



# InVEST Scenarios Case Study: Borneo, Indonesia

Andy Dean, Thomas Barano, Nirmal Bhagabati, Emily McKenzie,  
Anna Van Paddenburg, Amy Rosenthal, Agus Salim





excerpted from

## Developing Scenarios to Assess Ecosystem Service Tradeoffs

---

This case study highlights a real-world example of using InVEST scenarios to inform decisions about land use. In this example, scenarios were developed, ecosystem service impacts were assessed, and the results were used to make sound policy decisions. The case study offers background on the policy context and goals, and then delves deeply into the experience with scenarios and draws out lessons.

### Background

The tropical rain forest of Borneo is one of the most important and biologically diverse ecosystems on Earth, providing natural habitats for a diverse range of species, and containing forests, rivers and watersheds that supply ecosystem services to millions of people. These resources are at risk due to rapid economic development, including unsustainable practices for mining and timber extraction, and land conversion for palm oil, pulp and paper plantations, and agriculture. Recognizing the importance of this region as a life-support system for climate, biodiversity, food and water security, and peoples' livelihoods, the governments of Indonesia, Malaysia and Brunei Darussalam jointly committed in 2007 to sustainably manage central Borneo's forest ecosystems. WWF supported the three governments in a transboundary "Heart of Borneo" initiative to develop a green economy, where governments, business and communities value ecosystem services, stop conversion of natural forests, reduce greenhouse gas emissions and generate equitable livelihoods. This initiative is supported by ecosystem-based spatial planning, and linked to fiscal policy and diversified and equitable incentives that reward local communities, business and governments for conservation and sustainable practices.

The three governments are implementing national action plans to make these commitments a reality. However, implementation is proving challenging. Current economic plans are not aligned with the goals for the Heart of Borneo, and do not integrate conservation or sustainable land management at the scale required. Revenues from economic sectors such as mining and palm oil are far greater than revenues from standing forests; the opportunity costs of conservation are significant, with few local incentives to implement the commitments made at the national level. Policy and finance mechanisms that reward provision of ecosystem services—such as carbon sequestration, reduced carbon emissions and payments for watershed protection—are emerging, but not yet at sufficient scale. A shift in the economy to ensure equitable growth, reduce poverty, and support environmental sustainability is critical.

WWF and its partners carried out a climate, ecosystem and economic assessment using InVEST and other software and modeling tools to highlight the role of the Heart of Borneo in a green economy (Van Paddenburg et al. 2012).

### What policy questions did the InVEST analysis set out to address?

The two main goals for using InVEST were (1) to demonstrate how investing in natural capital supports sustainable economic growth and a prosperous society, and (2) to identify where sustainable finance mechanisms for ecosystem services may be feasible. To achieve these goals, InVEST was used to map several ecosystem services, assessing service values where possible, and identifying where services originated and were used.

### What scenarios were selected?

The team developed two scenarios for Kalimantan (the Indonesian area of the island of Borneo) that represent business as usual and a green economy:

- **Business as usual (BAU):** This scenario represents the next 20 years, assuming development follows its current trajectory, with weak governance and no financial incentives for sustainable development.
- **Green Economy (GE):** This scenario represents the next 20 years, assuming implementation of a spatial plan proposed to establish the Heart of Borneo as a Strategic National Area (KSN),<sup>1</sup> reform of tax laws, improved policies and legislation, strong law enforcement, adoption of environmental standards, and performance-based incentives. A green economy is defined as one that recognizes the value of natural capital, reflected in local actions.

### How were scenarios developed?

The scenarios were developed using a combination of a spatially explicit land-use and cover change (LUCC) model and information on land-use plans and permits. This approach aimed to combine information on historical trends in land-cover change with available spatial planning data.

IDRISI Land Change Modeler (LCM)—an integrated software application for land change analysis and prediction (Clark Labs, 2011)—was used to predict land cover based on past change observed between 2000 and 2009. Predictive modeling of future scenarios based on historical data was deemed to be appropriate for Kalimantan because significant land-cover change is occurring that does not adhere to the zones designated in government spatial plans. This scenario approach contrasts with the approach used in the Sumatra case study, where the scenarios reflected the spatial plans developed by government and a coalition of NGOs, without considering how drivers of land use might create futures that differ from those plans. However, because of the complexity of land-cover change in Kalimantan, IDRISI LCM was limited to modeling change in natural forest.

