely populated cities of continental Mediterranean France, which are prone to erosion, are facing a potentially multi-hazard threat, due to a rise in sea-level that is expected to increase by between 0.07 and 0.12 m during the 21st century. The aim of this study is the superimposition of two widely used empirical indexes - the Coastal Sensitivity Index and the Social Vulnerability Index. In this research, the CSI is based on the following 6 parameters: geomorphology, coastal slope, sea-level rise, shoreline changes, mean tidal range and significant wave height, while the SVI used is constructed from 9 parameters: population < 14 years old, population over 75 years old, women, single parent families, families with more than two children, tenants, average density (inhabitants/km²), unemployed population, population with no education and foreigners. The research was initially conducted on the French Mediterranean coast, where environmental inequality was observed, and led to the selection of 3 areas of interest for a further investigation in finer scale (municipality/department/coastal district scale). It was noted that in certain cases the socio-environmental vulnerability of a municipality (as a whole) differed from the one presented in its coastal district. Thus, the socio-environmental vulnerability of a place is related to the study's scale, and the interest lies in the recognition of the most vulnerable coastal districts of cities, in conjunction with coastal sensitivity, in order to prioritize the efforts for coastal management.

Mochizuki, J., Keating, A., Liu, W., Hochrainer-Stigler, S., & Mechler, R. (2018). An overdue alignment of risk and resilience? A conceptual contribution to community resilience. *Disasters*, 42(2), 361-391 <https://doi.org/10.1111/disa.12239>.

A systematic review of literature on community resilience measurement published between 2005 and 2014 revealed that the profound lack of clarity on risk and resilience is one of the main reasons why confusion about terms such as adaptive capacity, resilience, and vulnerability persists, despite the effort spared to operationalise these concepts. Resilience is measured in isolation in some cases, where a shock is perceived to arise external to the system of interest. Problematically, this contradicts the way in which the climate change and disaster communities perceive risk as manifesting itself endogenously as a function of exposure, hazard, and vulnerability. The common conceptualisation of resilience as predominantly positive is problematic as well when, in reality, many undesirable properties of a system are resilient. Consequently, this paper presents an integrative framework that highlights the interactions between risk drivers and coping, adaptive, and transformative capacities, providing an improved conceptual basis for resilience measurement.

Narchi, N. E., Cornier, S., Canu, D. M., Aguilar-Rosas, L. E., Bender, M. G., Jacquelin, C., . . . de Wit, R. (2014). Marine ethnobiology a rather neglected area, which can provide an important contribution to ocean and coastal management. *Ocean & Coastal Management*, 89, 117-126 <https://doi.org/10.1016/j.ocecoaman.2013.09.014>.

This report describes marine ethnobiology as it has been presented and discussed under the conference session "Ethnothalassic interactions" organized for the 13th International Congress of Ethnobiology. We define marine ethnobiology as a field within ethnobiology that specifically comprises the study of the relationships of present and past human societies to marine biota and ecosystems. The session stimulated discussion on this emerging field and its contribution to coastal and ocean management, by exchanging experiences on a diverse array of studies within this field that include: co-management of marine protected areas, seascape management, demise, re-discovery and reimplementation of traditional knowledge-based management schemes, history of artisanal shellfish-farming and of the management of artisanal fisheries, medicinal knowledge of algae, as well as the outreach of ethnobiological studies for the conservation of the cultural-ecological heritage in the coastal zone. We here offer the conclusions of the conference session in the form of a *longue duree* perspective on coastal management that highlights a broad array of human adaptations to coastal environments. We suggest that these adaptations have to be researched and understood in detail in order to incorporate them into broader coastal management strategies in the presence of the severe environmental and political-economical pressures that currently threaten fishing stocks, marine habitats, and the livelihoods of the 2.6 billion people that depend on the oceans as their main source of protein.

Newton, A., & Weichselgartner, J. (2014). Hotspots of coastal vulnerability: A DPSIR analysis to find societal pathways and responses. *Estuarine Coastal and Shelf Science*, 140, 123-133 <https://doi.org/10.1016/j.ecss.2013.10.010>.

Dramatic loss of life and economic losses in coastal zones have focused attention on natural and man-made hazards. The paper starts with a review of the coastal vulnerability terminology. Coastal zones are then presented as complex, socio-ecological systems. Four main coastal hotspots of vulnerability; namely Arctic coasts, small islands, river-mouth systems and urban coasts (including megacities) are analysed to demonstrate the complexity of coastal vulnerability. A DPSIR framework is used to explore the causes and consequences of coastal vulnerability. The paper then focuses in particular on societal, as well as floods, storm-surges and tsunamis to technological and engineering solutions. These include raising awareness, advancing forecasting, enhancing preparedness and improving governance.

Nguyen, T. T. X., Bonetti, J., Rogers, K., & Woodroffe, C. D. (2016). Indicator-based assessment of climate-change impacts on coasts: A review of concepts, methodological approaches and vulnerability indices. *Ocean & Coastal Management*, 123, 18-43
<https://doi.org/10.1016/j.ocecoaman.2015.11.022>.

