APPLYING SPATIAL TOOLS TO SUPPORT SUSTAINABLE PLANNING IN THE GREATER MEKONG SUBREGION

GREATER MEKONG
SUBREGION
CORE ENVIRONMENT
PROGRAM

CONTENTS

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Cover photo: Jiao Xi

ABBREVIATIONS

API	Application Programming Interface
BAU	business-as-usual
BCC	Biodiversity Conservation Corridor Project
CEP-BCI	Core Environment Program and Biodiversity Conservation Corridors Initiative
CT	criteria tree
DNP	Department of National Parks, Wildlife and Plant Conservation
DONRE	Department of Environment and Natural Resources
EOC	Environment Operations Center
EWEC	East-West Economic Corridor
GIS	Geographic Information System
GMS	Greater Mekong Subregion
ha	hectare
LUP	Land Use Plan
MAF	Ministry of Agriculture and Forestry
MEM	Ministry of Energy and Mines
NCCR	National Centre of Competence in Research
NLMA	National Land Management Authority
NSEC	North-South Economic Corridor
NSU	National Support Unit
NTA	National Tourism Authority
NTFP	non-timber forest products
PEI	Poverty-Environment Initiative
PF	primary forest
REL	reference emission levels
SAP	Strategy and Action Plan
SEA	Strategic Environmental Assessments
SEC	Southern Economic Corridor
SMCA	spatial multi-criteria assessment
SUFORD	Sustainable Forest Resource Development
UNDP	United Nations Development Programme
WCS	Wildlife Conservation Society
WREA	Water Resources and Environment Agency
WWF	Worldwide Fund for Nature

ANCHORING SPATIAL PLANNING TOOLS IN THE CEP-BCI

Since its inception in 2006, the Greater Mekong Subregion (GMS) Core Environment Program and Biodiversity Conservation Corridors Initiative (CEP-BCI) has continuously strived to:
1) increase broader awareness of geographical information systems (GIS);
2) demonstrate its usefulness and contribution to planning processes;
3) develop and test dedicated spatial decision support tools; and 4) build cross-sector conceptual and technical GIS capacity through stand-alone and on-the-job training.

To provide necessary focus, CEP-BCI's GIS efforts were aligned to the planning cycle most countries and organizations follow (Figure 1):

- Early in the planning cycle, ex-ante Strategic Environmental Assessments (SEAs) of sector plans and strategies utilizing scenario-based models were conducted to preview the geographic outcomes of different development priorities;
- Identification of locations for sustainable investments were supported by building capacity in spatial multi criteria assessment (SMCA);
- On-the-ground interventions such as the establishment of Biodiversity Conservation Corridors were carried out with the help of species and threat modeling tools;
- Ex-post monitoring and evaluation was strengthened by developing crowd sourced interactive collaboration and mapping tools;
- Awareness raising and targeted dissemination of geographic knowledge to decision makers was supported through the development of an Interactive Atlas of the GMS.

Focus on practical solutions

While spearheading and promoting the integration of advanced GIS applications into each aspect of the planning cycle, CEP-BCI has recognized the need for developing practical solutions that adjust to the specific context of each GMS country. Therefore, priority has been given to developing robust approaches that could be maintained and institutionalized in government institutions in the long-term. Depending on the skills profile and budgetary situation of each individual institution, CEP-BCI utilized and built capacity on open-source GIS software and stand-alone models (freeware) alongside commercial solutions. The same principle has been applied for interactive collaboration and web-mapping tools, where tools built on freeware (e.g. DevMap) have been developed alongside commercial solutions such as ArcGIS Server (GMS interactive atlas).

Figure 1.
Planning cycle and spatial decision support tools

Key achievements

Implementing this approach over the past five years has resulted in several tangible outcomes. Four SEAs have made use of land demand allocation models, biodiversity pressure models, and spatial multi-criteria analysis at a level that is considered innovative not only within the region, but also in comparison to global SEA practice. This was recognized at the Annual Meetings of the International Association of Environmental Impact Assessment, where GMS delegates have been reporting on these achievements since 2008. Several hundred staff from all GMS countries have been trained on GIS. As a result, the Environment Operations Center (EOC) was able to hand down mapping and monitoring responsibilities to its national BCI focal points and implementing agencies in 2007. Additional GIS responsibilities are currently being integrated into the newly formed National Support Units (NSUs). In the meantime, EOC has made important steps towards transforming itself into a regional knowledge hub, developing and deploying its regional knowledge portal (web site), web-based collaboration tools (e.g. DevMap), and an interactive atlas of the GMS.

APPLICATION 1

PREVIEWING THE GEOGRAPHIC OUTCOMES OF DIFFERENT DEVELOPMENT PRIORITIES

Figure 2. (previous page)
Rice farming in the coastal plains of Quang Nam province, Viet Nam (Photo: Stephen Griffiths)