For the business-as-usual scenario, the team ran IDRISI LCM, predicting future forest cover based on historical drivers of land-cover change between 2000 and 2009. Additional drivers included existing roads, fire distribution, slope, elevation, and settlement. Some constraints were introduced that reflect the possibility of specific land uses (see Table 1, p. 3). Spatial data on plans for mining, palm oil, and forestry were also integrated.

---

<sup>1</sup> KSN refers to regulation, under presidential decree, to protect the Heart of Borneo Strategic National Area for its natural capital value. A spatial plan is in development to guide conservation and development efforts in this area.

**TABLE 1 Rules for business-as-usual scenario in Borneo**

| Scenario Rules   | Datasets                             |
|--|--------------------------------------|
| <p><b>Spatial Development Plans</b><br/>No enforcement or reconciliation of spatial development plans</p> <p>Forest status is enforced, since it is one aspect of spatial development plans that is unlikely to change</p> | Forest status                        |
| <p><b>Forestry</b><br/>Inactive forestry concessions result in forest degraded due to lack of forest management</p>  | Forest concession status, land cover |
| <p><b>Agriculture</b><br/>Oil-palm expansion proceeds where permits have been granted, including forested areas. Palm oil will not expand in some areas, e.g., active mining concessions, urban areas</p>                  | Palm oil permits, land cover         |
| <p><b>Mining</b><br/>Mining expansion will take place within concession areas</p> <p>Mining causes natural forest degradation within the concession</p>  | Mining concessions                   |

The green economy scenario also reflected predicted change based on historical change in land cover between 2000 and 2009, but there were additional constraints (see Table 2, p. 4). The rules increased protection of areas with high biodiversity, carbon stocks, and watersheds. This assumed that under the green economy scenario there would be improved governance, adherence to spatial plans and implementation of sustainable finance mechanisms.

The rules were selected to reflect important drivers of land-cover change. They were developed by a small technical team, based in part on storylines and drivers identified by government and NGO representatives during initial scenario development exercises at a stakeholder workshop. Table 1 and Table 2 show the main rules, focusing predominantly on how specific types of concessions would expand or be implemented. For example, under the green economy scenario, palm oil would expand on degraded land only, not on peat soils or natural forest. In contrast, for the business-as-usual scenario, palm oil concessions would expand into all areas where concessions had been issued, regardless of land-cover type. Implementing the rules required data on existing and planned concessions.

### How were scenarios translated into land-cover maps?

The IDRISI LCM is a spatial tool, so the results from LCM were easily integrated with other spatial data in a Geographic Information System to create the final scenarios. No additional analysis—beyond what is described in the section above—was required to turn scenario storylines into maps.

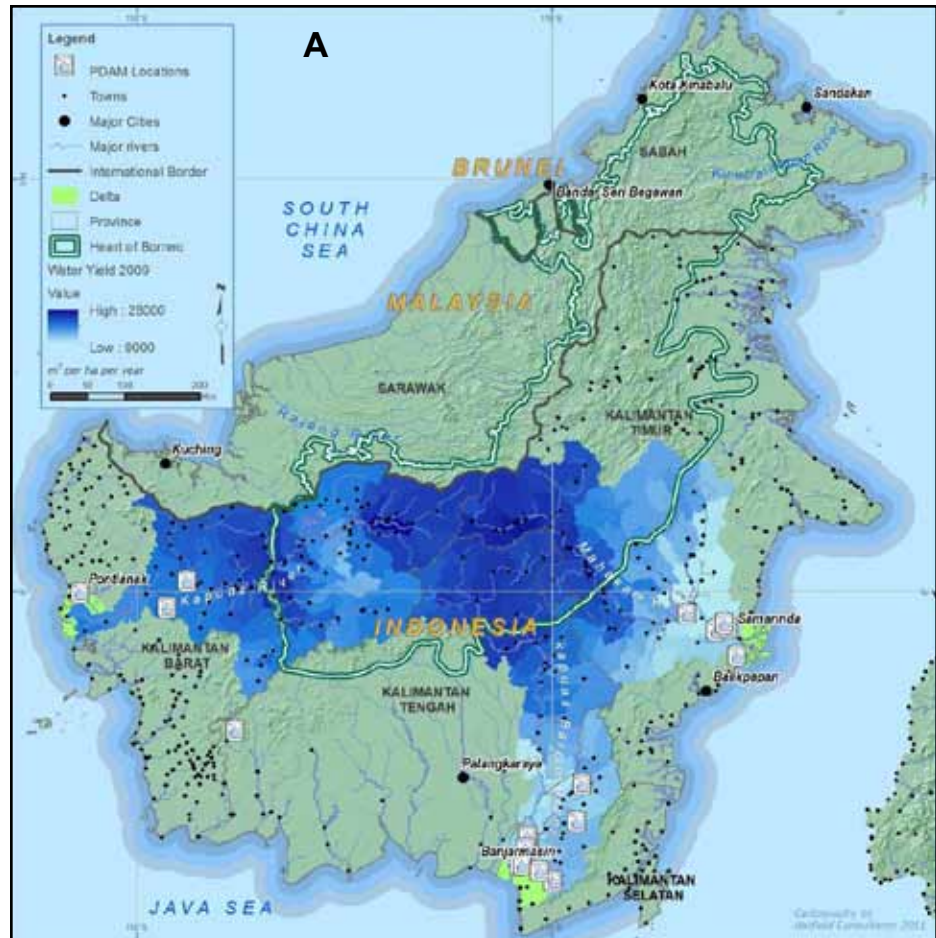
**TABLE 2 Rules for green economy scenario in Borneo**