Increasing human pressures on coastlines and associated threats posed by sea-level rise have stimulated development of a range of different concepts and methodological approaches to assess coastal vulnerability. The first section of this paper summarizes the concepts associated with vulnerability, natural hazards and climate change. The most widely adopted analytical approaches to vulnerability assessment are described, including spatial scales, the need for hybrid approaches comprising both biophysical and social dimensions of vulnerability, and the gradual incorporation of resilience aspects into such methodologies. In particular, the development and application of vulnerability indices is examined, based on a review of more than 50 studies that applied such indices across a range of hazards. The analytical procedures, proposed typologies, and most commonly selected variables are discussed. This overview demonstrates the breadth of vulnerability studies. This leads inevitably to lack of standardization of concepts and assumptions, which results in limited comparability between outputs for coasts from different areas. However, the widespread demand for vulnerability assessment as a component of decision-making in integrated management of the coast justifies pursuing indicator-based vulnerability assessments. In some cases these will explicitly adopt a consistent methodology that enables comparison between sites, whereas alternatively, metrics may be developed that are designed around particular system components and the site-specific functions for which they are valued.

O'Neill, A. C., Erikson, L. H., Barnard, P. L., Limber, P. W., Vitousek, S., Warrick, J. A., . . . Lovering, J. (2018). Projected 21st Century Coastal Flooding in the Southern California Bight. Part 1: Development of the Third Generation CoSMoS Model. *Journal of Marine Science and Engineering*, 6(2), 31 <https://doi.org/10.3390/jmse6020059>.

Due to the effects of climate change over the course of the next century, the combination of rising sea levels, severe storms, and coastal change will threaten the sustainability of coastal communities, development, and ecosystems as we know them today. To clearly identify coastal vulnerabilities and develop appropriate adaptation strategies due to projected increased levels of coastal flooding and erosion, coastal managers need local-scale hazards projections using the best available climate and coastal science. In collaboration with leading scientists world-wide, the USGS designed the Coastal Storm Modeling System (CoSMoS) to assess the coastal impacts of climate change for the California coast, including the combination of sea-level rise, storms, and coastal change. In this project, we directly

address the needs of coastal resource managers in Southern California by integrating a vast range of global climate change projections in a thorough and comprehensive numerical modeling framework. In Part 1 of a two-part submission on CoSMoS, methods and the latest improvements are discussed, and an example of hazard projections is presented.

Orencio, P. M., & Fujii, M. (2013). An Index to Determine Vulnerability of Communities in a Coastal Zone: A Case Study of Baler, Aurora, Philippines. *Ambio*, 42(1), 61-71 <https://doi.org/10.1007/s13280-012-0331-0>.

A coastal community vulnerability index (CCVI) was constructed to evaluate the vulnerability of coastal communities (Buhangin, Pingit, Reserva, Sabang, and Zabali) in the municipality of Baler, Aurora, Philippines. This index was composed of weighted averages of seven vulnerability factors namely geographical, economic and livelihood, food security, environmental, policy and institutional, demographic, and capital good. Factor values were computed based on scores that described range of conditions that influence communities' susceptibility to hazard effects. Among the factors evaluated, economic and livelihood, policy and institutional and food security contributed to CCVI across communities. Only small variations on CCVI values (i.e., 0.47-0.53) were observed as factor values cancelled out one another during combination process. Overall, Sabang received the highest CCVI, which was contributed mainly by geographical and demographic factors. This technique to determine factors that influenced communities' vulnerability can provide information for local governments in enhancing policies on risk mitigation and adaptation.

Pradhan, B. (2013). A comparative study on the predictive ability of the decision tree, support vector machine and neuro-fuzzy models in landslide susceptibility mapping using GIS. *Computers & Geosciences*, 51, 350-365 <https://doi.org/10.1016/j.cageo.2012.08.023>.

The purpose of the present study is to compare the prediction performances of three different approaches such as decision tree (DT), support vector machine (SVM) and adaptive neuro-fuzzy inference system (ANFIS) for landslide susceptibility mapping at Penang Hill area, Malaysia. The necessary input parameters for the landslide susceptibility assessments were obtained from various sources. At first, landslide locations were identified by aerial photographs and field surveys and a total of 113 landslide locations were constructed. The study area contains 340,608 pixels while total 8403 pixels include landslides. The landslide inventory was randomly partitioned into two subsets: (1) part 1 that contains 50% (4000 landslide grid cells) was used in the training phase of the models; (2) part 2 is a validation dataset 50% (4000 landslide grid cells) for validation of three models and to confirm its accuracy. The digitally processed images of input parameters were combined in GIS. Finally, landslide susceptibility maps were produced, and the performances were assessed and discussed. Total fifteen landslide susceptibility maps were produced using DT, SVM and ANFIS based models, and the resultant maps were validated using the landslide locations. Prediction performances of these maps were checked by receiver operating characteristics (ROC) by using both success rate curve and prediction rate curve. The validation results showed that, area under the ROC curve for the fifteen models produced using DT, SVM and ANFIS varied from 0.8204 to 0.9421 for success rate curve and 0.7580 to 0.8307 for prediction rate curves, respectively. Moreover, the prediction curves revealed that model 5 of DT has slightly higher prediction performance (83.07), whereas the success rate showed that model 5 of ANFIS has