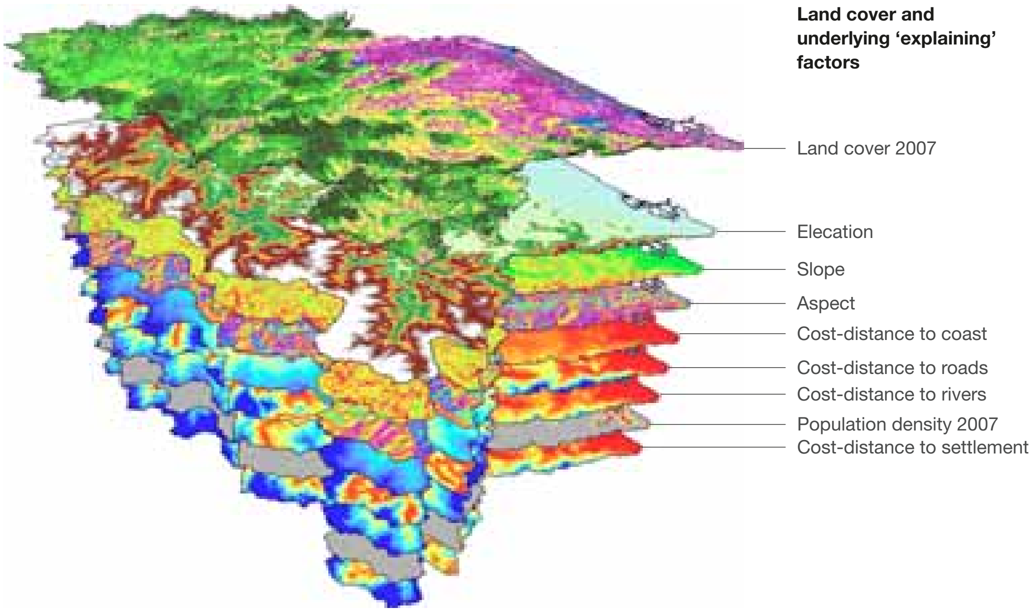
Figure 3. (above)
Construction of a hydropower dam in the Central Annamites of Quang Nam province, Viet Nam (Photo: Stephen Griffiths)

Land demand allocation modeling in the SEA of the Quang Nam LUP 2011-2020

Quang Nam Province, located in Central Vietnam, is characterized by unique development challenges. To the west, rise the Central Annamites, a mountain range rich in biodiversity and natural resources. This area is inhabited by ethnic minorities who have made use of forest resources in a sustainable way for NTFPs and small-scale subsistence farming for centuries. In stark contrast, the coastal plains to the east have been transformed into intensive farming systems and aquaculture. Additionally, the neighboring city of Da Nang – Central Vietnam's largest business hub – has catalyzed the development of a manufacturing industry and related transport networks. Much of the growth and corresponding demand for natural resources (timber), as well as the demand for energy (hydropower) is supplied directly by its environmentally and socially sensitive mountainous hinterlands. Population growth is adding pressure through increased demand for farm land which can no longer be satisfied in the coastal plains alone.

Considering that the present and future economic performance of the province is heavily dependent on sectors that build on a healthy natural resource base (agriculture, forestry, tourism and hydropower), environmentally sound planning approaches need to be piloted and institutionalized. To ensure its allocation of land and natural resources is aligned well with the carrying capacity of the underlying environment, EOC supported the Quang Nam Department of Environment and Natural Resources (DONRE) in conducting an SEA of its Land Use Plan (LUP) for 2011-2020.

Figure 4.
Quang Nam, Viet Nam: Present land cover map and underlying layers used to guide the future land demand allocation



To highlight the geographic implications of different development priorities with the DONRE land use planning team, the CLUE land demand allocation model* was tested in a pilot application. It provided an important preview of where different priorities and corresponding land demand projections are likely to trigger land conversion in the future, and how these changes are associated with the interests of other development sectors (e.g. tourism, energy – hydropower) whose performance depends on intact forest ecosystem services.

Important components of the model are: 1) Definition of future land use requirements (land demand); 2) Explanation of typical land conversion trajectories (e.g. primary forest to extensive agriculture, secondary forest to primary forest); 3) Identification of legal restrictions (e.g. protected areas, existing concessions); and 4) Correlation of land use types with underlying environmental and socio-demographic conditions as shown in Figure 4 (e.g. forest concentrated on steep slopes and ridges, agriculture where fertile soils occur). All of these components were developed in consultation with DONRE and line agencies, which provided the spatial data and expert knowledge (e.g. scenarios) required to configure and execute the model.

After the model was configured with these knowledge inputs and spatial data, two land conversion maps were produced for the year 2020. One showed the consequences of traditional agricultural expansion, and the second provided a preview of future landscape servicing and maximizing the growth potential of the hydropower and tourism sectors. Highlighting forest conversion areas and overlaying the location of protected areas (tourism potential) and hydropower catchments (energy security, Figure 6) provided an initial impression of the potential impact of land conversion on these sectors. This impression can help strategic planners to establish overall costs and benefits. Considering that many of these strategic planning exercises have significant implications on long-term economic performance (e.g. for hydropower which can be operational for 30-40 years), land demand allocation models can add important value to harmonizing strategic decisions and subsequent investment plans and projects.

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* The Conversion of Land Use and its Effects. www.cluemodel.nl

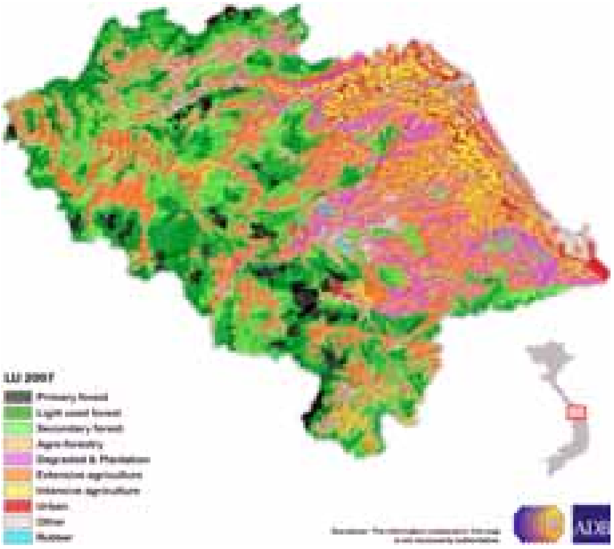


Figure 5. (top left)
Map of Quang Nam Land Use 2007

Figure 5. (top right)
Map of areas at risk of deforestation, depending on different land demand scenarios

