Coastal and Marine Spatial Planning with InVEST

Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) can help in coastal and marine spatial planning (CMSP) by providing spatially explicit, quantified outputs, enabling planners to efficiently account for both development and conservation priorities. InVEST includes a suite of marine and coastal models that quantify food from fisheries and aquaculture, tourism and recreational opportunities, aesthetic views, protection from coastal hazards, and renewable energy (waves and wind). Models for marine water quality and habitat risk assessment can quantify the impact of human activities on coastal and water-column habitats, and an InVEST spatial overlap model can analyze multiple human activities that occur simultaneously. These tools empower planners to consider diverse sectors active in coastal and marine areas, and manage their potentially conflicting uses. Outlined below are InVEST's key contributions to CMSP:

Planning step	How InVEST can help
1. Scoping	Explore how ecosystem services interact
2. Engage Stakeholders	*N/A*
3. Develop governance structure	*N/A*
4. Define indicators and thresholds	Assess how marine use may affect ES
5. Assess existing conditions	Assess current ES status
6. Develop future scenarios	Develop future scenarios based on possible alternatives
7. Assess future scenarios	Assess impacts of future scenarios
8. Develop spatial management plan	Inform plan (based on previous steps)
9. Identify sustainable finance	Identify ES beneficiaries
10. Implementation	Identify ES providers/beneficiaries for enforcement plan
11. Monitoring and evaluation	Inform design of monitoring plans
12. Adaptive management	Assess returns of management plans; inform adaptation

InVEST In Practice

The *InVEST in Practice* Series outlines the InVEST software's applicability to policy and planning processes. This guidance is based on our experiences developing and applying InVEST in more than 20 places around the world.

The applicability of InVEST depends on the quality and availability of data, modeling capacity, local institutional and governance structures, and the policy time frame. This guidance should be considered in light of the social, environmental, and institutional conditions where InVEST is used.

Marine spatial planning is a process for allocating human activities in marine areas to achieve ecological, economic, and social objectives.[1] An ecosystem-based management (EBM) approach to CMSP can balance the interests of diverse stakeholders and incorporate networks of marine protected areas that sustain habitats and their associated biota.[2] Management practices that optimize for a single target species without considering habitat, non-target species, and the interactions between people and the environment are often ineffective at maintaining the health of ecosystems. As a more holistic approach, EBM considers multiple spatial and temporal scales, links ecosystems and community activities, connects management efforts across air, land and sea boundaries, and aims to meaningfully engage with stakeholders.[3]

1: Scoping

What is the area of the marine spatial plan? What are its goals regarding protection of species, habitats and ecosystem services, and improvements to human well-being?

Determine objectives with stakeholder input and information from ecosystem simulation models, statistical analyses and conceptual models. InVEST can help develop plausible objectives that account for interactions within the ecosystem. For example, an InVEST analysis of how marine management is likely to affect coastal protection and fisheries could help define objectives for efficient service delivery.

2: Engage stakeholders

What are the local priorities regarding ecosystem services (ES) and economic activities?

Identify relevant stakeholders, using InVEST to help determine where key ES are provided. Discuss how ES information has previously informed decision-making.

3: Develop governance structure and design process

How will the overall CMSP be managed?

Designate an implementing authority and establish a strong governing body to design and organize the overall CMSP process. This is largely a political and administrative process.

4: Define indicators and thresholds

Which indicators will be used to monitor the achievement of planning objectives?

Determine indicators, and targets for each indicator, in collaboration with stakeholders. InVEST can help identify indicators and thresholds. For example, an InVEST analysis of how change in marine use is likely to affect fisheries could help set a target for efficient delivery of that service.

5: Assess existing conditions

What is the current status of ES and human uses?

Map important biological and ecological areas, oceanographic and other physical features, and current human uses of the system. Use InVEST to assess the levels and types of marine ES provided in specific locations, including food from fisheries and aquaculture, coastal protection, tourism and recreation, and energy from waves and wind. InVEST helps identify possible conflicts and compatibilities among existing uses and ES delivery. This step enables the creation of zoning categories, which is helpful for Step 6.

6: Develop future scenarios

What are the possible future marine use plans?

Re-engage with local partners to collect input for scenario building. Generate scenarios that depict possible futures for the area, based on alternative plans, zoning arrangements being considered for policy, and possible climate change.

7: Assess future scenarios

What are the potential impacts of different planning scenarios on biodiversity and ES?

Determine the tradeoffs under different future scenarios (heuristic scenarios can also be used for illustrative purposes). InVEST does not generate scenarios, but when provided with spatially-explicit scenarios such as those generated by InSEAM[4], it can compare the resulting supply and delivery of ecosystem services throughout the area. This produces a "tradeoff map" for various sectors and ecosystem services. See the InVEST Scenario Guide[5] for more information.

8: Develop spatial management plan

What are the impacts of possible management measures?

Assess the effectiveness of management measures, such as marine protected areas, fishing regulations, and multi-use marine zones. Evaluate how these measures will meet objectives, and select the preferred plan. InVEST can assess how ES are likely to be affected by alternative plans or zoning arrangements, and clarify the tradeoffs among choices.