better prediction (94.21) capability among all models. The results of this study showed that landslide susceptibility mapping in the Penang Hill area using the three approaches (e.g., DT, SVM and ANFIS) is viable. As far as the performance of the models are concerned, the results appeared to be quite satisfactory, i.e., the zones determined on the map being zones of relative susceptibility.

Sahoo, B., & Bhaskaran, P. K. (2018). Multi-hazard risk assessment of coastal vulnerability from tropical cyclones - A GIS based approach for the Odisha coast. *Journal of Environmental Management*, 206, 1166-1178 <https://doi.org/10.1016/j.jenvman.2017.10.075>.

The coastal region bordering the East coast of India is a thickly populated belt exposed to high risk and vulnerability from natural hazards such as tropical cyclones. Tropical cyclone frequencies that develop over the Bay of Bengal (average of 5-6 per year) region are much higher as compared to the Arabian Sea thereby posing a high risk factor associated with storm surge, inland inundation, wind gust, intense rainfall, etc. The Odisha State in the East coast of India experiences the highest number of cyclone strikes as compared to West Bengal, Andhra Pradesh, and Tamil Nadu. To express the destructive potential resulting from tropical cyclones the Power Dissipation Index (PDI) is a widely used metric globally. A recent study indicates that PDI for cyclones in the present decade have increased about six times as compared to the past. Hence there is a need to precisely ascertain the coastal vulnerability and risk factors associated with high intense cyclones expected in a changing climate. As such there are no comprehensive studies attempted so far on the determination of Coastal Vulnerability Index (CVI) for Odisha coast that is highly prone to cyclone strikes. With this motivation, the present study makes an attempt to investigate the physical, environmental, social, and economic impacts on coastal vulnerability associated with tropical cyclones for the Odisha coast. The study also investigates the futuristic projection of coastal vulnerability over this region expected in a changing climate scenario. Eight fair weather parameters along with storm surge height and onshore inundation were used to estimate the Physical Vulnerability Index (PVI). Thereafter, the PVI along with social, economic, and environmental vulnerability was used to determine the overall CVI using the GIS based approach. The authors believe that the comprehensive nature of this study is expected to benefit coastal zone management authorities.

Sarker, S., Rahman, M. M., Yadav, A. K., & Islam, M. M. (2019). Zoning of marine protected areas for biodiversity conservation in Bangladesh through socio-spatial data. *Ocean & Coastal Management*, 173, 114-122 <https://doi.org/10.1016/j.ocecoaman.2019.03.002>.

Marine protected areas (MPAs) have become one of the most widely employed marine management tools worldwide for conserving species and habitats, maintaining ecosystem functioning, and ensuring sustainable use of marine resources. In this study, we adopted a science-based, stakeholder-driven and ecosystem based approach to identify coastal and marine habitats for potential MPA declaration towards achieving Aichi target 11. In addition, we also proposed an integrated management approach for MPA management in Bangladesh. Primary data were collected through stakeholder consultations from the three coastal zones of Bangladesh and secondary data were collected from an extensive literature review. We developed a priority index to select the most important habitats for MPA declaration. Our analysis suggests five potential habitats within the maritime boundary of Bangladesh for MPA declaration. These habitats cover an area of 8838 km² which is about 7.5% of the total

maritime area of Bangladesh. Declaration of the MPAs will contribute to conserve the nursing and breeding habitats of fishes, crabs and seabirds, and thus will protect the marine biodiversity. To achieve this goal, local community involvement is required. This study will serve as a baseline for declaring MPAs in a solid scientific way through community engagement.

Smith, G. (2015). Creating the spaces, filling them up. Marine spatial planning in the Pentland Firth and Orkney Waters. *Ocean & Coastal Management*, 116, 132-142
<https://doi.org/10.1016/j.ocecoaman.2015.07.003>.

Marine spatial planning (MSP) is a leading management tool worldwide for organising the way we interact with the marine environment. MSP utilises the latest and most accurate data available on the marine and coastal space and socio-economic factors in order to inform policy. But what does governance under MSP look like? In the Pentland Firth and Orkney Waters strategic planning area in north-eastern Scotland MSP is 'the new kid on the block'. This paper draws on the concept of governmentality to better understand how a new governance system (the block) is emerging to support MSP by making people and the seas more governable. It suggests that the local authorities – The Orkney Islands Council and The highland council – are strong contenders to be leaders in this new system, in collaboration with other key actors such as Marine Scotland. These actors are vying for influence over the new system. For this they need to legitimise their positions and legitimise MSP itself. One way that they do this is by nurturing a 'mentality of space' among stakeholders and the general public. Teaching other actors to think and communicate in spatial terms eases the transition to MSP. Certain technologies are used to aid the learning process, such as maps, models and diagrams. However, the system is still in the making and uncertainties and resistance remain. On a theoretical level these findings demonstrate how closely related the governance system, governmentality, and MSP are, and how they co-evolve. Appreciating these links can help inform current and future experiences with MSP, and help us to understand the role of power in processes of social organisation.

