

## **InVEST: A Tool for Integrating Ecosystem Services into Policy and Decision-Making**

The integration of ecosystem services into decisions relies on access to good scientific information showing where ecosystem services are provided and how they will be affected by alternative plans and policies. InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) is a suite of ecosystem service models developed by the Natural Capital Project to provide such information. InVEST is designed to help local, regional and national decision-makers incorporate ecosystem services into a range of policy and planning contexts for terrestrial, freshwater and marine ecosystems, including spatial planning, strategic environmental assessments and environmental impact assessments.

InVEST models are based on production functions that define how an ecosystem's structure and function affect the flows and values of ecosystem services. The models account for both service supply (e.g. living habitats as buffers for storm waves) and the location and activities of people who benefit from services (e.g. location of people and infrastructure potentially affected by coastal storms). Since data are often scarce, the first version of InVEST offers relatively simple models with few input requirements. These models are best suited for identifying patterns in the provision and value of ecosystem services. With validation, these models can also provide useful estimates of the magnitude and value of services provided. The Natural Capital Project is also developing more complex, data intensive models for informing policies that require more certainty and specificity in results.

In terrestrial and freshwater ecosystems, InVEST models habitat quality (terrestrial only) and the benefits of: carbon sequestration; annual water yield for hydropower, water purification (for nutrients); erosion control (for reservoir maintenance), crop pollination; timber production, and non-timber forest product harvest. In coastal and marine systems, InVEST models the benefits of food from fisheries, food from aquaculture, coastal protection, wave energy conversion, the provisioning of aesthetic views and recreation. InVEST is spatially explicit, allowing the production of maps indicating where ecosystem services are provided and where they are consumed. It can provide biophysical results (e.g. meters of shoreline retained) and economic values (e.g. avoided cost of damage to property). A relative index of habitat quality is also provided, but biodiversity is not given an economic value directly.

The process of using InVEST begins by identifying critical management choices being considered by stakeholders. From these, alternative scenarios can then be developed to explore how the current delivery of services is likely to change under alternative decisions or conditions such as climate change. InVEST models how these alternative futures influence ecosystem processes, and how such changes affect biodiversity and the flows and values of ecosystem services. Model outputs can inform:

- **Spatial planning** by assessing the current and potential status of ecosystem services under alternative, spatially-explicit future scenarios.
- **SEA and EIA** by identifying how policies, plans and programs can affect multiple ecosystem services and guiding selection of the best alternatives.
- **Payments for ecosystem services (PES)** by identifying how payments can affect multiple goals, where to distribute payments or establish programs, and how to improve investment efficiency.
- **Permitting and mitigation** by assessing impacts of proposed activities and providing guidance for where mitigation activities will provide the greatest ecosystem service benefits.
- **Climate adaptation strategies** by showing how future changes in climate patterns will influence the delivery of services that affect human well-being.

*The Natural Capital Project is a joint initiative of the University of Minnesota, The Nature Conservancy, Stanford University and World Wildlife Fund. InVEST is freely downloadable at: <http://invest.ecoinformatics.org/>. Background information on InVEST and the Natural Capital Project is available at [www.naturalcapitalproject.org](http://www.naturalcapitalproject.org)*

## Applying InVEST to Spatial Planning: China, Colombia, Hawaii and Indonesia

**China<sup>1</sup>:** Provincial and county planners in China now base land use plans on ‘Ecosystem Function Conservation Areas’, which reflect areas of critical importance for ecosystem services and biodiversity. In Baoting County, an ecosystem service mapping and modeling tool called InVEST was used to design development zones that avoid areas of high ecosystem service provision and importance for conservation. This is helping local policy makers to integrate biodiversity and ecosystem service status into cross-sectoral, multi-objective land-use plans. The mapping exercise highlighted that development activities are planned in areas important for several priority ecosystem services. These developments are now being reconsidered by local government as the next Baoting county Land Use Master Plan is drafted.

**Colombia<sup>2</sup>:** Water funds link water users to nature, the source of the clean water upon which they depend. Users have an incentive to find the lowest cost option for maintaining access to a clean, regular water supply. In the Andean region, natural ecosystems provide these ecosystem services at low cost so investing in nature conservation makes economic sense. One such investment – water funds – are proliferating in the Andes. Water funds are long-term trust funds that involve a public-private partnership of water users who determine how to invest financial interest in conservation activities in priority areas. InVEST, an ecosystem service mapping and modeling tool, was used in the East Cauca Valley Water Fund in Colombia to help direct the fund’s conservation investments towards areas with the highest potential for reducing sedimentation and maintaining water yield.

**Hawai‘i<sup>3</sup>:** A quantitative ecosystem services assessment helped Kamehameha Schools (KS), the largest private landowner in Hawai‘i, to design and implement a plan that fulfills its mission to balance environmental, economic, cultural, educational, and community values. With the Natural Capital Project, KS used InVEST software to evaluate the impacts on ecosystem services of alternative planning scenarios on its iconic 10,500 hectare landholding on the North Shore of O‘ahu. The scenarios included returning agricultural lands to sugarcane as a biofuel feedstock, diversified agriculture and forestry, and residential development. The quantified services were carbon storage and water quality, as well as financial return from the land. Cultural services were incorporated qualitatively. The results informed KS’ decision to rehabilitate irrigation infrastructure and make the other investments required to pursue diversified agriculture and forestry.

**Indonesia<sup>4</sup>:** District and provincial government policy makers in Sumatra, Indonesia are integrating ecosystem services and biodiversity into Sumatra’s next land-use plan. This ecosystem-based spatial plan guides local government planners in decisions on whether, and where, to award concessions for economic activities, such as oil palm and pulp and paper plantations. An ecosystem service mapping and modeling tool called InVEST was used to assess the quantity and location of high quality habitat, carbon storage and sequestration, annual water yield, erosion control, and water purification under two scenarios, representing implementation of the current government spatial plan and an ‘Ecosystem Vision’ of sustainable land use that better balances environmental, social and economic considerations. This information is helping to design and locate the best areas for forest restoration, payments for carbon and watershed services, and best management practices for forestry and plantations.

