REDD-PAC

(REDD+ Policy Assessment Centre)

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REDD-PAC Partner Information

List of Beneficiaries / Deliverable Lead				
Beneficiary Number	**Beneficiary name**	**Beneficiary short name**	**Country**	**Deliverable Lead**
1 (Coord.)	International Institute for Applied Systems Analysis	IIASA	Austria	**X**
2	United Nations Environment Programme World Conservation Monitoring Centre	UNEP-WCMC	UK	
3	Instituto Nacional de Pesquisas Espaciais	INPE	Brazil	
4	Central African Forest Commission	COMIFAC	Cameroon	

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1. Introduction

Reducing Emissions from Deforestation and Forest Degradation, plus conservation and enhancement of forest carbon stocks and sustainable management of forests (REDD+) has become a major component of continuing negotiations under the United Nations Framework Convention on Climate Change (UNFCCC). REDD+ aims to achieve sustainable and efficient emissions reductions through the generation of measurable, reportable and verifiable (MRV) REDD+ credits that are linked to a robust financing regime. Policies for implementing REDD+ will potentially have major impacts on land use, which in turn are likely to affect biodiversity and ecosystem services. Hence, understanding land use change processes and how different REDD+ policies are likely to influence land use change is essential for enabling development of REDD+ policies that safeguard and enhance biodiversity and other ecosystem values and help countries to meet the objectives of the UN Convention on Biological diversity (CBD).

Implementation of REDD+ potentially requires a wide range of policies and activities. Such REDD+ programmes have the potential to deliver multiple benefits, including ecosystem services and social benefits, and also carry some social and environmental risks. Recognition of these has prompted the UNFCCC to put in place safeguards for REDD+, which highlight some specific risks and include a request to 'enhance other social and environmental benefits' (UNFCCC 2010). An increasing number of countries are interested in planning for multiple benefits from REDD+, and in anticipating its potential impacts, including on biodiversity.

Currently, there is a lack of capacity and technical know-how on issues that will ensure the efficiency, effectiveness and environmental integrity of REDD+ implementation, ranging from the development and implementation of methodologies for identifying reference emissions levels for REDD+ to basic planning for multiple benefits and the operationalisation of safeguards. Consequently, there is a need for support to countries on REDD+ and land use planning in relation to biodiversity objectives. This includes assistance in undertaking initial spatial analyses on potential benefits, as well as in developing high quality, spatially explicit assessments of the impacts of REDD+ policy options, in relation to the safeguards negotiated under the UNFCCC and the objectives of the CBD.

REDD-PAC will help support countries in REDD+ planning by refining a global land use model (GLOBIOM) for use in scenario analysis of land use changes under different

REDD+ policies, with a focus on Brazil and the member countries of the Central African Forests Commission (the Congo Basin). Analyses will take account of existing land use policies and will assess the effects of incorporating biodiversity conservation priorities into REDD+ planning. The land use change outputs of the model will be used to assess the economic and biodiversity impacts of different REDD+ policy options, and their potential role in contributing to progress towards specific goals, such as the CBD's Aichi Biodiversity Targets, economic growth or food security.

Furthermore, the project will act as a global forum for sharing and improving global data on forests and deforestation drivers, developing methodologies for determining reference levels and best practices for national REDD+ modelling, as well as more general land-use planning. The project will also support work on multiple benefits from REDD+ with national partners in a further six countries (China, Ecuador, Peru, the Philippines, Uganda and Vietnam). This work will draw on spatial analysis of potential benefits from REDD+ and will be tailored to the specific needs of each country, and therefore will vary amongst them.

2. Broad scientific questions

2.1. General REDD+ related issues

Countries face several challenges in developing their REDD+ programmes. These challenges include establishing reference levels and understanding the likely impact of different policy options in order to identify appropriate REDD+ policies.

Regardless of the specific form of the REDD+ mechanism, the emissions reductions achieved by a country will need to be assessed against reference levels that estimate the likely emissions without REDD+ activities. Determining appropriate emissions reference levels presents a challenge for many countries. There are several possible methodologies for setting reference levels and the use of different options is likely to have implications for the climate effectiveness, cost efficiency, and distribution of REDD+ finance among countries. Options for setting reference levels include extrapolation of historical rates, adjustment to these rates based on economic development or position on the forest transition curve, and model-based estimates of forest loss under business as usual scenarios. Each of these approaches has its own advantages and difficulties.