Tragaki, A., Gallousi, C., & Karymbalis, E. (2018). Coastal Hazard Vulnerability Assessment Based on Geomorphic, Oceanographic and Demographic Parameters: The Case of the Peloponnese (Southern Greece). *Land*, 7(2), 56 <https://doi.org/10.3390/land7020056>.

Today low-lying coastal areas around the world are threatened by climate change-related hazards. The identification of highly vulnerable coastal areas is of great importance for the development of coastal management plans. The purpose of this study is to assess the physical and social vulnerability of the Peloponnese (Greece) to coastal hazards. Two indices were estimated: The Coastal Vulnerability Index (CVI) and the Social Vulnerability Index (SVI). CVI allows six physical variables to be related in a quantitative manner while the proposed SVI in this study contains mainly demographic variables and was calculated for 73 coastal municipal communities. The results reveal that 17.2% of the shoreline (254.8 km) along the western and northwestern coast of the Peloponnese, as well as at the inner

Messiniakos and Lakonikos Gulfs, is of high and very high physical vulnerability. High and very high social vulnerabilities characterize communities along the northwestern part of the study area, along the coasts of the Messinian and Cape Malea peninsulas, as well as at the western coast of Saronikos Gulf.

van Putten, I., Villanueva, C., & Cvitanovic, C. (2017). The Influence of Community Size and Location on Different Dimensions of Vulnerability: a case study of Australian coastal communities. *Australian Geographer*, 48(1), 121-142 <https://doi.org/10.1080/00049182.2016.1168727>.

Coastal communities are part of the Australian identity but little is known about their characteristics and their long-term prosperity prospects. Increased migration to coastal areas and increased exposure to extreme climatic events indicates a need for social and economic data to inform socio-ecological systems planning. Here, we undertake a geo-spatial analysis to develop a typology of Australian coastal communities and assess relative vulnerability to climate-driven environmental change for a range of social and economic indicators. The aim of this study is to understand how the vulnerability of Australian coastal communities varies with geographic location or community size, and in comparison to other community types. Results show that both the population size and location of a coastal community matter and that coastal communities overall are more vulnerable on some socio-economic dimensions to climate-driven environmental change than their rural equivalents. However, results also demonstrate that the smallest coastal communities are strong in some important aspects of the human, social and financial domains, putting them in a good position to deal with some changes. Scale-appropriate and context-specific social policies are needed to address identified socio-economic vulnerabilities, supported by a range of formal and informal institutional structures, such as strategies to improve education and female workforce participation, and encourage participation in volunteering to increase human and social capital.

Zhu, Z. T., Cai, F., Chen, S. L., Gu, D. Q., Feng, A. P., Cao, C., . . . Lei, G. (2019). Coastal Vulnerability to Erosion Using a Multi-Criteria Index: A Case Study of the Xiamen Coast. *Sustainability*, 11(1), 20 <https://doi.org/10.3390/su11010093>.

The assessment of coastal vulnerability to erosion is urgently needed due to increasing coastal erosion globally. Based on the coastal characteristics of the Xiamen artificial coastline, which accounts for more than 80% of the coastline in this area, this study provides an integrated approach based on a multi-criteria index. The evaluation index system of the local coastal vulnerability to the erosion of Xiamen includes 12 indexes based on natural (coastal characteristics, coastal forcing), and socio-economic factors (coastal infrastructure, disaster reduction). The spatial differentiation characteristics of the coastal vulnerability to erosion along the Xiamen coast (2018) have been quantitatively assessed with the aid of GIS (Geographic Information System) and RS (Remote Sensing) technology. The results show that the very high vulnerability, high vulnerability, medium vulnerability, low vulnerability and very low vulnerability areas of coastal erosion accounted for 4.6%, 30.5%, 51.6%, 12.5% and 0.8% of the Xiamen coast, respectively. The coastal vulnerability to erosion classes of artificial coasts is significantly higher than those of natural coasts. This difference is mainly controlled by the coastal slope and coastal buffer ability. The results of the evaluation are basically consistent with the present situation. The rationality of the index system and the applicability of the theoretical method are well explained. The evaluation model constructed in this study can be extended to other areas with high ratios of artificial coasts.

Section II: Decision Support Systems Integrating Social and Ecological Factors

Chacko, J., Rees, L. P., Zobel, C. W., Rakes, T. R., Russell, R. S., & Ragsdale, C. T. (2016). Decision support for long-range, community-based planning to mitigate against and recover from potential multiple disasters. *Decision Support Systems*, 87, 13-25
<https://doi.org/10.1016/j.dss.2016.04.005>.

