Strategic Environmental Assessments with InVEST

Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) can help design strategic environmental assessments (SEAs) that guide selection among policy and program alternatives. InVEST models support analysis of a suite of key ecosystem services (ES), illustrate tradeoffs among alternative options, and enable policy makers and planners to meet multiple ES goals.

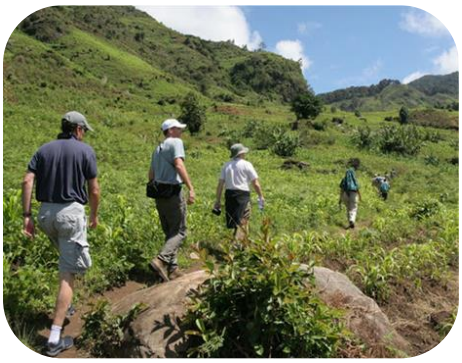
SEAs are applied to a broad range of policy and planning contexts and can incorporate a variety of analytical methods. Given the diversity of their application, SEAs will benefit from InVEST analysis to varying degrees. InVEST can support initial SEA screening and facilitate comparison of alternative project scenarios and potential mitigation measures. Spatially explicit, quantified InVEST outputs enable planners to efficiently account for both development and conservation priorities. Outlined below are InVEST's key contributions to SEAs:

Planning step	How InVEST can help
1. Screen whether SEA is needed	Identify likely ES impacts of policy or plan
2. Scope political and planning contexts	*N/A*
3. Assess baseline	Assess current ES status and/or trends without new plans or policy
4. Identify alternatives	Compare no-action scenario with proposed plans and feasible alternatives
5. Identify impacts of alternatives	Assess ES impacts of alternatives
6. Assess mitigation measures	Determine where and how to mitigate impacts on ES, and where full mitigation is not possible
7. Prepare report and consultation	Provide data and visual aids for discussion, and inform iterative policy and plan development

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. The guidance should be considered in context of local social, environmental, and institutional conditions where InVEST is used.



SEAs involve systematic processes to integrate environmental considerations and analysis of environmental impacts into policies, development plans, and programs.[1] Public authorities, such as governments and development banks, usually conduct SEAs. They are generally broader in scope than Environmental Impact Assessments (EIAs), which explore mitigation of project-level impacts.[2] SEAs often assess large-scale and cumulative effects, including those from multiple smaller projects, and consider a range of environmental consequences as well as tradeoffs among economic and social considerations[3]. Sectors that commonly conduct SEAs to inform decisions include spatial and land-use planning, water, waste, transport, and energy.[4]

1: Screen whether SEA is needed

Is the policy, plan or program likely to have significant environmental consequences?

Determine whether an SEA is required. This typically involves consulting pre-determined criteria from legislation, as well as expert judgment from designated authorities. In most cases, where data are not easily available or screening criteria are in place, an InVEST analysis is likely to be more time-intensive than is efficient for the screening stage. However, if the screening process results in ambiguous or conflicting recommendations, a low-resolution InVEST analysis could be useful to predict – albeit with some uncertainty – the scale and location of potential ecosystem service impacts. This process helps determine whether a full SEA is warranted and it can raise public awareness of the need for further assessment.

2: Scope political and planning contexts

What are the objectives, constraints and opportunities for the SEA?

Assess the relevant context for the SEA, including the relationship to other policies, programs, and plans. Identify objectives and key ecosystem indicators, and specify constraints and opportunities the SEA will face. In data-poor contexts, an InVEST analysis is likely to require more time and resources, than is efficient for the scoping stage. Other activities, such as policy analysis, may be more relevant here.

3: Assess baseline

Where are ES supplied on the landscape, and how will they be supplied in the future without the policy or plan?

Document the current state of ES. In many cases, the SEA will attempt to identify how ES will change if the new policy or plan is *not* implemented. This provides a baseline "Business-as-Usual" (BAU) scenario for comparing ES delivery against potential alternatives. InVEST can help assess the provision of ES on the current landscape, and estimate its change under expected future land use. Land-use change modelers can help here.

4: Identify alternatives

How will ES change under alternative planning options?

Identify feasible alternatives for the proposed policy, plan or program. These typically include a BAU option (see Step 3), the recommended option (if one exists) and a number of feasible alternatives. Alternatives are often developed with stakeholders to carefully consider the objectives, context and scope of the proposed plan. InVEST can be combined with optimization tools, such as Marxan, to identify planning arrangements for meeting ecosystem service supply goals. The InVEST Scenario Guide[5] and scenario development tools like InSEAM[6] can be useful in identifying feasible alternatives.

5: Identify ES impacts of alternatives

What are the relative ES impacts of alternative options?

Measure the likely environmental impacts of the alternatives specified in Step 4. This process typically involves a variety of modeling and analytical approaches. InVEST can quantify the ES impacts of alternatives in biophysical terms, such as tons of carbon sequestered, and in economic value in dollar terms, using a variety of economic valuation techniques. InVEST can also use the Serviceshed Mapper[7] to assess which populations will be affected by ES change.

6: Assess mitigation measures

How can the remaining adverse effects of the policy, plan or program be mitigated?

Outline measures to avoid, reduce or offset harmful impacts. Mitigation options include changing the original plan, establishing protected areas, compensating stakeholders, or offsetting particular ES impacts through mitigation banking schemes. Estimates of change to particular ES (see Step 5) generated with InVEST can help determine the type and placement of offsets and mitigation activities.

7: Report preparation and consultation

How can results be communicated to stakeholders?

Include results and conclusions in a written report, with a summary for public consultation with stakeholders. InVEST does not generate reports, but it can provide data and spatially-explicit data, such as scenarios, ecosystem service maps and balance sheets. The SEA report is typically disseminated to inform and consult with relevant authorities and the public. As responses are received, the SEA report is taken into account in existing and future policies, programs, and plans.