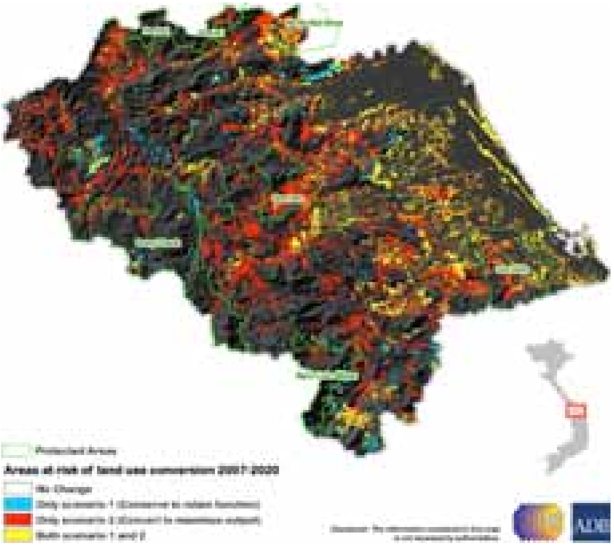


Figure 6. (bottom left)
Map of protected areas overlaid on areas at the risk of deforestation

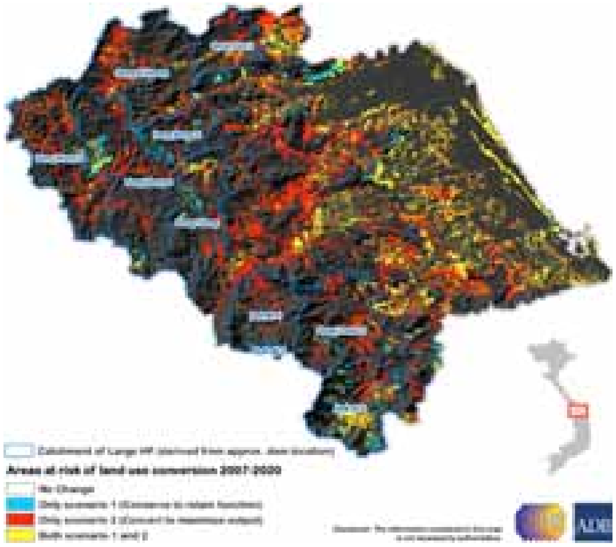


Figure 6. (bottom right)
Map of hydropower catchments overlaid on areas at risk of deforestation.

Use of land demand allocation modeling in NSEC and EWEC

Land demand allocation modeling was also piloted as part of the SEA of the North-South Economic Corridor (NSEC) Strategy and Action Plan. Both 'business-as-usual' (BAU) and 'environmentally optimized' land demand scenarios were translated into maps showing areas at risk of land conversion. This supported the SEA team to identify threatened primary forest patches where conservation efforts should be intensified.

EOC also plans to implement a land demand allocation model for Savannakhet province in Lao PDR as part of its Carbon Neutral Transport Corridor Initiative. Combined with an ex-post assessment of carbon stocks from satellite imagery to establish reference emission levels (REL), the ex-ante land demand allocation model will project the REL (BAU) scenario into the future to preview deforestation and degradation trajectories and identify potential areas for emission reductions through improved protection or reforestation.

Photo: Lothar Linde

Protected Area	Area (ha)	Scenario 1 (ha)	%	Scenario 2 (ha)	%
Ngoc Linh	19,173	611	3	1,108	6
Phu Ninh	31,000	3,884	13	7,601	25
Que Son	18,605	309	2	5,390	29
Sao La 1	8,034	7	0	784	10
Sao La 2	9,993	55	1	894	9
Song Thanh	85,594	2,510	3	4,653	5
Total	**172,398**	**7,376**	**4**	**20,430**	**12**

Figure 7.
Table showing potential deforestation in protected areas, by land demand scenario.

APPLICATION 2

MAPPING LAND SUITABILITY FOR SUSTAINABLE INVESTMENTS

Spatial Multi-Criteria Assessment (SMCA) for Lao PDR rubber plantations

Over the past two decades, the GMS has experienced significant economic growth. Much of this growth is generated by domestic and foreign direct investments into the agriculture (particularly rubber and biofuels), forest, mining and energy sectors – all of which heavily depend on a healthy and abundant provision of ecosystem goods and services.

With investment volume increasing, and much of the land and natural resources already being allocated, finding suitable areas for additional investments becomes increasingly challenging. Remaining resources may not be of optimal quality and economic opportunity, and additionally, are likely to fall into remote and vulnerable areas that impose higher environmental and social costs. Additionally, the increasing density of sector investments also requires factoring in the cumulative impacts of new investments on existing ones (e.g. impacts of a logging operation in the catchment of a hydropower dam). If this increased complexity is not appropriately considered and addressed in planning and allocating future investments, they might be placed in areas that yield more costs than benefits to both the investor and society.

To address these issues with suitable planning tools, EOC has taken steps to increase awareness and build conceptual and technical capacity on Spatial Multi-Criteria Assessments. This tool is based on collating and structuring knowledge from non-spatial experts in a hierarchical way (the building of a criteria tree), which is subsequently translated into a map using a GIS. Regardless of the planning question, it follows the same key steps:

Figure 8. (previous page)
Rubber concessions are a core focus of foreign direct investments in Lao PDR and a source of significant and growing land demand (Photo: Stephen Griffiths)