This paper discusses a new mathematical model for community-driven disaster planning that is intended to help decision makers exploit the synergies resulting from simultaneously considering actions focusing on mitigation and efforts geared toward long-term recovery. The model is keyed on enabling long-term community resilience in the face of potential disasters of varying types, frequencies, and severities, and the approach's highly iterative nature is facilitated by the model's implementation in the context of a decision support system. Three examples from Mombasa, Kenya, East Africa, are discussed and compared in order to demonstrate the advantages of the new mathematical model over the current ad hoc mitigation and long-term recovery planning approaches that are typically used.

de Sherbinin, A., Chai-Onn, T., Jaiteh, M., Mara, V., Pistolesi, L., Schnarr, E., & Trzaska, S. (2015). Data Integration for Climate Vulnerability Mapping in West Africa. *Isprs International Journal of Geo-Information*, 4(4), 2561-2582 <https://doi.org/10.3390/ijgi4042561>.

Vulnerability mapping reveals areas that are likely to be at greater risk of climate-related disasters in the future. Through integration of climate, biophysical, and socioeconomic data in an overall vulnerability framework, so-called hotspots of vulnerability can be identified. These maps can be used as an aid to targeting adaptation and disaster risk management interventions. This paper reviews vulnerability mapping efforts in West Africa conducted under the USAID-funded African and Latin American Resilience to Climate Change (ARCC) project. The focus is on the integration of remotely sensed and socioeconomic data. Data inputs included a range of sensor data (e.g., MODIS NDVI, Landsat, SRTM elevation, DMSP-OLS night-time lights) as well as high-resolution poverty, conflict, and infrastructure data. Two basic methods were used, one in which each layer was transformed into standardized indicators in an additive approach, and another in which remote sensing data were used to contextualize the results of composite indicators. We assess the benefits and challenges of data integration, and the lessons learned from these mapping exercises.

González, A., Donnelly, A., Jones, M., Chrysoulakis, N., & Lopes, M. (2013). A decision-support system for sustainable urban metabolism in Europe. *Environmental Impact Assessment Review*, 38, 109-119
<https://doi.org/10.1016/j.eiar.2012.06.007>.

Urban metabolism components define the energy and material exchanges within a city and, therefore, can provide valuable information on the environmental quality of urban areas. Assessing the potential impact of urban planning alternatives on urban metabolism components (such as energy, water, carbon and pollutants fluxes) can provide a quantitative estimation of their sustainability performance. Urban metabolism impact assessment can, therefore, contribute to the identification of sustainable urban structures with regards, for example, to building types, materials and layout, as well as to location and capacity of transportation and infrastructural developments. In this way, it enables the formulation of

planning and policy recommendations to promote efficient use of resources and enhance environmental quality in urban areas. The European FP7 project BRIDGE (sustainaBle uRban plannIng Decision support accountinG for urban mEtabolism) has developed a decision-support system (DSS) that systematically integrates urban metabolism components into impact assessment processes with the aim of accurately quantifying the potential effects of proposed planning interventions. The DSS enables integration of multiple spatial and non-spatial datasets (e.g. physical flows of energy and material with variables of social and economic change) in a systematic manner to obtain spatially defined assessment results and to thus inform planners and decision-makers. This multi-criteria approach also enables incorporation of stakeholders' perceptions in order to prioritise decisive assessment criteria. This paper describes the methodological framework used to develop the DSS and critically examines the results of its practical application in five European cities.

Habersack, H., Schober, B., & Hauer, C. (2015). Floodplain evaluation matrix (FEM): An interdisciplinary method for evaluating river floodplains in the context of integrated flood risk management. *Natural Hazards*, 75, 5-32 <https://doi.org/10.1007/s11069-013-0842-4>.

Strengthening of non-structural measures for flood protection by enforcing natural retention processes on river floodplains not only is required by the EU Floods Directive but also implicates a variety of socio-economic conflicts related to the multipurpose use of floodplains. In order to ensure the achievement of multiple benefits of such non-structural measures in the most effective way, it is crucial to determine which floodplains are highly relevant for preservation and/or restoration not only concerning flood protection (hydrology/hydraulics) but also for ecological and sociological reasons. Therefore, the main objectives of this paper are to identify on different spatial scales those hydrological/hydraulic, ecological and sociological parameters that are important for an integrated evaluation of floodplain effectiveness. The results are finally assembled in the novel multidisciplinary floodplain evaluation matrix (FEM) serving as decision support for the relevant stakeholders and indicating where efforts of floodplain preservation/restoration should be spent first within an integrated flood risk management. At the end of this paper, an integrative evaluation on macro-scale level for the Austrian Kamp River is exemplarily presented. Detailed sectoral investigations of the hydrological and hydraulic parameters are further described in a case study of the Austrian Danube (see paper "Assessing the role of floodplains along the Austrian Danube for flood hazard reduction using the hydrological and hydraulic parameters of the FEM-method").