| Scenario Rules  | Datasets                                      |
|---|---|
| <p><b>Spatial Plans</b><br/>Forest status is enforced, as one aspect of spatial development plans that is unlikely to change; standing primary and secondary forest is maintained</p>   | Forest status, land cover                     |
| <p><b>Forestry: Logging</b><br/>Concession management is improved, and there is no degradation of inactive concessions; restoration concessions are implemented</p>   | Forest concession status, land cover          |
| <p><b>Forestry: Plantations</b><br/>Plantations do not replace HCV forests, and are instead cultivated on available degraded idle land (i.e., where concession is not active, land not in use)</p>  | Land cover—RCAs, degraded idle lands          |
| <p><b>Agriculture: Palm Oil</b><br/>Palm oil development priority on degraded idle lands or Responsible Cultivation Areas (RCA)<br/><br/>Palm oil concessions do not proceed in areas with natural forest, even if the land is allocated for development<br/><br/>Palm oil development avoids carbon-rich peat lands and swamp forest, protection forest, national park</p> | Palm oil permits, land cover, RCA, peat soils |
| <p><b>Mining</b><br/>Mining expansion will take place within concession areas<br/><br/>Progressive restoration for large projects/ companies and mining has no long-term impacts</p>  | Mining concessions, land cover                |

**How did the scenarios shape the final results for policy makers?**

These two scenarios enabled policy makers to see the impacts on ecosystem services of two contrasting futures: business as usual and a green economy. This provided a more informed basis for policy discussions, investments and commitments to make the vision of a green future a reality. In particular, it is helping to direct investments by national government and multilateral and bilateral donors and put multiple policies and local incentives into practice.

**FIGURE 1** Water yield in 2009 and under business-as-usual and green economy scenarios in Borneo (cont. on pp. 6–7)



The distribution of water yield by watershed in the Heart of Borneo in 2009 (A).