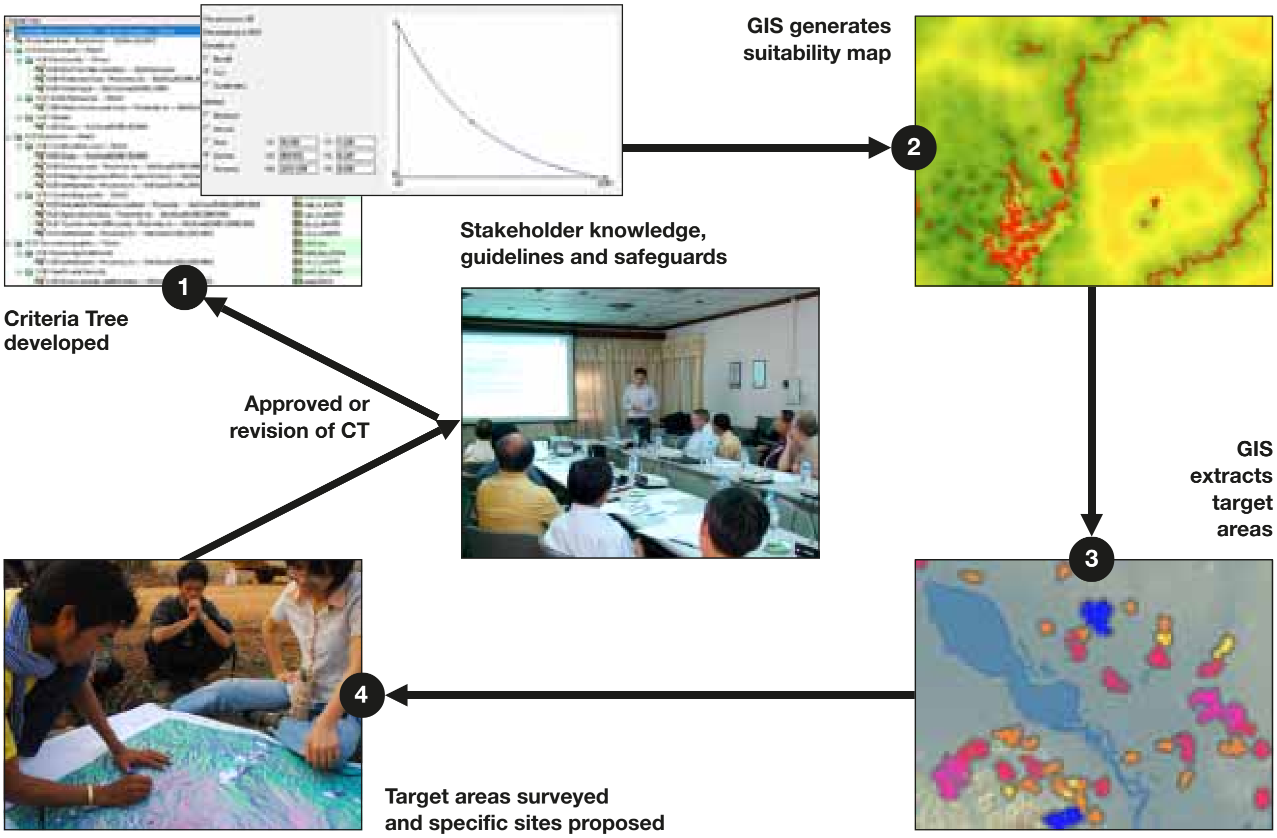
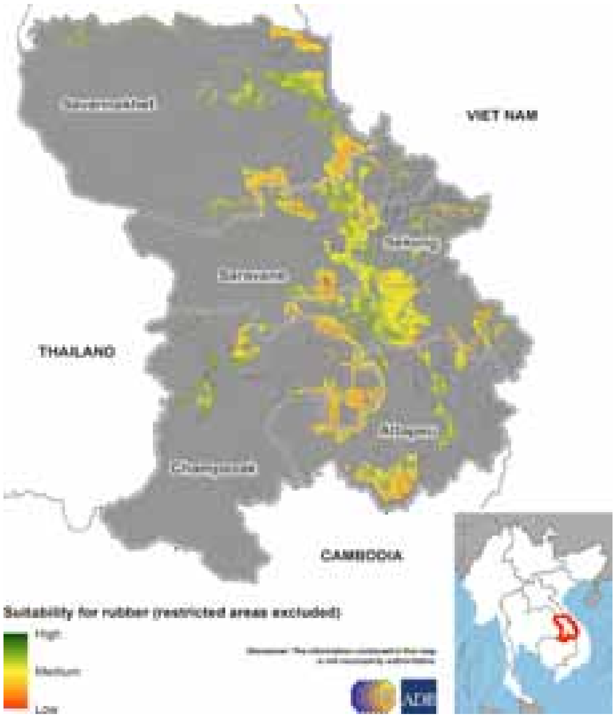


Figure 9. (below)
SMCA process



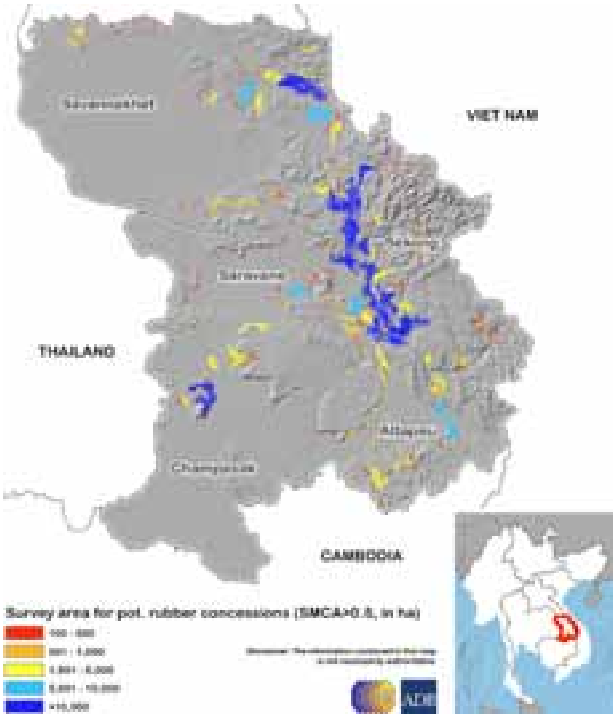


Figure 10. (above left) Map showing the outputs of the SMCA for rubber plantations in southern Lao PDR

Figure 10. (above right) Map of SMCA outputs, filtered by high suitability and size of area.