Hanson, D., Hachmeister, L., Hale, D., & Hassler, E. (2014). Gulf Of Mexico Ecosystem Restoration: A Risk-based Integrated Environmental, Economic, And Social Resource Management Decision Support Framework. *WIT Transactions on Ecology and the Environment*, 181, <https://doi.org/10.2495/EID140451>.

The natural systems that make up the United States coastal waters of the Gulf of Mexico, its watershed, and adjacent marine waters serve as critical natural infrastructure supporting water supply, transportation, power generation, recreation, commercial fishing, agriculture, forestry, manufacturing, and a wide variety of other valued resources for the people in the watershed. Development activities, multiple uses, and both natural and human-induced disasters have placed significant stresses and impacts on the unique biodiversity of the ecosystem and its sustainable uses. This paper presents results

of Phase 1 of a NOAA-funded assessment of the freshwater and marine fisheries that focused on the Mobile Bay (Alabama, USA) watershed, the related aquatic system, and the stresses placed on this system by both anthropologic and natural conditions. Three collaborative multi-stakeholder workshops were held in order to gain a perspective on the most immediate perceived threats to a sustainable Mobile Bay system. Challenges associated with the governance of the Mobile Bay system were ranked as the greatest category of threat for a sustainable system compared to more traditional anthropologic-perturbations such as habitat loss, non-point source pollution, or aging infrastructure. A decision support system framework was developed to better understand and quantify interactions between environmental, economic, social, and built capital systems. Following the Deepwater Horizon oil release in 2010, the system framework was modified to align with the five long-term ecosystem restoration goals and priority actions

Hirschfeld, J., Dehnhardt, A., & Dietrich, J. (2005). Socioeconomic analysis within an interdisciplinary spatial decision support system for an integrated management of the Werra River Basin. *Limnologica*, 35(3), 234-244 <https://doi.org/10.1016/j.limno.2005.06.007>.

The implementation of the European Water Framework Directive is highly challenging to researchers, planning authorities and stakeholders. Presenting results from an interdisciplinary research project at the Werra River in central Germany, this paper focuses on a socioeconomic analysis and its integration into a spatial decision support system (SDSS). Starting from a status quo description, two baseline scenarios concerning the use of land and water up to the years 2015 and 2021 have been formulated. Potential measures to reach a good ecological status have been evaluated in a cost and benefit analysis. Additionally, an actor network analysis and an institutional analysis were carried out to evaluate the acceptance and social dimension of the potential policy measures. A newly formulated “cooperation index” summarizes these findings. Finally, a spatial decision support system helps to integrate and evaluate planning results from all disciplines involved (hydrology, ecology, sanitary engineering, social sciences). The system provides a tool for decision makers and stakeholders to screen and discuss alternative strategies for the implementation of the Water Framework Directive.

Iavarone, R., Alberico, I., Gravagnuolo, A., & De Vita, G. E. (2019). The Role of Cultural Heritage in Urban Resilience Enhancement. In F. Calabro, L. DellaSpina, & C. Bevilacqua (Eds.), *New Metropolitan Perspectives: Local Knowledge and Innovation Dynamics Towards Territory Attractiveness through the Implementation of Horizon/E2020/Agenda2030, Vol 2* (Vol. 101, pp. 369-377). Cham: Springer International Publishing Ag. https://doi.org/10.1007/978-3-319-92102-0_39

Place-based urban regeneration suggests the need of shift from a fragmented to a systemic model to understand the interrelation between sub-systems and the effects that a changing sub-system can pose on the others. In this context, urban regeneration strategies resilience oriented may include actions able to improve the economic, physical, social and environmental conditions and thus the human well-being of urban areas. The great quantity of information involved in the resilience assessment of urban systems require the use of Spatial Decision Support Systems (SDSS) that make possible to record, analyze and summarize data with different spatial and temporal resolution. In the present work, we described the structure of a framework for the Resilience and Disaster Risk Management. Particularly, we focused our

attention on the identification of indices expressing the contribution of cultural heritage in making cities resilience toward natural hazards. These tools allow identifying replicable and scaling-up successful practices and converting the impalpable values of cultural heritage in measurable ones.

Laurans, Y., & Mermet, L. (2014). Ecosystem services economic valuation, decision-support system or advocacy? *Ecosystem Services*, 7, 98-105 <https://doi.org/10.1016/j.ecoser.2013.10.002>.