Key Issues for Strategic Environmental Assessments

Policies vs. plans and programs

It may be easier to use InVEST for SEAs of plans and programs than for high-level policies. Plans and programs are usually specific and spatially defined, and therefore more directly linked to land-use changes. Conducting an InVEST analysis of a policy may be difficult if it is hard to determine specific impacts on land use. SEAs at the policy level often involve following environmental checklists or seeking expert opinion, rather than conducting detailed impact assessment.

Applicable ecosystem services

InVEST can model a range of services that are relevant to SEA: sediment retention/erosion control, carbon storage and sequestration, forage products (including NTFPs), crop pollination, water purification, habitat quality, water yield, and timber production. InVEST also has a simple biodiversity module that estimates habitat integrity and rarity as a proxy for biodiversity. In the future, InVEST will also include models for flood control, irrigation water for agriculture, and agricultural production. A monthly water yield model, which includes consideration of groundwater, is also under development. Other tools are likely to be needed in order to assess water supply-related services when groundwater is a significant component of yield, or when ES impacts will greatly affect groundwater or the ground/surface water balance.

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.

Relative vs. absolute values

Without calibration to on-the-ground data, InVEST is most useful for identifying the relative supply of ecosystem services across the landscape, which can help identify where to focus policies, plans, programs or mitigation measures. If InVEST models are calibrated and there is good correlation between modeled results and observations, InVEST can estimate absolute values of services, which may be useful for comparing across social, economic and environmental impacts. InVEST's non-hydrological models (e.g. carbon, habitat quality, NTFPs) typically do not require calibration.

Alternative measures for InVEST outputs

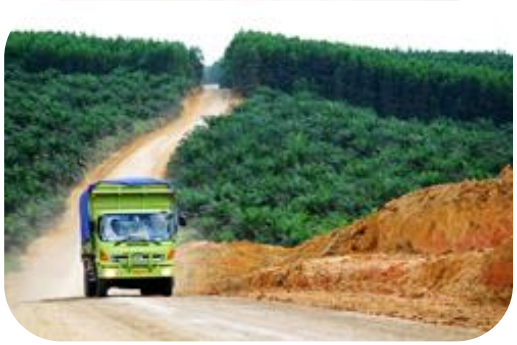
InVEST can quantify ecosystem services in biophysical terms (e.g. tons of carbon sequestered), which can be useful for targeting decisions across landscapes. It can also estimate economic values, in dollar terms, using a range of techniques such as avoided damage or treatment costs and market valuation. For hydrologic services, valuation can only be completed once the biophysical parts of the models are calibrated to time series data. Future versions of InVEST will allow users to consider additional dimensions of human well-being, such as health and livelihood outcomes.

Time and resources required

On the lower end, it will take 1-3 people two months to a year to compile data and run InVEST; the scope of the project, models used and availability of data will affect the amount of time required. For example, the team may use global datasets for initial estimates of ES values, or work with partners to compile detailed local data (which can be time consuming). In our experience, data collection, scenario development and iteration (re-running the models with better data) tend to take the most time. The team's existing familiarity with InVEST will also be relevant here, since experienced InVEST users may be able to complete analyses more quickly. In the context of SEAs, the team will require someone with intermediate GIS proficiency. For more information, see the InVEST User's Guide.

InVEST in Practice: Example Applications

Balanced development planning: Sumatra



In 2010 InVEST supported district and provincial policy makers in conducting ecosystem-based spatial planning to balance development and conservation goals in central Sumatra, Indonesia. Planners applied InVEST models to assess the quantity and location of high quality habitat, carbon storage, annual water yield, erosion control, and water purification under contrasting land-use scenarios. Results were used to inform the siting of land concessions for economic activities such as oil palm and pulp production, and for prioritizing conservation activities such as forest restoration, forest carbon payments and forestry best management practices. These activities helped inform 3 SEAs in the region; Jambi Province has also used InVEST analyses and data in the Strategic Environmental Assessment required when developing its provincial spatial plan.[8] www.naturalcapitalproject.org/where/sumatra.html

Informing SEA Activities: Virungas National Park

A coarse InVEST analysis was undertaken with communities of the Greater Virungas Landscape to measure the quantity and flow of ES under business as usual, market and green scenarios, and to inform policy makers of potential ecosystem impacts of development.[9] The study revealed major ES derived from this biodiverse landscape, including timber and non-timber forest products, water supply and regulation, sediment retention, carbon storage, and tourism.
www.naturalcapitalproject.org/where/tanzania .html

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

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We are grateful for comments from Sabine Bergman.

[1] DAC Guidelines and Reference Series. (2006). *Applying strategic environmental assessment: Good practice guidance for development co-operation*. OECD.

[2] Abaza, H., Bisset, R., Sadler, B. (2004). Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated Approach. The United Nations Environment Programme. Accessed via www.unep.ch/etu/publications/textONUbr.pdf, August 2013.

[3] Ibid.

[4] Sadler, B. (2000). *A framework approach to strategic environmental assessment: Aims, principles, and elements of good practice*. Paper at the International Workshop on Public Participation and Health Aspects in Strategic Environmental Assessment, Szentendre, Hungary.

[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] InSEAM is an online interactive mapping tool. The current version is a prototype in internal testing, with a public release planned for 2014.

[7] See NatCap's serviceshed website. The Serviceshed Mapper is in development, although RIOS maps servicesheds for watershed-only services.

[8] 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

[9] ARCOS, WWF and the University of Cambridge. 2011. Capturing the benefits of ecosystem services to guide decision-making in the Greater Virunga's Landscape of the Albertine Rift Region. Report to the John D. and Catherine T. MacArthur Foundation.

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