1. Formulate the planning question (e.g. Where are the most sustainable areas for rubber plantations located?);
2. Identify suitability and vulnerability factors to be considered (e.g. soil fertility, accessibility, slope, existing land use, existing level of protection);
3. Identify areas that should not be considered in the assessment (i.e. due to existing land use restrictions such as within protected areas);
4. Group the remaining factors into thematic categories (e.g. economic factors, environmental factors, social factors);
5. Rank and weigh the factors according to their relative importance or national priority (e.g. economic: 50 percent, environment: 20 percent, social: 30 percent)
6. Define the suitability range for each factor (e.g. accessibility: only if within 20 km to market, slope: only if slope is between 10-25 degrees).
7. Connect each factor with a GIS layer to establish the geographic reference (e.g. digital slope model).

Executing this geographic criteria tree in a GIS (Figure 9, steps 2 and 3) produces a feasibility layer that integrates economic suitability with environmental and social vulnerability and its associated cost implications. Such a layer provides planners with a comprehensive picture of opportunities and implications, reducing the risk of suboptimal allocations for specific investments and maximizing the opportunities between competing sectors.

This functionality was demonstrated in a pilot application on demand for rubber concessions in Lao PDR. A cross-institutional expert group comprised of WREA, MAF, NLMA, MEM and the NTA was formed and jointly developed a criteria tree for rubber plantations. Non-governmental and international stakeholders such as WWF, UNDP PEI, NCCR and SUFORD were asked to provide additional inputs. The final criteria tree was implemented in a GIS and maps highlighting potential areas for rubber investments were produced. These materials were used as a base for a GIS ‘training of national trainers’, who then applied their knowledge on conceptual design and implementation to the provincial level, conducting an awareness raising event in Savannakhet Province in June 2010.

Use of SMCA in NSEC, EWEC, and SEC

Aside from feeding into land demand allocation models, SMCAs can be tailored to enrich almost any environmental analysis. For instance, in the SEA of the North-South Economic Corridor (NSEC) Strategy and Action Plan (SAP), SMCA was used to explore the optimal alignment of the NSEC road (Lao PDR section) using a least-cost path calculation on an aggregated suitability layer. SMCA was also demonstrated as a tool to identify broader target areas for Jatropha plantations in Cambodia, and to identify the potential for carbon sequestration as part of the Carbon Neutral Transport Corridor feasibility study.

Photo: Jiao Xi

APPLICATION 3

ASSESSING BIODIVERSITY CORRIDOR VALUES

Modeling Species Distribution and Threats in Tenasserim, Thailand

The Biodiversity Conservation Corridors Initiative (BCI) is the flagship initiative under the Core Environment Program (CEP). Since its inception, six conservation corridor pilots have been established, reconnecting important protected areas across the GMS. Local communities were actively involved in restoring ecosystem connectivity, and alternative income opportunities were developed to maintain these achievements and improve local livelihoods at the same time.

An important pillar of this success, and critical prerequisite for further investments, is the establishment of a site monitoring system that assesses the state of the ecosystem, tracks changes and improvements, and identifies ecosystem service benefits provided to local livelihoods and sector investments (e.g. hydropower, tourism) alike.

A particularly successful example for establishing such a monitoring system is the Tenasserim BCI Pilot Site in Thailand. Here, the Department of National Parks, Wildlife and Plant Conservation (DNP), and the Wildlife Conservation Society (WCS) Thailand teamed up and successfully implemented a comprehensive, GIS-based assessment of the site characteristics and values, staggered into three consecutive steps:

1. Landscape-wide forest and land-use classification (10 classes) from recent satellite imagery, identifying the extent of habitats, habitat fragmentation and potential corridor strips or stepping stones (Figure 11);
2. GPS field surveys to point-map the incidence of landscape species and threats in the corridor zone. Landscape species mapped included Asian elephant, Gaur, Serow, Great Hornbill, Common Muntjac, Indochinese tiger and leopards and Sambar. Human utilization and threats recorded include NTFP collection, hunting, tree cutting, encroachment and domestic animals;
3. Extrapolation of the point survey data to get an estimate of the distribution and abundance of landscape species and intensity of human threats within the corridor area (maximum entropy method for modeling geographic distributions with presence-only data).

The results were used to delineate a conservation corridor with a total coverage of 787 km^2. A further division of the corridor into land use management zones was undertaken based on the percentage of remaining primary forest (PF) per grid cell (maintenance: >50 percent PF, regeneration: 1-50 percent PF, restoration: <1 percent PF). These management zones are the essential building blocks for corridor planners to direct their interventions to improve connectivity for key landscape species (Figure 12).

Such an elaborate GIS baseline assessment has to be complemented with long-term wildlife and threat monitoring, to measure and document the success of the BCI concept. DNP and WCS identified local staff already familiar with undertaking occupancy surveys, and plans to conduct these surveys for 16 and 68 cells and sub-grid cells, respectively, every two to three years. Other stakeholders, including local communities, national and local government agencies, and non-government organizations, will be actively involved in these tasks to build ownership and commitment.

Identifying forest fragmentation in biodiversity corridors

As part of the Biodiversity Conservation Corridor baseline assessment and monitoring, EOC has also used GIS to measure forest cover, road density and forest fragmentation in the BCC Sites of Cambodia, Lao PDR and Viet Nam. Forest cover was calculated from Landsat ETM (2001, 30m resolution) and SPOT XS (2010, 10m resolution) using a mix of supervised and unsupervised classification techniques. Road density was derived from road network GIS layers produced by national government agencies. To calculate forest fragmentation, dense forest patches in BCC Sites (2001 and 2010) were intersected with the road network GIS layers, producing a layer on large-scale forest fragments. Comparing the fragmentation in 2001 (Landsat) with the initial results of the 2010 classification (SPOT) suggests that large-scale forest fragmentation has not significantly increased in BCC Sites (compared to 2001 levels). Final conclusions on forest fragmentation will be drawn after ground verification and refinement of the forest cover classifications and the inclusion of updated national road datasets produced and provided by national line agencies.