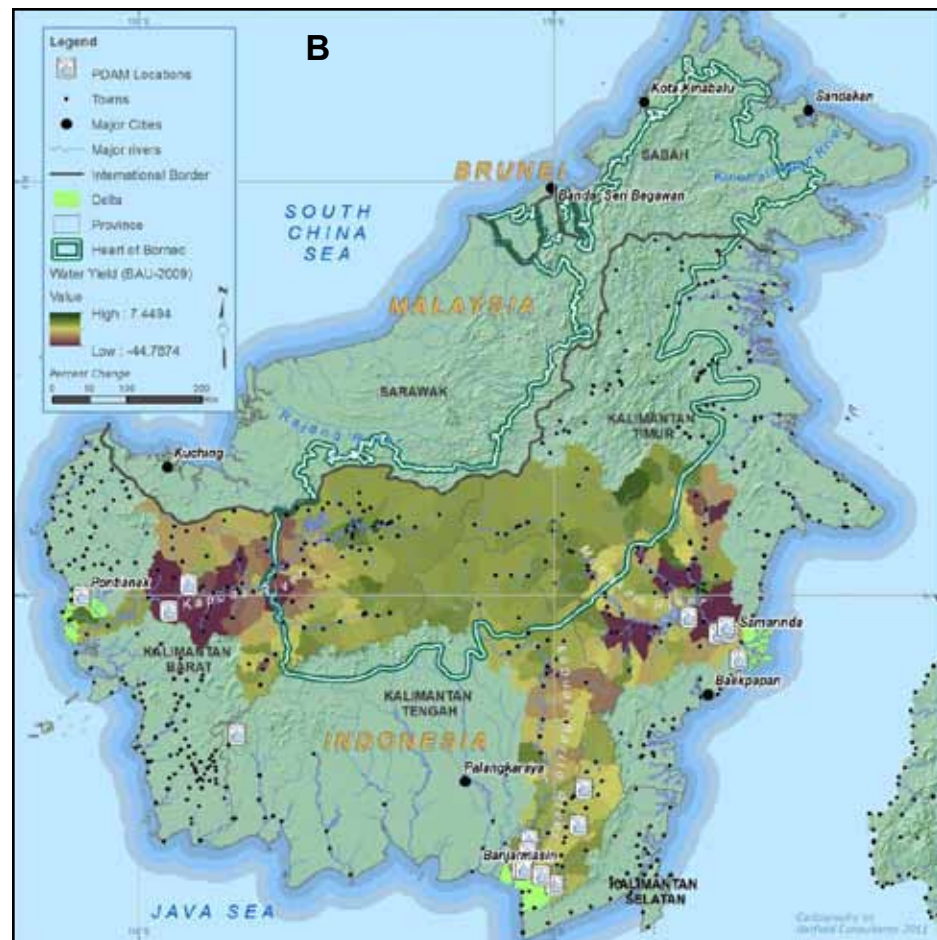
### Key assumptions

- Historical drivers and patterns of natural forest cover change provide a good way to predict future change.
- Land-use change from palm oil, forestry and mining is better predicted based on issued licenses rather than spatial modeling.
- Forest protection and better enforcement of land use can be delivered in a green economy scenario.

### Strength

- A hybrid approach was taken, combining predictive modeling (using IDRISI LCM) with rules and storylines based on stakeholder input and existing concessions and spatial plans. This combination enabled the scenarios to reflect both planned and unplanned developments.

FIG. 1, cont.

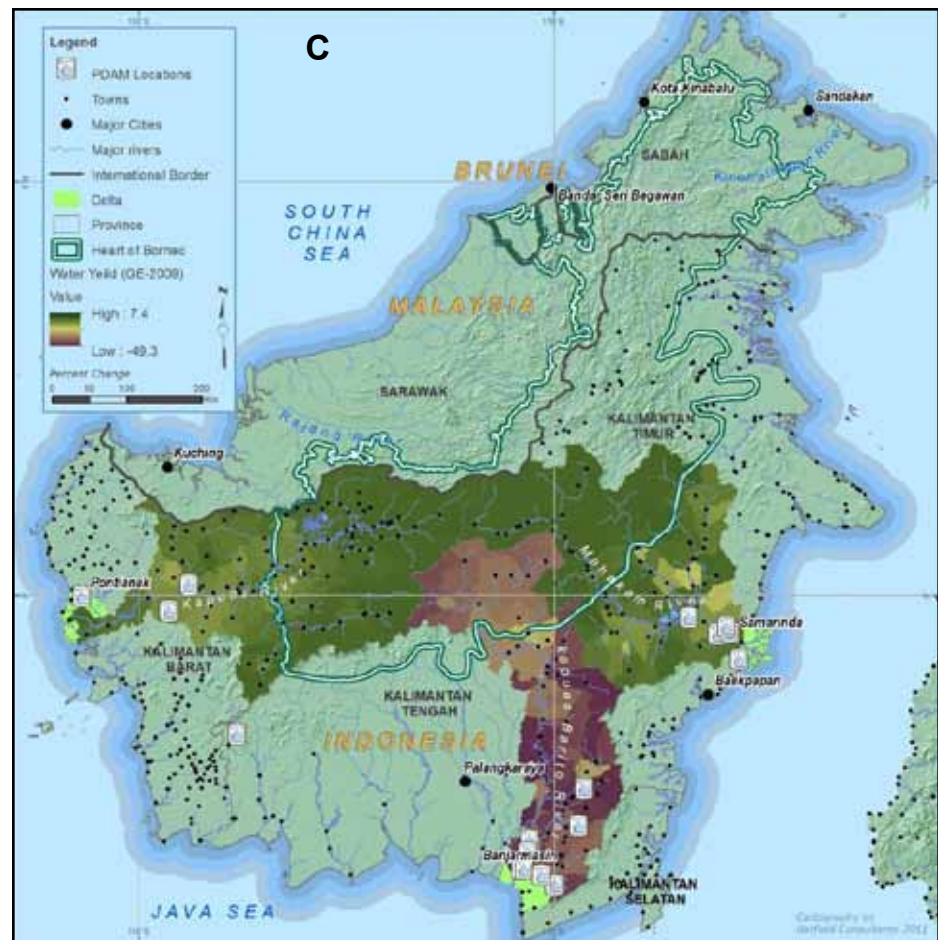


The change in water yield relative to 2009 under the business-as-usual scenarios (B).