9: Identify sustainable finance

What are the potential sources of finance for marine management?

Explore potential financing instruments, including payments for ecosystem services, user-fees or taxes and subsidies. InVEST can assess where ES are delivered and determine the location of stakeholders who benefit and therefore might have an interest in financing elements of marine management. Supplement InVEST outputs with additional social, economic and demographic information and direct discussions with potential financiers to determine whether they are willing and able to providing funding.

10: Implementation

Implement new management measures, enforcements and regulations. InVEST provides information on where, and for whom, enforcement actions may be needed.

11: Monitoring and Evaluation

Is the plan successfully meeting objectives?

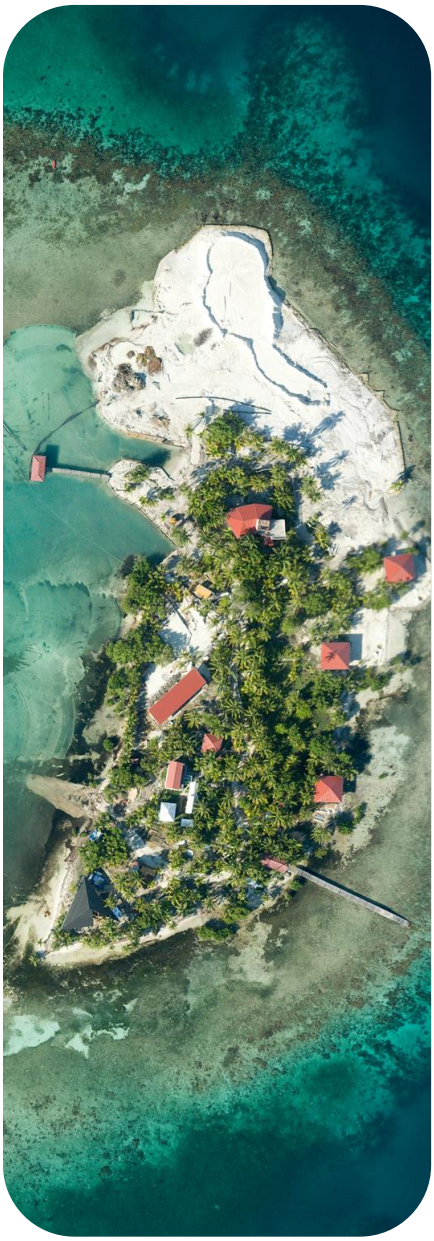
InVEST is not a real-time monitoring device, and is not a substitute for field measures of actual delivery towards objectives. However, InVEST can help determine where to place monitoring stations, thereby improving the efficiency of the monitoring design. Outputs from InVEST models can also be used to monitor supporting services (e.g., the contribution of nursery habitat and forage fish to the catch of target fish species) that cannot be measured directly in the field.

12: Adaptive Management

How can marine spatial plans be adapted to improve performance?

As marine spatial plans are monitored and evaluated, adapt the plan to fit changing economic and environmental conditions. Just as in Steps 6 and 7, InVEST can be used to evaluate alternative scenarios for adaptive management.

Key Issues for Coastal and Marine Spatial Planning



Applicable ecosystem services

Currently, InVEST can model food from fisheries and aquaculture, the provisioning of recreational and tourism opportunities, aesthetic views, protection from coastal hazards, and renewable energy (waves and wind). (A model for carbon storage and sequestration in coastal habitats is near completion; check NatCap's website for updates). In addition, models for marine water quality and habitat risk assessment can assess the impact of human activities on coastal and water-column habitats, and an overlap tool enables analysis of multiple human activities occurring simultaneously.

Relative vs. absolute values

Without calibration, InVEST is most useful for identifying how the production of ecosystem services will change relative to current conditions, given specifications of where marine uses and activities will take place. However, if InVEST models are calibrated and there is good correlation between modeled results and observations, InVEST also can be used to estimate absolute values of changes in ecosystem services.

Geographic scale

InVEST has been applied to decisions made at the global, national, provincial, district, basin, and sub-basin levels. The most appropriate spatial scale for InVEST models depends on the ecosystem services modeled, the resolution of the available data, and the decision context. In general, hydrological models are best interpreted at the sub-watershed level (>1km^2), since the processes they represent are better understood at that scale, rather than at the pixel level. Results from other non-hydrological models (e.g., carbon, pollination, habitat quality) or from RIOS may be adequately interpreted at the pixel level, keeping in mind that the quality and resolution of input data relative to the size of the area of interest will still impact these results.

Alternative measures for InVEST outputs

InVEST can quantify ecosystem services in biophysical terms (e.g. number of fish), which can be useful for targeting marine zones across seascapes, for example. It can also estimate economic values in monetary currency, using a range of techniques such as avoided damage or treatment costs and market valuation. Valuation can only be done once the biophysical parts of the models are calibrated to time series data. Given the simplifications in the biophysical and economic models, economic value estimates should be treated as first estimates only, for example, for gaining support for marine spatial plans.