As a wide range of different policies and actions could be implemented to achieve REDD+ outcomes, another challenge for countries is identifying their possible policy options. Countries need to choose not only how to balance their efforts amongst the five activities recognized within the UNFCC[1] but also how best to carry out those activities. Each of the different ways of implementing the activities is likely to have different impacts and effectiveness. Hence, there is a pressing need to assist nations with high quality assessments of the potential impacts of REDD+ policies. Understanding the impact of different policy options will help support countries in selecting specific REDD+ policies from among the many options. The economic, social and environmental implications of REDD+ are likely to be variable depending on the specific policy options chosen.

The choice of policies will depend on the countries' aims both for REDD+ emissions reductions and for wider benefits from REDD+ . Such potential benefits include socio-economic benefits such as poverty reduction and secured land tenure, and environmental benefits such as biodiversity conservation, protection of water resources and soil stabilisation. Specific REDD+ policies may be chosen to achieve specific benefits, for example by prioritising the conservation of forest carbon stocks in important watersheds in order to maintain water quality, or by facilitating adoption of new technology by farmers in order to reduce demand for new agricultural land.

Achievement of emissions reductions depends on the reference levels chosen, the objectives set and the effectiveness of the policy options selected. The use of GLOBIOM will allow an explicit representation of the trade-offs between different land uses through a multi-sectorial approach and the corresponding assessment of REDD+ opportunity costs. Land heterogeneity is taken into account through agriculture and forestry potentials based on bio-physical characteristics, market accessibility and carbon content. Application of an approach such as GLOBIOM for modeling business-as-usual land use change also avoids artificial inflation ("hot air") of deforestation levels. Furthermore, the global framework helps to resolve uncertainties on the potential impacts of different REDD+ policy options due to displacement of production

[1] The five activities proposed for UNFCCC REDD+ are (i) reduced deforestation and degradation of forests, (ii) sustainable forest management, (iii) forest-carbon enhancement, (iv) forest conservation, (v) capacity building and ongoing monitoring.

between countries. Indeed, it ensures that external drivers of deforestation are taken into account since pressures on forests could be driven by external demand. For instance, deforestation in a first country may be a response to the implementation of a REDD+ policy in a second country, the demand for agricultural or forest products in the second country being met by the supply from the first country Being able to identify the potential for such 'leakage' is critical to the development of effective policy options.

Economic development and poverty alleviation are priorities both in Brazil and the Congo Basin. As such, REDD+ policies must be analyzed in the context of the overall regional development.

REDD+ has the potential to help conserve forest biodiversity. However, the biodiversity impacts of REDD+ policies are likely to extend beyond forests, through intensification or displacement of certain types of land use and associated pressures. Such indirect impacts are a source of uncertainty in evaluating REDD+ policy options. They may increase pressures on low carbon forests and other ecosystems, including those valuable for biodiversity conservation (e.g. Cerrado in Brazil). Therefore, understanding the potential impacts on land use both within and outside REDD+ areas is essential for assessing REDD+ impacts on CBD objectives.

The need to promote and support the UNFCCC safeguards, as well as other international commitments including the CBD's Aichi Biodiversity Targets may also influence policy selection. Four of the Aichi Targets are particularly relevant to REDD+:

- **Target 5**: By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.
- **Target 11:** By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.
- **Target 12:** By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained
- **Target 14**: By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.

REDD+ policies may contribute to achieving CBD objectives, including these targets. However, assessing the potential for this is made more challenging by the lack of standardised ecosystem service and biodiversity data and methodologies.

REDD+ implementation also faces challenges at the international level in ensuring the equity and the transparency of the REDD+ architecture. More specifically, it is crucial that REDD+ credits are fairly allocated. Enabling access to high-quality, independent and globally-consistent methods for policy assessment could help ensure equity and transparency. Additionally, equity and transparency may be increased if countries are enabled to share consistent data about deforestation patterns, key economic drivers, protected areas and biodiversity priority areas. There is also a pressing need for access to standardised methodologies for determining reference levels and leading national REDD+ policy assessments.