There appears to be a discrepancy between the massive presence of Ecosystem Services (economic) Valuations (ESV) in biodiversity discourse and literature and the small number of examples where it is documented and demonstrated that they have been instrumental in changing policies. Part of this discrepancy may reflect an insufficient fit of ESV to the organizational and political dimensions of decision-making. This paper thus explores the relation between decision-making as it is viewed in the theoretical roots of ESV and also as it is depicted in disciplines that take decision as their central topic. Three alternative and complementary types of decision models (rational decision-maker, organization and political process) each shed a different light on what ESV can be useful for, and what qualities are then required of it. In general, the contribution of ESV to decision-making relies both on its ability to bring rationality to decision-making, and on its procedural qualities as resource of influence that is needed for advocacy and justification. Thus, the usefulness of ESV cannot be enhanced by either the strengthening of their rigor or the enhancement of their procedural qualities alone: to successfully address the challenge, both of these measures are required in combination. This produces a tension between the rational and substantial abilities that ESV must sustain on the one hand, and the rhetorical and procedural qualities it should develop on the other hand. To overcome this tension, it may prove useful to draw lessons from the field of policy evaluation. In this field, rationalization-based and process-based methodologies once fiercely contested each other. However, process-based and content-based methodologies are now deliberately combined in diverse designs.

Maskrey, S. A., Priest, S., & Mount, N. J. (2019). Towards evaluation criteria in participatory flood risk management. *Journal of Flood Risk Management*, 12(2), 14 <https://doi.org/10.1111/jfr3.12462>.

Flood risk consists of complex and dynamic problems, whose management calls for innovative ways of engaging with a wide range of local stakeholders, many of whom lack the technical expertise to engage with traditional flood risk management practices. Participatory approaches offer potential for involving these stakeholders in decision-making, yet limited advice is available to users in choosing which techniques to employ and what they might expect them to deliver. Assessing the effectiveness of participatory approaches in local flood risk management is a critical step towards better understanding how community resilience is built. This article presents a framework for evaluating participatory approaches to flood risk management that covers four evaluation elements (context, process, substantive, and social outcomes). Practical success criteria are provided for evaluation, with references indicating where further advice and guidance can be sought. Criteria are tailored to the requirements of flood risk management, and aim to be sufficiently flexible for the framework to be easily transferable.

Meyer, I., Hama, M., Jandl, R., Leitner, M., Keuschnig, M., Anders, I., . . . Eder, B. (2019). Co-creating a desirable and resilient future for Lienz, Austria-a local case study in socio-economic scenario development. *Regional Environmental Change*, 19(4), 1059-1071 <https://doi.org/10.1007/s10113-018-1439-y>.

The aim of this case study was to conduct a participatory approach to socio-economic scenario development in the city of Lienz (East Tyrol) and to suggest this process-oriented approach as an element of an integrated guiding and decision support tool for local resilience and risk management to policy makers, business leaders, and civil society. The paper takes a socio-economic perspective and describes the settings of the case study, the process, and approach taken for co-creating two distinct normative socio-economic scenario narratives for the city of Lienz: a desirable or resilient future and an undesirable or stagnant future. Results are presented as sector-specific scenario narratives. Matching the local scenario narratives with the global shared socio-economic pathways, it derives that local peculiarities such as population decline due to outmigration trends or decentralized manufacturing industry and educational institutions were judged to be critical factors in securing local resilience for a prospering future.

Pinto, R., da Conceição Cunha, M., Roseta-Palma, C., & Marques, J. C. (2014). Mainstreaming Sustainable Decision-making for Ecosystems: Integrating Ecological and Socio-economic Targets within a Decision Support System. *Environmental Processes*, 1(1), 7-19 <https://doi.org/10.1007/s40710-014-0006-x>.

Ecosystem sustainable management, and the underlying decision-making process, generally requires the analysis of ecological, social and economic information, integrating both value judgements and policy goals. Since this process can be regarded as complex and tricky, natural resource management requires a well-structured and transparent decision-making process. In this regard, it is necessary to search for and implement sets of measures which can effectively solve emerging problems. Based on the assumption that decisions concerning the management of watersheds may imply trade-offs between their different functions, the intent was to test if software tools, such as MULINO, could be used to enhance multi-level governance of ecosystems. To achieve this, the DPSIR and MCA were incorporated, to analyze and quantify the explicit trade-offs between several types of services provided by estuarine ecosystems and stakeholder objectives. The Mondego Estuary (Portugal) was used as case study. This system is under constant pressure, from both natural and anthropogenic drivers. Urban expansion and tourism were identified as having a strong impact on system development, while agriculture, although declining, had a determinant role in the system's status. The study evaluated potential alternatives focusing on the water quality improvement goals that could be designed for the system. The MCA ranked several alternatives and pinpointed as the "best" option the alternative that combines buffer zones, eco-tourism enhancement, wastewater treatment plant development, the Murraceira trademark and bivalves bio-control. This analysis allowed a simplification of several management objectives; nonetheless, further tests are still required to understand the real connection between these outcomes and decision-makers.

Pittman, S. J., Poti, M., Jeffrey, C. F. G., Kracker, L. M., & Mabrouk, A. (2018). Decision support framework for the prioritization of coral reefs in the US Virgin Islands. *Ecological Informatics*, 47, 26-34 <https://doi.org/10.1016/j.ecoinf.2017.09.008>.