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<sup>1</sup> Wang Yukuan, Chris Colvin, Driss Ennaanay, Emily McKenzie, Chen Min. Mapping Ecosystem Function Conservation Areas to Integrate Ecosystem Services into Land Use Plans in Baoting County, China. TEEB D2 Case Study.

<sup>2</sup> Rebecca L Goldman, Silvia Benitez, Alejandro Calvache, Sarah Davidson, Driss Ennaanay, Emily McKenzie, Heather Tallis. Linking People and Nature through Watershed Conservation in the East Cauca Valley, Colombia. TEEB D2 Case Study.

<sup>3</sup> Joshua H. Goldstein, Giorgio Caldarone, Chris Colvin, T. Ka‘eo Duarte, Driss Ennaanay, Kalani Fronda, Neil Hannahs, Emily McKenzie, Guillermo Mendoza, Kapu Smith, Stacie Wolny, Ulalia Woodside, Gretchen C. Daily. Integrating Ecosystem Services into Land-Use Planning in Hawai‘i. TEEB D2 Case Study.

<sup>4</sup> Thomas Barano, Nirmal Bhagabati, Marc Conte, Driss Ennaanay, Oki Hadian, Emily McKenzie, Nasser Olwero, Heather Tallis, Stacie Wolny, Ginny Ng. Integrating Ecosystem Services into Spatial Planning in Sumatra, Indonesia. TEEB D2 Case Study.

# **Mapping Ecosystem Function Conservation Areas to integrate ecosystem services into land use plans in Baoxing County, China**

By Wang Yukuan, Fu Bin, Chris Colvin, Driss Ennaanay, Emily McKenzie, Chen Min

## **Key Message**

Provincial and county planners in China now base land use plans on ‘Ecosystem Function Conservation Areas’, which reflect areas of critical importance for ecosystem services and biodiversity. In Baoxing County, an ecosystem service mapping and modeling tool called InVEST was used to design development zones that avoid areas of high ecosystem service provision and importance for conservation. This is helping local policy makers to integrate biodiversity and ecosystem service status into cross-sectoral, multi-objective land-use plans. The mapping exercise highlighted that development activities are planned in areas important for several priority ecosystem services. These developments are now being reconsidered by local government officials as the next Baoxing county Land Use Master Plan is drafted in 2010.

## **What is the problem?**

Over the past two decades, China has experienced double digit rises in GDP, large-scale alleviation of poverty, and overall improvement in livelihoods and physical infrastructure. However, this rapid economic growth and industrialization have generated negative environmental impacts. The death and destruction caused by the floods in the Yangtze River basin in 1998, exacerbated by deforestation on steep slopes, illustrate the economic and social costs of environmental degradation. Many of China’s key industries – and its citizens’ local livelihoods – depend upon ecosystem services. For example, tourism relies on the unique local natural beauty and biodiversity, while dredging costs in hydropower plants are kept low by the retention of sediment by natural ecosystems.

The government is now placing environmental protection higher on the national agenda. It has developed a range of regulations, policies and economic instruments, such as eco-compensation programs and environmental taxes. However, these efforts have not been sufficient to mitigate the environmental pressures generated by rapid economic growth. Local policies often continue to place economic growth above other objectives, without considering ecosystem services and the economic and social benefits of biodiversity. Local planning is often not effectively coordinated across sectors, with authority scattered among different government departments, such as Planning Commissions, Bureaus of Commerce, and Ministries of Finance, Land Resources, Forestry, Agriculture and Environmental Protection. In addition, existing zoning maps are often too coarse to enable effective local decision making – finer scales are required.

## **What is being done to solve it and what is the role of local policy?**

Since the 1980s, the focus of China’s many government plans has shifted to recognize the importance of coordinated consideration of demographic, environmental, social and economic priorities. The most influential plans – the Five-Year Plan for National Economic and Social Development (FYPs) and Land Use Master Plan (LUMP) – must now consider critical ecosystem service areas when designating zones where development is permitted. FYPs set down a general framework and targets for guiding government decisions, while LUMPs are

spatial land-use strategies. Lands are divided into four principal zones that affect the level of development allowed: optimized, intensive, restricted and prohibited development zones. The assignment of these zones is based on a variety of factors, but the first step now involves the identification of 'Ecological Function Conservation Areas' (EFCAs), where no – or only limited – development is allowed. EFCA zoning helps to integrate biodiversity and ecosystem service considerations into plans, including outside protected areas. EFCA's cross-sectoral nature can also help to resolve the inconsistency across different sector plans.

EFCA zoning occurs at national, provincial, county and city scales. While larger scale EFCA zoning provides guidance for deploying overall protection and development projects in China, local scale mapping of EFCA's is critical for implementation. Once adopted by the local People's Congress, EFCA plans become law, governing all sector and development plans. Baoxing is one county that has recently focused on local level EFCA planning. Baoxing is located in the western mountainous area of Sichuan province, in the Upper Yangtze River Basin. Many ecosystem services are important in Baoxing, but sediment and soil retention, water retention, and carbon sequestration are considered to be the highest priorities.