### Challenges and areas for future improvement

- The team found using IDRISI LCM with many different land-cover classes led to a complicated analysis, with many different land-cover transitions. This led the team to focus only on transitions between primary and secondary forest, including degradation of primary forests to secondary forest. With more time, the team would also like to predict transitions between additional land-cover types, such as secondary and non-forest.
- In Kalimantan most of the suitable lowland forest areas have been converted. Therefore, the difference between scenarios may not appear to be dramatic at this scale. However, at a more local scale there are important areas of natural forest that are protected under a green economy scenario. InVEST analysis showed how these areas can result in significant differences in ecosystem service provision.

FIG. 1, cont.



The change in water yield relative to 2009 under the green economy scenario (C). From WWF et al. (In Press).

- Inconsistent input data caused problems for spatial modeling. For example, impossible transitions between land-cover classes occurred, such as secondary returning to primary forest within 9 years. This was resolved by checking the consistency of past and current land-cover data used in the scenario analysis.
- The team found that IDRISI LCM works best with few land-cover datasets whereas InVEST gives more nuanced results with a rich set of land-cover categories and the capability to iteratively model and compare land-cover changes. The combination of LCM analysis and spatial plan data provided good inputs for InVEST.
- It proved difficult to efficiently model in LCM or InVEST how incentives could alter behavior. The team attempted to do this with the Threshold 21 economic model (Bassi and Baer 2009).



## SNAPSHOT | Borneo

### POLICY CONTEXT

#### Policy level

Local (district and province), national and regional (tri-national)

#### Policy questions

- advocate green economy
- recommend where performance-based incentives could be implemented

#### Ecosystem services included

Carbon storage and sequestration, biodiversity, sediment retention, nutrient retention; intend to include nontimber forest products

### SCENARIO PRODUCT AND PROCESS

#### Scenario format

Maps produced by IDRISI LCM, with additional spatial rules and constraints applied

#### Number of scenarios

2

#### Time frame for scenarios

2020 for both scenarios

#### Time frame for ES assessments

Assessment was based on extrapolating scenarios for next 20 years

#### Spatial extent of scenarios

Kalimantan (Indonesian area of Borneo)

#### Spatial extent of policy recommendations

Local, national and tri-national

#### Stakeholder participation in scenarios

Medium

#### Consideration of exogenous drivers

Medium

#### Consideration of endogenous drivers

High

#### Capacity and time required

High

### Case Study References

Clark Labs. 2009. "The Land Change Modeler for Ecological Sustainability." In *IDRISI Focus Paper*. Worcester, MA: Clark Labs.

Bassi, A.M., A. E. Baer. 2009. "Quantifying Cross-Sectoral Impacts of Investments in Climate Change Mitigation in Ecuador." *Energy for Sustainable Development*: 13: 116–123, doi:10.1016/j.esd.2009.05.003

Van Paddenburg, A., A. Bassi, E. Buter, and A. Dean. 2012. *Heart of Borneo: Investing in nature for a green economy*. Jakarta: WWF.



THIS CASE STUDY WAS DEVELOPED THROUGH THE NATURAL CAPITAL PROJECT, WHICH IS A PARTNERSHIP AMONG



INSTITUTE ON THE ENVIRONMENT  
UNIVERSITY OF MINNESOTA  
Driven to Discover™



**Developing Scenarios to Assess Ecosystem Service Tradeoffs: Guidance and Case Studies for InVEST Users** is a resource for practitioners who want to assess the provision of ecosystem services under alternative future scenarios. The guide draws on case experiences where InVEST was used to compare ecosystem service tradeoffs under different scenarios. It can help InVEST users choose appropriate types of scenarios and methods, engage stakeholders, and create scenario maps. The guide highlights key issues and questions for reflection, along with tools, case studies, references and resources for those who want to learn more.

InVEST is a suite of ecosystem service models, developed by the Natural Capital Project, for mapping, quantifying and valuing ecosystem services under different scenarios. InVEST helps decision makers incorporate ecosystem services into policy and planning at different scales in terrestrial, freshwater and marine environments.

Further materials are available on the scenarios page at [naturalcapitalproject.org](http://naturalcapitalproject.org)