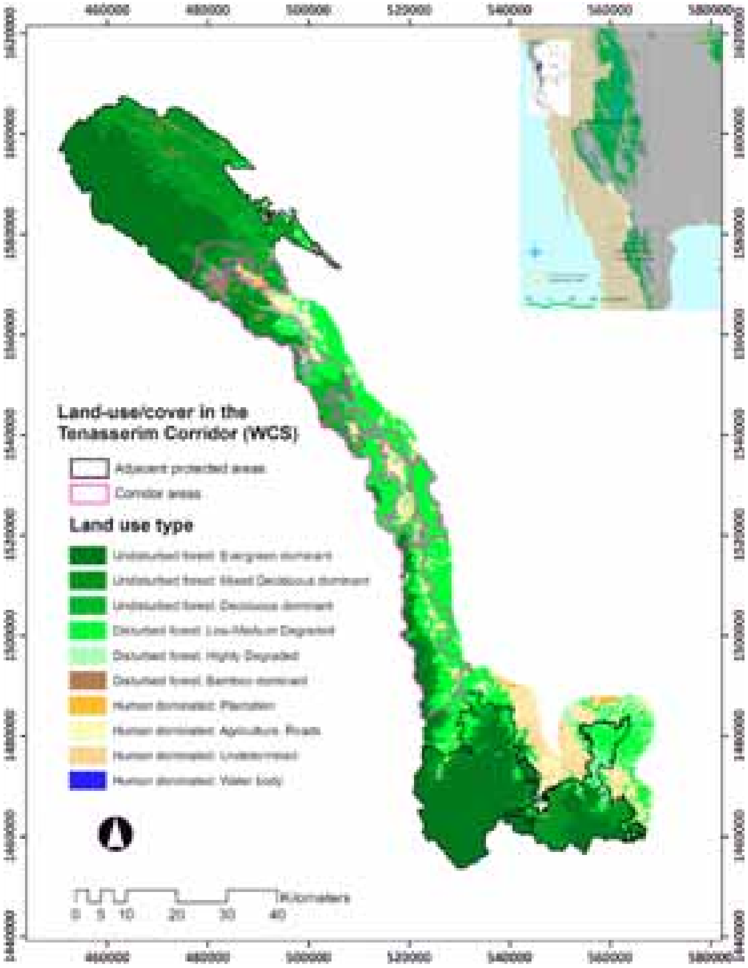


Figure 11. (above)
Land cover/use in the Tenasserim Biodiversity Conservation Corridor, Thailand, 2009

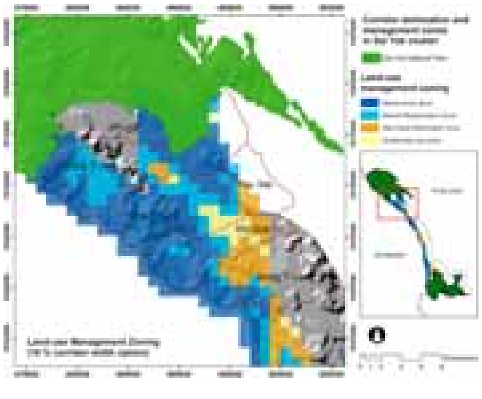


Figure 12. (right)
Model-based corridor delineation and management zones, Sai Yok cluster of the Tennasserim Biodiversity Conservation Corridor, Thailand

APPLICATION 4

IMPROVING COLLABORATION ON MONITORING AND EVALUATION

Mapping development activities

In order to design appropriate technical assistance and well-targeted investment projects, planners need to:

1. review lessons learned from past projects,
2. connect with ongoing projects, and
3. integrate efforts with projects and initiatives of other development agencies.

Being able to efficiently access key information on past, present and planned projects is a critical prerequisite to time-efficient and sound project design. This has direct implications on the success of later project implementation and delivery of expected impacts and outcomes.

At present, reviewing project portfolios to identify strategic priorities, synergies and conflicting investments remains time