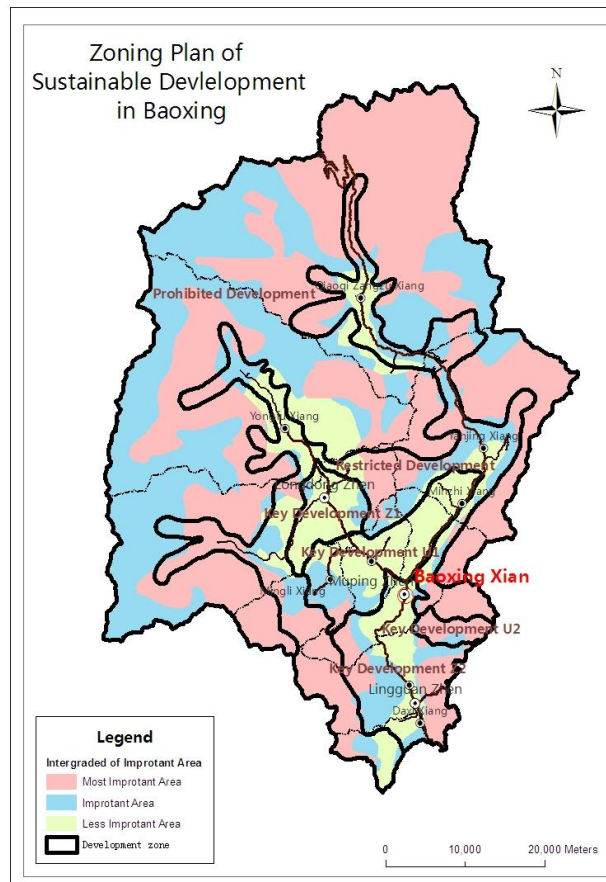
### **What has been achieved?**

InVEST – Integrated Valuation of Ecosystem Services and Tradeoffs – is a software tool developed by the Natural Capital Project (Tallis et al. 2010) that models ecosystem services on the basis of biophysical and economic 'production functions'. These models translate land-use and land-management scenarios into estimates of the supply, location and value of ecosystem services. InVEST was used in Baoxing County to assist Chinese local government with EFCA zoning at finer scales than had been looked at before, in order to integrate ecosystem services into the Baoxing Land Use Master Plan. InVEST's sediment retention, water retention and carbon models were used to estimate and map the annual average delivery of these services. The resulting maps were bundled and overlaid with a biodiversity map to delineate and identify areas suitable for development with minimum negative impacts on important sources of ecosystem service supply (see Figure 1 below). The mapping exercise showed that protected areas cover the boundaries of key ecosystem services, particularly in the north. However, it highlighted that development activities are planned in areas important for several priority ecosystem services. These developments are now being reconsidered by local government officials as the next Baoxing county Land Use Master Plan is drafted in 2010.

If the revised Land Use Master Plan is designed and implemented such that it successfully conserves biodiversity and priority ecosystem services, a number of local development benefits are likely to arise for the people of Baoxing. Avoiding development in areas that are important for erosion control and water retention is likely to reduce the risk of flooding, mudslides and related natural disasters, both in the Baoxing region and downstream in the Upper Yangtze River Basin. Three industries that are key to economic development in Baoxing – tourism, hydropower and marble – are also likely to benefit. Preservation of biodiversity is essential to continue to draw tourists to the region that is the homeland of the Giant Panda. Meanwhile ensuring sediment is retained by natural ecosystems will reduce the costs of erosion control and sediment dredging by local hydropower stations. According to Baoxing's hydropower development plan, 8 cascade hydropower stations are planned in the region, with 4.33 billion kwh electricity generation capacity (Min. 2010). The marble industry in Baoxing relies on a clean, regular water supply for the marble mining and production process.

The health of communities also relies on medicines made using local herbal plants. In the longer term, conservation of forests may provide an additional source of income through carbon market trading, as carbon markets develop, and assuming necessary forest tenure reform occurs.

**Figure 1:** Planned ‘development’ areas compared to important ecosystem service areas (based on water retention, carbon storage, soil retention, and biodiversity conservation)



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# **Linking People and Nature through Watershed Conservation in the East Cauca Valley, Colombia**

By Rebecca L Goldman, Silvia Benitez, Alejandro Calvache, Sarah Davidson, Driss Ennaanay,  
Emily McKenzie, Heather Tallis

## **Key Message**

Water funds link water users to nature, the source of the clean water upon which they depend. Users have an incentive to find the lowest cost option for maintaining access to a clean, regular water supply. In the Andean region, natural ecosystems provide these ecosystem services at low cost so investing in nature conservation makes economic sense. One such investment – water funds – are proliferating in the Andes. Water funds are long-term trust funds that involve a public-private partnership of water users who determine how to invest financial interest in conservation activities in priority areas. InVEST, an ecosystem service mapping and modeling tool, was used in the East Cauca Valley Water Fund in Colombia to help direct the fund's conservation investments towards areas with the highest potential for reducing sedimentation and maintaining water yield. With quantitative estimates of ecosystem service returns, it was possible to identify the most efficient investment portfolio for each watershed in the fund.

## **What is the problem?**

The Northern Andes region faces three critical problems: 1) natural ecosystems – the key hydrologic regulators of the region – are threatened by conversion to crop and ranch land; 2) ranchers and farmers depend on the land for their livelihoods making it unjust, inequitable, and unsustainable to stop their land usage; and 3) growing populations and demands for water, coupled with unpredictable impacts from climate change, threaten the long term availability of the resource.

The watersheds of the Northern Andean region are characterized by a mix of high altitude grasslands (páramo) and forests which provide valuable water services: flow regulation (Buytaert et al. 2007) and improved water quality through decreased sedimentation (White et al. 2009), among others. The demand for clean, regular water by downstream users – namely citizens, water utilities, hydropower companies, agriculture companies, and beer and water bottling companies – is ever-increasing. Coupled with unpredictable impacts on rainfall and temperature due to climate change, access to clean, regular supplies of water is a growing concern. Natural areas that are important for biodiversity conservation and water regulation are often officially protected. However, the budgets of the Ministries of Environment in this region are insufficient for effective protected area management, even in buffer zones, where most of the pressures of land use change exist.

The main threat to the páramo and forests is conversion to crop and ranch land by relatively poor families living in the watershed, upstream from the main water users. Preventing access to the natural ecosystems would unjustly harm their livelihoods. However, allowing continued conversion increases the likelihood of ecosystem degradation and threatens access to ecosystem services for these same people, as well as downstream users and beneficiaries.

### **What is done to solve it and what is the role of local policy?**

The Nature Conservancy (TNC), with many partners, has launched an effort to provide a sustainable funding source for conservation and protection of natural ecosystems in order to provide valuable ecosystem services while maintaining or enhancing the livelihoods of watershed communities. These projects are called water funds, and the first was launched in Quito, Ecuador in the late 1990s, led by TNC in close collaboration with Fundación Antisana who together approached the city's mayor (see Arias et al. TEEB D2 case study). Now, with 13 water funds in some stage of development in the Northern Andes region, TNC is developing a step-by-step methodology for how to create a water fund (see Ramos et al. *forthcoming*).