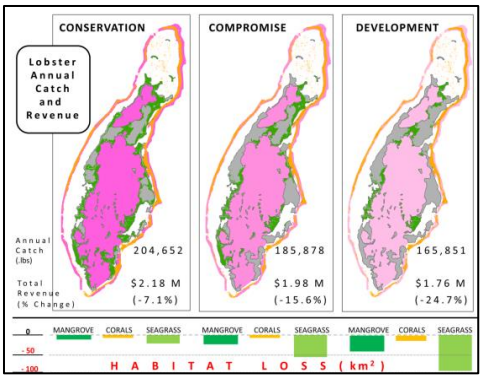
Time and resources required

The scope of the project and availability of data affect the amount of time and capacity required to apply InVEST. On the lower end, it will take 1-3 people two months to a year to compile data and run the InVEST models. In our experience, the parts of the process requiring the most time include data collection, scenario development and iteration (re-running the models with better data, for refined decision-making). A full application of InVEST results within the context of marine spatial planning will take longer, and require a team-member with intermediate GIS proficiency. For more detail on data requirements, see the InVEST User's Guide.

InVEST in Practice: Example Applications

Coastal Belize

InVEST tools have informed decisions in multiple coastal and marine contexts.[6] Recently, InVEST informed a national integrated coastal zone management plan for Belize, which designates marine and coastal areas for preservation, restoration, development, and other uses.[7] Scenarios were used to help design the plan, depicting ES outcomes under planning options at the local level (e.g. scenarios shown on Turneffe Atoll, right). InVEST models used to assess ES change included the habitat risk assessment, coastal protection, recreation, and spiny lobster models. The process enabled decision makers to consider tradeoffs among different sectors, and demonstrated the importance of stakeholder engagement in scenario development and CMSP.



Further Resources

The Natural Capital Project
naturalcapitalproject.org

InVEST User's Guide
naturalcapitalproject.org/InVEST.html

InVEST download
naturalcapitalproject.org/download.html

InVEST Toolbox
naturalcapitalproject.org/toolbox.html

InVEST and Scenarios
naturalcapitalproject.org/decisions/scenarios.html

Belize CZMP web portal:
geointerest.frih.org/NatCap

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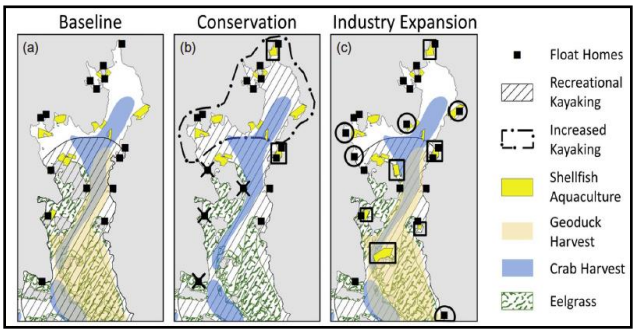
West Coast of Vancouver Island (WCVI), BC

The Natural Capital Project worked with The West Coast Aquatic Management Board (WCA) in a four-year marine spatial planning process on WCVI. These activities helped the WCA balance industrial and commercial interests (e.g. shipping, aquaculture, tourism development) with stakeholder interest in maintaining recreation areas and access to seafood, developing renewable energy, and preserving the aesthetic and cultural values provided by the natural environment. InVEST analyses assessed how alternative spatial plans might affect a range of ES and helped identify and avoid or minimize potentially conflicting uses. The three alternative management scenarios developed by WCA are depicted below:



[1] UNESCO. (2009). Marine Spatial Planning at: www.unesco-ioc marinesp.be/marine_spatial_planning_msp

[2] Ruckelshaus, M., Klinger, T., Knowlton, N., & DeMaster, D. P. (2008). Marine ecosystem-based management in practice: Scientific and governance challenges. *BioScience, 58*(1), 53 – 63.

[3] Leslie, H.M., & McLeod, K.L. (2007). Confronting the challenges of implementing marine ecosystem-based management. *Frontiers in Ecology and Environment, 5*(10), 540 – 548.

[4] InSEAM is an online interactive mapping tool.

[5] McKenzie, E., A. Rosenthal et al. (2012). Developing scenarios to assess ecosystem service tradeoffs: Guidance and case studies for InVEST users. World Wildlife Fund, Washington, D.C.

[6] Ruckelshaus, M., McKenzie, E., Tallis, H., Guerry, A., Daily, G., Kareiva, P., Polasky, S., Ricketts, T., Bhagabati, N., Wood, S. A., Bernhardt, J. (2013). Notes from the field: Lessons learned from using ecosystem service approaches to inform real-world decisions. *Ecological Economics*, Available online 23 August 2013

[7] The plan is currently under review and is set to be voted on in Fall 2013. Clarke, C., M. Canto, S. Rosado. (2013). Belize Integrated Coastal Zone Management Plan. Coastal Zone Management Authority and Institute (CZMAI), Belize City. Accessed via http://www.coastalzonebelize.org/?page_id=681, August 2013

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