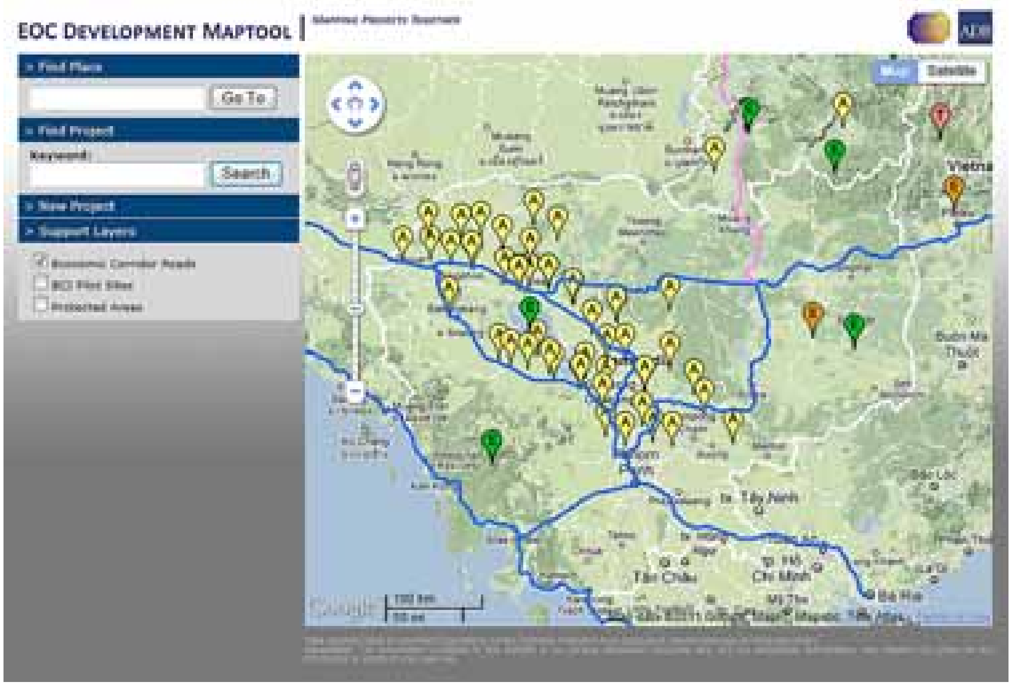
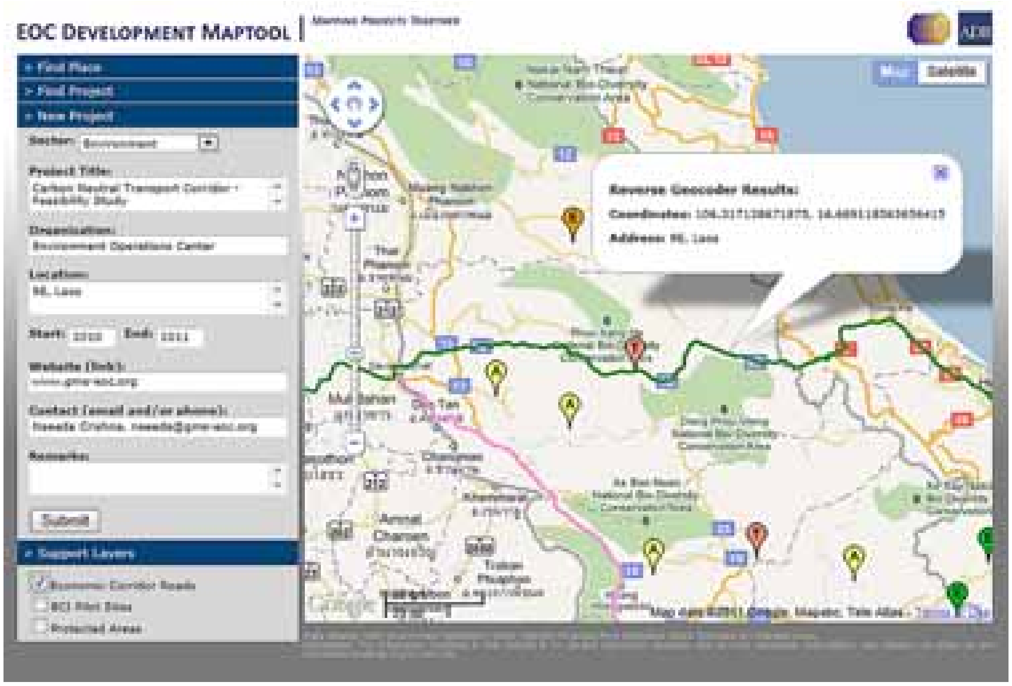


Figure 13.
DevMap showing the ADB profect porfolio

Figure 14.
DevMap: An attached feedback form allows users to actively map and update their projects



Sector: Environment

Project Title: Carbon Neutral Transport Corridor - Feasibility Study

Organization: Environment Operations Center

Location: [illegible] Laos

Start: 2010 End: 2011

Website (link): www.gms-eoc.org

Contact (email and/or phone): Naeeda Crishna, naeeda@gms-eoc.org

Remarks:

☑ Economic Corridor Roads
☐ BCI Pilot Sites
☐ Protected Areas

Reverse Geocoder Results:
Coordinates: [illegible]
Address: [illegible] Laos

consuming. Existing database designs and formats are often cross-institutionally and even inter-departmentally incompatible, making easy access and direct comparison of information difficult. They are also often lacking simple user interfaces that allow planners to directly browse the database 'on demand' and engage in its maintenance (add projects, update projects). Last but not least, geographic location is often not recorded, losing out on a simple but important first measure on overlaps, duplications, and synergies with other projects.

One solution to some of these challenges is to combine an interactive web-map interface with a server-side database. While the web-map interface serves as a geo-reference to identify project locations, feedback forms allow the user to input additional information on the project and submit project location and description to the database. From this database an activity layer is generated each time a project is added or updated, and automatically overlaid on the interactive map for easy browsing of the information. Additional support information such as economic corridor roads can be overlaid to increase geographic detail and context. EOC has designed such an application and deployed it as the 'Development Maptool' – or DevMap – during COP-10 in Nagoya, Japan in October 2010.

DevMap makes cross-institutional project planning and coordination easier in several ways. Firstly, it provides an intuitive map interface that facilitates identification of potential synergies and conflicts early on in project planning. Furthermore, DevMap not only provides browsing functionality, but enables the user to add and update information in real time. DevMap focuses on key information to keep feedback forms short and individual effort low. Lastly, the application is cost-neutral: the client accesses it through a website without any software installation required.

Considering the flexibility of the application design, the code can be easily customized to target other stakeholders and their mapping and monitoring requirements. It was adapted for the mapping and monitoring of rural health facilities, and for the interactive display of environmental and social indicators. Potential future applications could include the mapping and documentation of soil quality (agriculture sector), construction material sites (transport sector), and forest quality/carbon stocks (REDD).

APPLICATION 5

VISUALIZING GEOGRAPHIC INFORMATION

Web-based interactive atlas of the Greater Mekong Subregion

Static overlay maps have been an important part of the work of the CEP-BCI since planning started in 2004. They were used, for instance, to assess the distribution of biodiversity values and threats for biodiversity corridor establishments, visualize the risks of development activities on eco- and ethno-tourism assets, show the distribution of forests in hydropower catchments, and identify vulnerable areas along economic corridor roads. More than 1,000 maps have been produced and have supported planners in making more informed decisions as part of ex-ante SEAs, BCC establishment, and ex-post performance monitoring.