In a water fund, water users voluntarily put money into a trust fund; the users and other key stakeholders in the watershed form a public-private partnership to make decisions on how to spend interest, and in some cases a portion of the trust itself, to finance conservation activities in the watershed (see Goldman et al. 2010). These user group public-private partnerships include public agencies such as water utilities and hydropower companies and sometimes representatives from the National Park agencies and/or regional environmental authorities. Private companies can include water bottling companies or beer companies, among others. Different non-government organizations are also members.

The conservation activities take various forms. For example, to help protect natural ecosystems and associated ecosystem services, water funds hire, train, and pay salaries of community-based park guards. To improve and secure water service provision and biodiversity from working landscapes in the watershed, water funds help land managers implement best management practices, such as fencing riparian areas and re-vegetating the landscape. Water funds include a mechanism for compensating people for their investment by reducing current production costs (e.g. building a community milk bottling plant to cut out the middle man) or supplying or subsidizing products families would otherwise have to purchase (e.g. giving families seeds and training to grow commonly consumed vegetables).

### **What was achieved?**

In the East Cauca Valley of Colombia, TNC and Asocaña, an association of sugar cane producers who provided most of the funding, led the creation of a water fund, called Fondo de Agua por la Vida y la Sostenibilidad (FAVS) – Water Fund for Life and Sustainability. Asocaña relies on a regular supply of clean water for sugar cane production. The capital fund is currently worth USD 1.8 million. Several other groups, including community-based grassroots organizations, the regional environmental authority, and a peace and social justice organization also participate in the fund. Nine watersheds feed the valley. The goals of the water fund are to secure biodiversity and water-related service benefits, particularly reduction in sedimentation and maintenance of regular water flows. Activities carried out through investments by the fund include conserving at least 125,000 hectares of the natural ecosystems and improving management of the landscape. These activities will benefit 920,000 people downstream and sugar cane production, an important industry for the Colombian economy.

In order to 1) identify priority areas for FAVS investment, 2) establish quantitative ecosystem service goals, and 3) develop a portfolio of the most efficient activities, TNC and partners used a watershed scoring process and a modeling tool called InVEST (Integrated

Valuation of Ecosystem Services and Trade-offs), developed by the Natural Capital Project (Tallis et al. 2010). First, a conservation activity (restoration, reforestation, fencing or silvopastoral practices) was assigned to each part of the landscape based on the behavior of landowners in the region and successful investments by early members of the water fund over the last 20 years. These assignments implicitly considered factors such as opportunity costs and land owners' willingness to change activities. For example, no water fund investments and associated conservation activities were assumed to occur in sugar cane growing areas because the opportunity costs are so high in sugar cane regions. The landscape was ranked to highlight the places where possible conservation investments were likely to yield the greatest improvement in water yield and erosion control. Factors included in the ranking were those known to affect the hydrological response of the services, such as slope, soil depth, distance to stream or water body, aspect, elevation and precipitation. Data from historic conservation investments in each watershed were used to estimate how much the proposed conservation activity in each location would cost. Combining the landscape ranking and cost information enabled selection of the highest ranked locations for each activity, tallying costs until the target budget level was met. The resulting selected activities across the landscape formed the water fund investment portfolio. This process was repeated for five budgets, ranging from the level of investment currently committed by the fund (USD\$10 million) to a doubling of that investment (USD\$20 million).

With this set of investment portfolios as scenarios for future management, InVEST was used to estimate the ecosystem service returns from each. InVEST quantifies, maps and values ecosystem services under current and possible future conditions. The models currently included in this free software tool estimate habitat quality, and the biophysical level and economic value of carbon storage and sequestration, annual water yield for hydropower (and other uses), avoided sedimentation, water purification (for nutrients), crop pollination, timber production and open access harvest (of non-timber forest products and other natural products). In the FAVS water fund case, InVEST was used to assess two of the main services of interest to Asocaña: annual water yield and avoided sedimentation. With the quantitative estimates of ecosystem service returns, it was possible to identify the most efficient investment portfolio for each watershed in the fund. For example, the estimates show where in a sub-watershed the water fund should reforest or restore vegetation and where it would be more cost effective to fence off areas or engage in silvopastoral practice. Using these targeted activity maps the water fund partnership can now evaluate where these practices are most feasible given the social context of communities living in the watersheds.

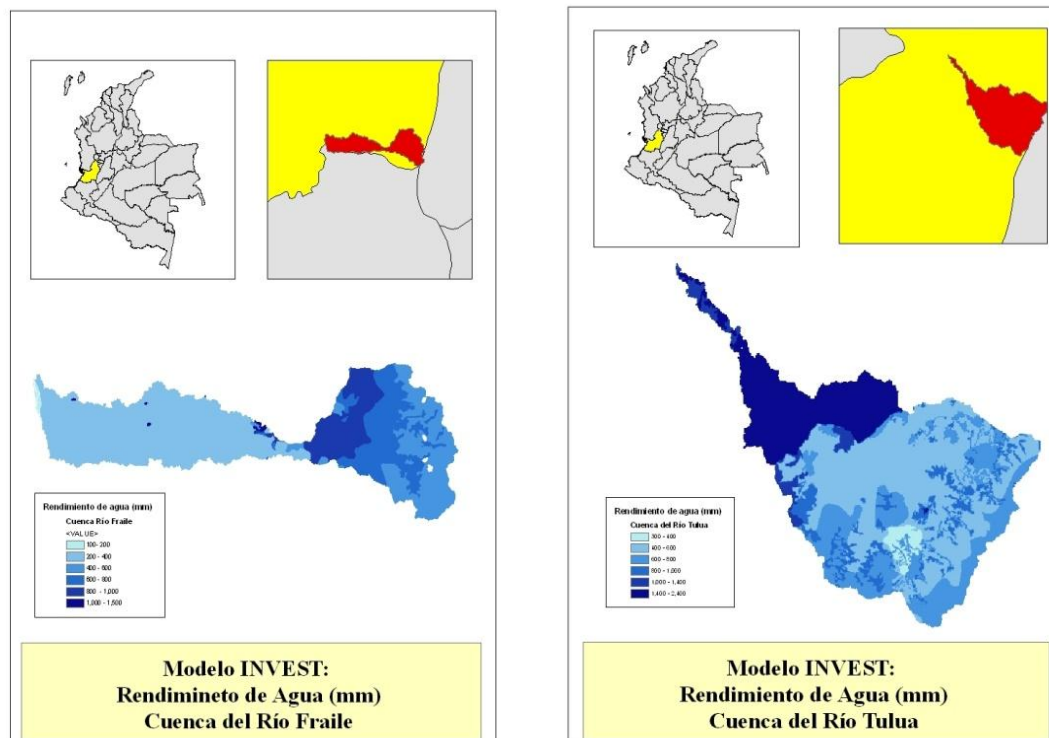
Both watershed communities and water fund decision-makers benefited from this prioritization exercise. Watershed communities benefit since practices are implemented where there are greater returns from the investments (such as availability of water on their own farm or ranch) with costs that can be readily offset. For the water fund decision making process, with nine watersheds as potential areas for investment and limited revenue for conservation practices, a cost-benefit assessment basing benefits on ecosystem services returns, provides an efficient and effective way to target action.