The coral reef ecosystems of the U.S. Virgin Islands are some of the most intensively surveyed and threatened tropical ecosystems on earth. These coral reefs vary widely in terms of biophysical structure, seascape context, socio-economic value and exposure to threats presenting a complex challenge for resilience-based management. How and where should managers prioritize actions to maximize conservation outcomes? To meet multiple conservation objectives, a novel map-based decision-support tool was designed which synthesized large amounts of data to help managers identify and rank coral reefs according to multiple ecological qualities, ecosystem services and threats. The spatial framework integrates local expert knowledge from SCUBA divers, scientific field data and spatial models to characterize and rank priority coral reefs. With user-defined flexibility, the tool provides information to guide management processes such as risk assessments of coastal development, management of protected areas, site selection in science and monitoring design, broader marine spatial planning and community education and outreach.

Tampekis, S., Sakellariou, S., Samara, F., Sfougaris, A., Jaeger, D., & Christopoulou, O. (2015). Mapping the optimal forest road network based on the multicriteria evaluation technique: the case study of Mediterranean Island of Thassos in Greece. *Environmental Monitoring and Assessment*, 187(11), 1-17 <https://doi.org/10.1007/s10661-015-4876-9>.

The sustainable management of forest resources can only be achieved through a well-organized road network designed with the optimal spatial planning and the minimum environmental impacts. This paper describes the spatial layout mapping for the optimal forest road network and the environmental impacts evaluation that are caused to the natural environment based on the multicriteria evaluation (MCE) technique at the Mediterranean island of Thassos in Greece. Data analysis and its presentation are achieved through a spatial decision support system using the MCE method with the contribution of geographic information systems (GIS). With the use of the MCE technique, we evaluated the human impact intensity to the forest ecosystem as well as the ecosystem's absorption from the impacts that are caused from the forest roads' construction. For the human impact intensity evaluation, the criteria that were used are as follows: the forest's protection percentage, the forest road density, the applied skidding means (with either the use of tractors or the cable logging systems in timber skidding), the timber skidding direction, the visitors' number and truck load, the distance between forest roads and streams, the distance between forest roads and the forest boundaries, and the probability that the forest roads are located on sights with unstable soils. In addition, for the ecosystem's absorption evaluation, we used forestry, topographical, and social criteria. The recommended MCE technique which is described in this study provides a powerful, useful, and easy-to-use implement in order to combine the sustainable utilization of natural resources and the environmental protection in Mediterranean ecosystems.

Wang, W.-M., Lee, A. H. I., Peng, L.-P., & Wu, Z.-L. (2013). An integrated decision making model for district revitalization and regeneration project selection. *Decision Support Systems*, 54(2), 1092-1103 <https://doi.org/10.1016/j.dss.2012.10.035>.

The main purpose of this research is to propose an effective hybrid process for evaluating district development directions concerning district revitalization and regeneration (DRAR) prospects along with simultaneous positive and negative conflict criteria and their interdependence. Accordingly, the fuzzy Delphi method (FDM), the interpretive structural modeling (ISM), and the analytic network process (ANP) with benefits, opportunities, costs, and risks (BOCR) are integrated to construct a project selection model regarding the DRAR. A real case in Jiufen in Taiwan is studied using the proposed model to evaluate four feasible development directions, and the results verify the applicability of the novel MCDM method. This hybrid process can not only transform complex interaction of district reviving factors into simple quantitative evaluation, but its result can also be guidance for determining future development direction.

Zanuttigh, B., Simcic, D., Bagli, S., Bozzeda, F., Pietrantoni, L., Zagonari, F., . . . Nicholls, R. J. (2014). THESEUS decision support system for coastal risk management. *Coastal Engineering*, 87, 218-239 <https://doi.org/10.1016/j.coastaleng.2013.11.013>.

While planning coastal risk management strategies, coastal managers need to assess risk across a range of spatial and temporal scales. GIS-based tools are one efficient way to support them in the decision making process through a scenarios analysis starting from social, economic and environmental information integrated into a common platform. However, this integration process requires a significant effort from a team of scientists in terms of a) identifying the appropriate scales and data resolution for analysing social, environmental and economic issues; b) selecting and linking an appropriate set of tools to build a coupled model; c) representing key emerging (and hence challenging) research issues, such as risk perception and social resilience in the model; d) developing multi-criteria analysis to integrate social, environmental, economic impacts; and e) accounting for the expectations of the stakeholders and therefore optimizing the opportunity for them to interact with the tool development and with the final tool itself. In this spirit, this paper presents an open-source Spatial Decision Support System developed within the THESEUS Project to help decision makers to scope optimal strategies to minimise coastal risks. The exploratory tool allows the users to perform an integrated coastal risk assessment, to analyse the effects of different combinations of engineering, social, economic and ecologically based mitigation options, across short (2020s), medium (2050s) and long-term (2080s) scenarios, taking into account physical and non-physical drivers, such as climate change, subsidence, population and economic growth.