When it comes to flexibility, however, static maps have limitations. They require dedicated software to handle and view geographic data. Skilled staff are required to collect GIS information first, and then produce maps with the help of this software. And even if published in reports and atlases, static maps and the information they contain cannot be adjusted and customized by other users to fit their own requirements. As a result, the use of static maps often remains limited to a single application, despite the fact that their information is often relevant for supporting other projects and the questions they need to answer.

EOC is bridging this gap by integrating its Desktop GIS with server capabilities (hardware and software) that can translate geographic datasets into dynamic layers for distribution on the internet. This GMS Interactive Atlas consists of three distinct tiers:

Tier 1 – Subregional Atlas: contains geographic layers that cover the entire GMS. It complements the 2nd GMS Atlas of the Environment and will be maintained and updated by EOC as new data becomes available (Figure 15). Tier 1 is aimed at the general public and professionals looking for broader economic, environmental and social benchmarks.

Tier 2 – Country Atlases: holds more detailed national datasets, delivered as country packages, and stacked on top of the Subregional Atlas (Tier 1). It allows for a more detailed assessment of conflicts, synergies and opportunities, and aims to provide WGE focal ministries with geographic information for day-to-day planning purposes. NSUs and EOC will keep these country atlases up to date, and access will be granted to WGE, WGE approved users and EOC.

Tier 3 – Activity Atlases: presents national and subregional GIS outputs produced by individual CEP-BCI activities, for instance satellite image classifications in BCI corridors, BCI field survey results (GPS tracks), land demand allocation maps, or SMCA layers. Tier 3 will be stacked on top

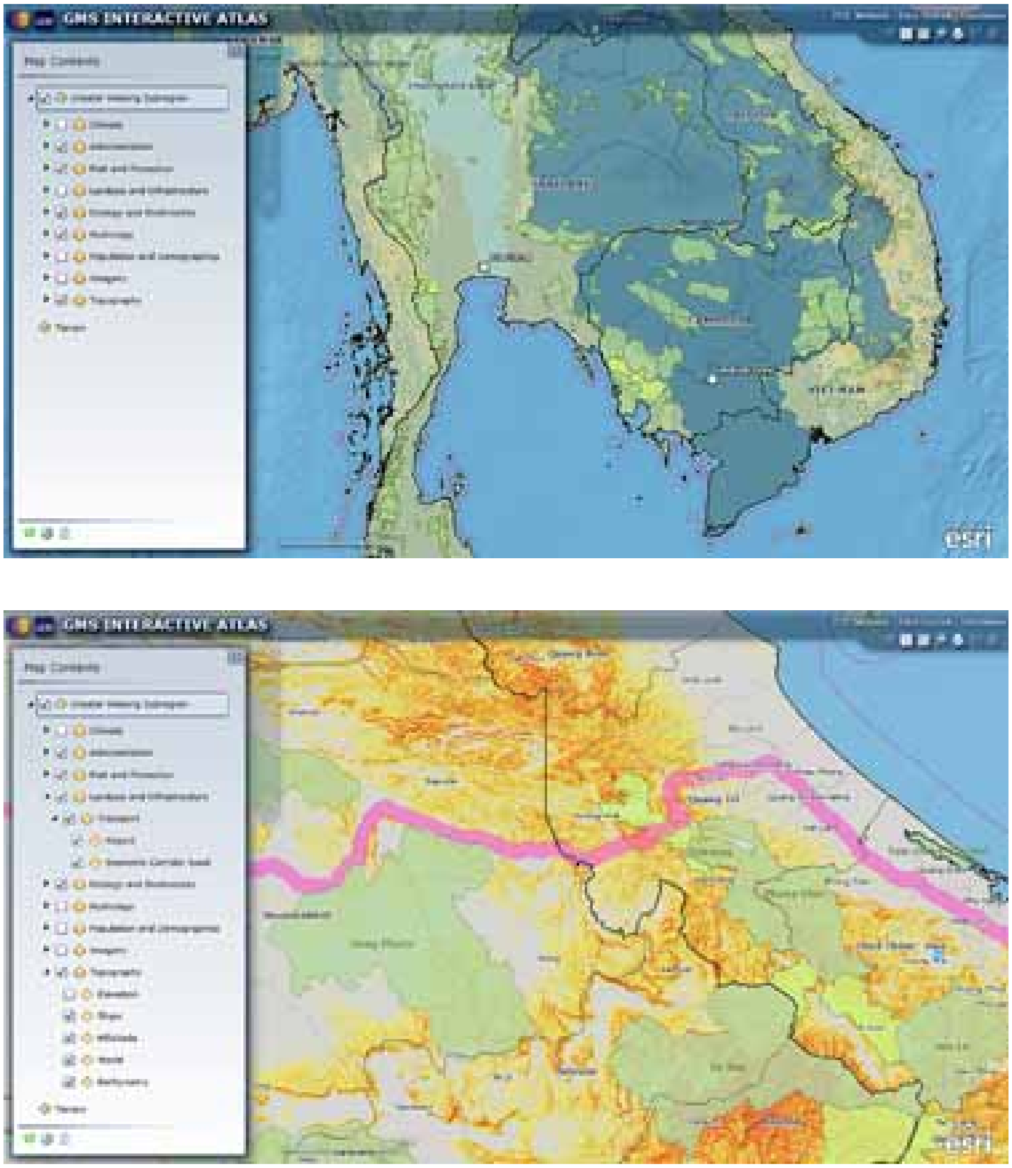


Figure 15.
GMS interactive atlas (work in progress)

of Tier 1 and/or 2 depending on the individual requirements of the activity. Access will be limited to WGE, WGE approved users and EOC.

The GMS interactive atlas is built on the ArcGIS Application Programming Interface (API) for Microsoft Silverlight, providing a seamless, feature rich browsing experience. It is accessible through any internet browser without the need for installing dedicated stand-alone software. The initial functionality of the GMS interactive atlas features browsing and querying, which will be upgraded incrementally with basic geoprocessing tools to allow more experienced users to perform simple analytical tasks.

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