The recommendations from this modeling exercise were based on current climate conditions, but it is well known that climate conditions are changing in the region, and are likely to affect precipitation and temperature in ways that may change the effectiveness of these



investment portfolios. To ensure that the water fund's investments are robust to climate change, new research is being done, in partnership with CIAT (International Center for Tropical Agriculture), using InVEST sedimentation and water yield models, FIESTA (Fog Interception of the Enhancement of Streamflow in Tropical Areas), and SWAT (Soil and Water Assessment Tool) to: 1) assess impacts from climate change on the provision of these services as well as on biodiversity and crops, 2) determine if on-the-ground activities promoted by the water fund are adapted for these changes, and 3) design activities to promote resilient ecosystems that will continue to provide the benefits people will increasingly need as they adapt to climate change. These activities will be designed using stakeholder workshops.

**Figure:** InVEST modeled estimates of water yield in the East Cauca Valley



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# **The Natural Capital Project, Kamehameha Schools, and InVEST: Integrating Ecosystem Services into Land-Use Planning in Hawai'i**

By Joshua H. Goldstein, Giorgio Caldarone, Chris Colvin, T. Ka'eo Duarte, Driss Ennaanay, Kalani Fronda, Neil Hannahs, Emily McKenzie, Guillermo Mendoza, Kapu Smith, Stacie Wolny, Ulalia Woodside, and Gretchen C. Daily

## **Key message**

A quantitative ecosystem services assessment helped Kamehameha Schools (KS), the largest private landowner in Hawai'i, to design and implement a plan that fulfils its mission to balance environmental, economic, cultural, educational, and community values. With the Natural Capital Project, KS used InVEST software to evaluate the impacts on ecosystem services of alternative planning scenarios on its iconic 10,500 hectare landholding on the North Shore of O'ahu. The scenarios included returning agricultural lands to sugarcane as a biofuel feedstock, diversified agriculture and forestry, and residential development. The quantified services were carbon storage and water quality, as well as financial return from the land. Cultural services were incorporated qualitatively. The results informed KS' decision to rehabilitate irrigation infrastructure and make the other investments required to pursue diversified agriculture and forestry. KS won an award from the American Planning Association Hawai'i Chapter for the quality of their overall land-use planning and community engagement process.

## **What is the problem?**

Mirroring global trends, Hawai'i is facing unprecedented pressures on its land base as a growing population intensifies demand for residential and commercial development, while concurrently there are rising concerns related to food security, fossil fuel reliance, climate change mitigation and adaptation, and other factors integral to the well-being of the state's residents and visitors. Recognizing these challenges, landowners, communities, and leaders are pursuing new strategies to incorporate the values of natural capital into land-use and policy decisions.

One such leader, Kamehameha Schools (KS), is an educational trust serving people of Hawaiian ancestry and is also the state's largest private landowner (owning approximately 8% of Hawai'i's land base). In managing its diverse portfolio of lands, in 2000 KS adopted a new approach to land management that seeks to "derive an overall balance of economic, educational, cultural, environmental, and community returns" (Kamehameha Schools 2000). From 2006 to 2008, KS undertook an extensive land-use planning process in partnership with local communities for one of its major land holdings on the North Shore region of the island of O'ahu. KS' lands in this region (approximately 10,500 hectares) have a rich historical legacy of use for agricultural production, aquaculture cultivation, and habitation. Recently, the agricultural lands (approximately 2,200 hectares) were in continuous sugarcane production for over one hundred years, ending in 1996 when the Waialua Sugar Company surrendered its lease of lands and infrastructure that showed the effects of years of deferred maintenance. Since then, agricultural use has been restored on only a third of the former plantation lands. The remainder is no longer in production and is being overtaken by the rapid advance of invasive plants. A key challenge for KS and the community was to determine what should be done with these agricultural lands to meet KS' and the community's needs and to contribute to statewide policy initiatives.

### **What is done to solve it and what is the role of local policy? (Focus on ecosystem services)**

KS worked with the Natural Capital Project to use InVEST software (Tallis et al. 2010) to evaluate the impacts of alternative futures for the agricultural lands on carbon storage (to mitigate climate change forces), water quality (to meet current and future needs), and financial return (to support KS' educational activities). Drawing upon input from the community, the research team developed three spatially-explicit and contrasting scenarios: (1) *biofuel feedstock* – returning the agricultural lands to sugarcane to produce an energy feedstock; (2) *diversified agriculture and forestry* – using the lower irrigated fields for diversified agriculture, establishing vegetation buffers to reduce field runoff, and undertaking native forestry plantings on the remaining higher elevation fields; (3) *residential development* – selling the lands for a residential housing development. While neither KS nor the community is disposed to pursue the latter scenario, it represents a development pattern that has played out repeatedly on former plantation lands across the state.

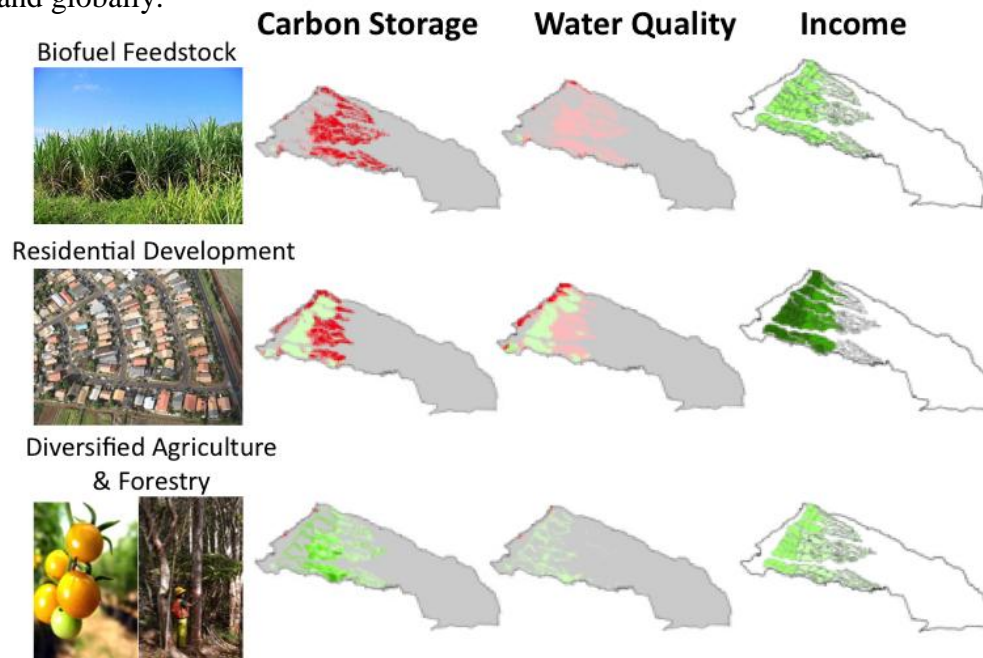
All three scenarios were projected to generate positive income streams for the agricultural lands that exceed the current negative returns. The residential development scenario, not surprisingly, was projected to generate the greatest economic net present value for the landowner. This income boost, however, is linked with reductions in carbon stock and water quality relative to current conditions. Reductions in carbon stock and water quality are even more pronounced for the biofuel feedstock scenario. In both cases, losses in carbon stock are driven by clearing invasive woody vegetation on abandoned fields. In contrast, the diversified agriculture and forestry scenario is projected to improve carbon stock and water quality relative to the current landscape and also generate positive income. While the residential development scenario would yield the largest financial return, the diversified agriculture and forestry scenario has the greatest potential to optimize balanced, positive returns across the modeled ecosystem services, thereby most effectively contributing to KS' multi-value approach to land management.

Cultural values are important to the North Shore community and to KS' approach to land management. While cultural ecosystem services were not assessed quantitatively in this analysis, the scenarios present some clear and contrasting implications. For instance, native forests play a supportive role in the water cycle and provide resources to promote Hawaiian cultural practices. Also, many residents prize the North Shore's rural character and are vocal advocates for maintaining active agricultural lands. These lands provide jobs and income to the local community, as well as contributing to a sense of place and connection with previous generations. Such benefits would be captured best by the diversified agriculture and forestry scenarios, rather than the biofuel feedstock or residential development scenarios.

### **What was achieved?**

An examination of the trade-offs among the three alternatives – what would be lost and gained – prioritized a land use plan involving diversified agriculture and forestry. Informed by the strengths and drawbacks of each alternative, KS is working with the community to implement a mixed land-use plan to deliver the desired balance of ecosystem services to stakeholders, while also having potential to contribute to statewide policy initiatives. In this context, biofuel feedstock may be incorporated along with diversified agriculture and forestry, and possibly other compatible uses. In doing so, KS and the community will be aware of the benefits and trade-offs inherent in their decision, enabling them to mitigate negative impacts where necessary. Kamehameha Schools received an award from the American Planning

Association Hawai'i Chapter for the quality of this land-use planning and community engagement process. Similar land-use planning initiatives that attempt to achieve a balance of biodiversity, ecosystem service, and community goals are now underway, both elsewhere in Hawai'i and globally.



**Figure:** Modeling results for the North Shore study region for each of the three planning scenarios. The maps for carbon storage and water quality show enhancements (green color) or reductions (red color) in ecosystem service provision for the scenario relative to the current landscape; gray color denotes no change. The income maps show projected land rental rates (biofuel feedstock and diversified agriculture & forestry scenarios) or sale price (residential development), with darker green colors representing greater values.

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# **Integrating Ecosystem Services into Spatial Planning in Sumatra, Indonesia**

By Thomas Barano, Emily McKenzie, Nirmal Bhagabati, Marc Conte, Driss Ennaanay, Oki Hadian, Nasser Olwero, Heather Tallis, Stacie Wolny, Ginny Ng

## **Key Message**

District and provincial government policy makers in Sumatra, Indonesia are integrating ecosystem services and biodiversity into Sumatra's next land-use plan. This ecosystem-based spatial plan guides local government planners in decisions on whether, and where, to award concessions for economic activities, such as oil palm and pulp and paper plantations. An ecosystem service mapping and modeling tool called InVEST was used to assess the quantity and location of high quality habitat, carbon storage and sequestration, annual water yield, erosion control, and water purification under two scenarios, representing implementation of the current government spatial plan and an 'Ecosystem Vision' of sustainable land use that better balances environmental, social and economic considerations. This information is helping to design and locate the best areas for conservation activities such as forest restoration, sustainable finance mechanisms such as payments for carbon and watershed services, and best management practices for forestry and plantations.

## **What is the problem?**

Sumatra has abundant biodiversity; it is the only place on earth where tigers, elephants, orangutans and rhinos all reside. Local communities rely on many ecosystem services, particularly the provision of a clean, regular water supply for drinking, hydropower and irrigation, protection from floods, droughts, forest fires and landslides, regulation of air pollution and maintenance of fertile soils for agriculture. However, deforestation and forest conversion, mostly for palm oil, pulp and paper plantations and illegal logging, are causing losses of biodiversity and degrading many ecosystem services. In particular, conversion of lowland deep peat forests – mostly in the province of Riau in eastern Sumatra – is a major contributor to global carbon emissions, creating adverse climate change impacts globally. Existing and prospective forest concessions threaten to have even greater adverse impacts.

The current lack of incentives to sustain ecosystem services is one of several root causes of these problems. The opportunity costs, in terms of profits from palm oil and other economic sectors, are currently more lucrative than conservation. There are few payment mechanisms to reward those who provide ecosystem services through sustainable land management. It is commonly overlooked that forests provide a range of valuable ecosystem services, beyond standing timber, that contribute to the livelihoods, security and wellbeing of local communities.

## **What is being done to solve it and what is the role of national and provincial policy?**

In October 2008, the ten provincial governors of Sumatra and four Indonesian government ministers made a historic commitment to protect the remaining forests and critical ecosystems of Sumatra. Local land-use planning is critical for achieving this commitment. Indonesia's national spatial planning process operates on a 5-year cycle. Spatial plans guide decisions about whether and where concessions are granted for economic activities, such as oil palm development and pulp and paper plantations, and where is reserved for conservation and restoration. Spatial planning has been undertaken in Indonesia for many years, but has only had a legal basis for measures to enforce compliance since 2007, following the Spatial Planning Law 26/2007 (see

Hudalah and Woltjer, 2007). Strategic Environmental Assessments (SEAs) are mandatory under the new Spatial Planning Law.

Having developed national, and several island-wide, spatial plans in 2009, the Indonesian government is working in 2010 to design spatial plans at province and district levels. Much decision-making power resides at this local scale since decentralization. District and provincial governments are integrating ecosystem services and biodiversity into spatial plans, through a Roadmap Action Plan, which sets out an 'Ecosystem Vision' for conserving Sumatran ecosystems. The Vision was launched in May 2010, and developed by a number of government departments (Internal Affairs, Public Works, Forestry, along with the Ministry of Environment, National Development and Planning Board and Coordinating Ministry of Economy Sector). It maps areas for protection and restoration based on critical biodiversity and habitat, and outlines measures to be taken to avoid additional ecosystem degradation. Decision makers are also considering how spatial planning affects ecosystem services that support the well being and livelihoods of local communities.

A final spatial plan for Sumatra will be developed by the end of 2010. The RIMBA ecosystem has been selected as a demonstration location to model best practice for sustainable spatial planning and development with low carbon emissions, eventually to be scaled up elsewhere in Sumatra and beyond. RIMBA is an area in Central Sumatra that spans 19 districts in the provinces of Riau, Jambi and West Sumatra. It encompasses remaining high-biodiversity montane, lowland, and peat swamp forest, and degraded areas prioritized for restoration.

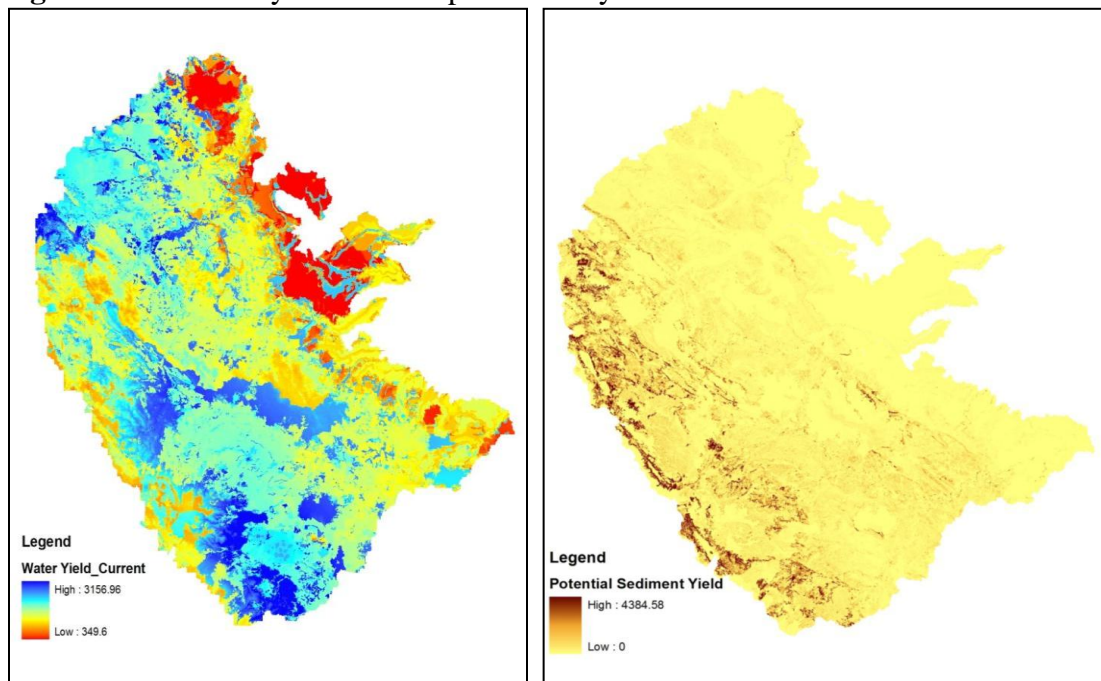
Given the high levels of carbon emissions from conversion of peatlands in Riau, this spatial plan has the potential to make a major contribution to the commitment by the Government of Indonesia to reduce green-house gas emissions by 26% by 2020 from the 2005 level. It can also support the 2-year moratorium on new permits to convert natural forests and peatlands, announced in May 2010. Building on partnerships forged between the Indonesian Government and the Governments of Norway and Australia, forest carbon projects are being planned in the RIMBA ecosystem, particularly in carbon rich peat land areas. Local communities may access new sources of income from these emerging markets and payments.

### **What has been achieved?**

A tool developed by the Natural Capital Project for mapping and valuing ecosystem services, InVEST (Integrated Valuation of Ecosystem Services and Trade-offs – see Tallis et al. 2010), is being used to inform the Sumatra spatial plan. Application of InVEST is one of the actions specified in the Roadmap Action Plan to help integrate ecosystem services into land use decisions. Following a request by government decision-makers, InVEST is being applied by the World Wildlife Fund, as part of a forum of NGOs who are assisting with land-use planning in Sumatra, known as Forum Tata Ruang Sumatera (ForTRUST). InVEST provides mapped information on where, and how much, ecosystem services are supplied on the landscape, and how these patterns might change under future land use scenarios. It can be overlaid with biodiversity information to see where ecosystem service and conservation priorities overlap. The Sumatra InVEST analysis focuses on the RIMBA ecosystem because it was selected as a demonstration site for sustainable spatial planning. Figure 1 shows early results for two important ecosystem services in RIMBA – water yield and sediment retention.



**Figure 1:** Preliminary InVEST maps of water yield and sediment retention in RIMBA, Sumatra



InVEST was used to model the quantity and location of high quality habitat, carbon storage and sequestration, annual water yield, erosion control, and water purification under two scenarios:

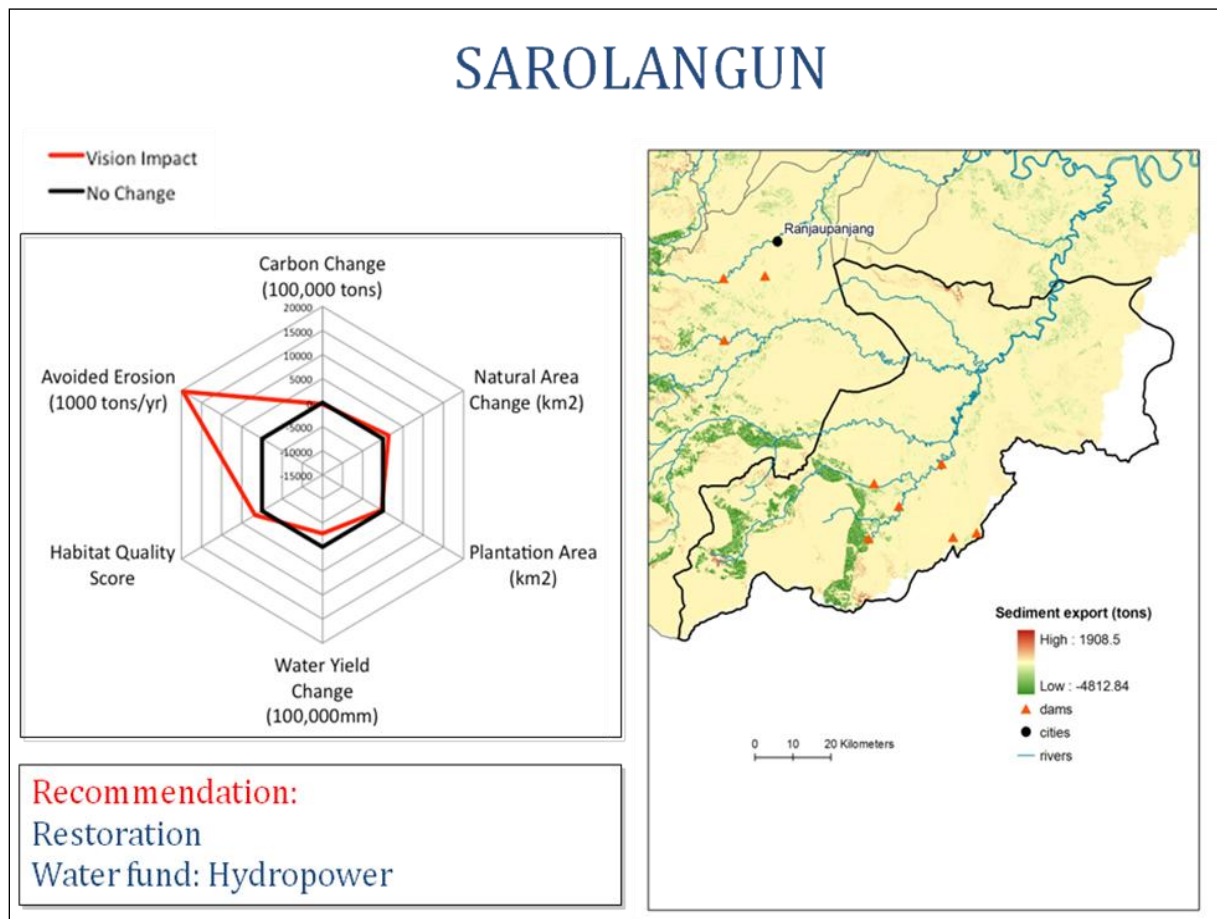
- the Sumatra ecosystem vision of sustainable land use as proposed in the Roadmap Action Plan
- a business as usual scenario corresponding to the government's current spatial plan

In June 2010, the results were disseminated to government representatives from nineteen districts in the RIMBA ecosystem. Preliminary recommendations on specific actions were offered for 18 districts (one district had insufficient data available) based on the potential gains or losses in ecosystem services if the ecosystem vision (as outlined in the Roadmap Action Plan) were implemented. For example, on the basis of InVEST results, recommendations were made on how to prioritize areas for forest restoration based on habitat quality and the potential for reducing erosion. Information on ecosystem services can also be used to advocate for, and help implement, commitments by local government policy-makers to establish incentive mechanisms that reward sustainable land use and conservation, such as forest carbon projects, payments for watershed services, certified forestry and agriculture, and ecotourism. InVEST results informed discussions of forest carbon projects by identifying where carbon storage and sequestration potential is high. (Future analysis will also look at opportunity costs and related threats of deforestation). Results were also relevant to the design of payments for watershed services, by identifying where the services of water yield and avoided erosion are provided, and where beneficiaries are located who could pay to ensure continued service delivery. For instance, a district that gains in sediment retention if a sustainable spatial plan is implemented, and has a town or dam downstream from the sediment retention area, could be a potential location for a payment for watershed services scheme to control erosion.



In this way, information on ecosystem services is helping to inform important decisions in the spatial plan, such as where restoration takes place, where concessions for oil palm and forestry are awarded, and where payment schemes for carbon and watershed services could be piloted. InVEST and other ecosystem service tools can also be used in the future to strengthen the scientific information within Strategic Environmental Assessments, which are mandated to support spatial planning in Indonesia.

**Figure 2:** Preliminary results showing gains and losses in ecosystem services, wildlife habitat and plantation area in the district of Sarolangun, Jambi province, under the Sumatra ‘Ecosystem Vision’



Follow-up actions will include further revision of these preliminary analyses to culminate in a final report. There will also be capacity building for local universities to enable verification of initial results, plus continued use of InVEST and additional socioeconomic analyses in other locations. Data and the InVEST software will be provided to province and district level government officials to enable regular, updated applications in the future.

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