2.2. Brazil specific issues on REDD+

2.2.1. The Brazilian experience with deforestation

The Brazilian Amazonian rain forest occupies an area of 4,100,000 km^2 where 720,000 km^2 have been deforested since the 1970s (INPE 2010). In the 1960s and 1970s, government policies and subsidies promoted migration into the Brazilian Amazon region in a bid to populate the region and integrate it into the rest of the country. After the 1990s, migration continued, as did the deforestation, largely because of private investments in agricultural expansion, associated with large-scale cattle ranching, soybean cultivation, and small-scale subsistence farming (Becker 2005).

Human occupation in Amazonia follows concentrated patterns along the axis of rivers and roads that connect the region to the Centre and South of Brazil (Alves 2002; Aguiar, Câmara et al. 2007). Deforestation occurs close to previously occupied areas, following a spatially dependent pattern. This leads to a fragmentation of the Amazon forest with population being scattered by large forest masses which could include indigenous lands and conservation units.

Deforestation has followed different paths across Amazon states. From 1990 to 2005, migrants from the South of Brazil cut 110,000 km^2 of forest in Mato Grosso. From 1970 to 1990, the state's population trebled from roughly 600,000 to 2,000,000 people. Better market connections and a mixture of forest and *cerrado* (savannah) areas have favoured large-scale agriculture. In 2008, 15 million tons of soybeans have been produced in Mato Grosso accounting for 25% of Brazilian total soybeans production.

To the contrary, the other states Amazonian states do not contribute significantly to grain production. In Pará and Rondônia, cattle ranching plays a significant role in deforestation. The Brazilian herd grew from 147 million heads in 1990 to 200 million in 2007 to become the world's largest commercial cattle herd. Most of this expansion (83%) occurred in the Amazon (Bowman, Soares-Filho et al. 2012). In Pará, cattle ranching is combined with large-scale wood logging (Becker 2005) and both activities mainly occurred by illegal poaching of public lands, due to lax attitudes to law enforcement until 2005. INPE and EMBRAPA (Brazil's Agricultural Research Agency) recently showed that pasture accounts for 63% of the forest cuts in Amazonia up to 2008 (Table 1. Cattle ranches in Amazonia use extensive practices, with less than 1 head of cattle per hectare. Cash crop agriculture accounts for only 4% of the deforestation. More than 20% of the area has been abandoned and is now regrowing as secondary vegetation.

Table 1: Land use after deforestation in Amazonia (reference year: 2008)

Class	AREA (km^2)	
Clean Pasture	335.714,94	46,7%
Secundary Vegetation	150.815,31	21,0%
Dirty pasture	62.823,75	8,7%
Regeneration with pasture	48.027,37	6,7%
Non-observed areas	45.406,27	6,3%
Agriculture (large-scale)	34.927,24	4,9%
Small farms and settlers	24.416,57	3,4%
Urban areas	3.818,14	0,5%
Mining	730,68	0,1%
Degraded areas	594,19	0,1%
Others	477,88	0,1%
Deforestation 2008	11.458,64	1,6%
TOTAL	719.210,99	

Much degradation in Amazonia could have been avoided had there been better law enforcement. Land rights in Amazonia are different from most other countries. The land is mostly state-owned and occupying it needs concessions from the State. After a farmer gets a concession, Brazilian law mandates landowners to set aside part of their farms for forest preservation. Brazil's Forest Code, passed in 1965, states that farmers have to keep 50% of the area of native forests in their properties. In 1986, the government increased protection to 80% of the forest area. But in practice, farmers ignored the law, cutting much more than allowed, resulting in large deforestation rates during the 1990s and early 2000s.

Under significant external and internal pressure, the Brazilian Federal Government changed its policies for Amazonia. In 2004, the government launched the Action Plan for Prevention and Control of Deforestation in the Legal Amazon, which directed different government institutions to act in an integrated way. Brazil set up a combined effort of improved satellite monitoring, increased law enforcement, and creation of protected areas in 2005., In 2008, reacting to a surge in deforestation, the government imposed restrictions on bank credits. These actions brought about a significant drop in deforestation rates, from 27,000 km^2 in 2004 to 6,500 km^2 in 2011 (INPE 2010).

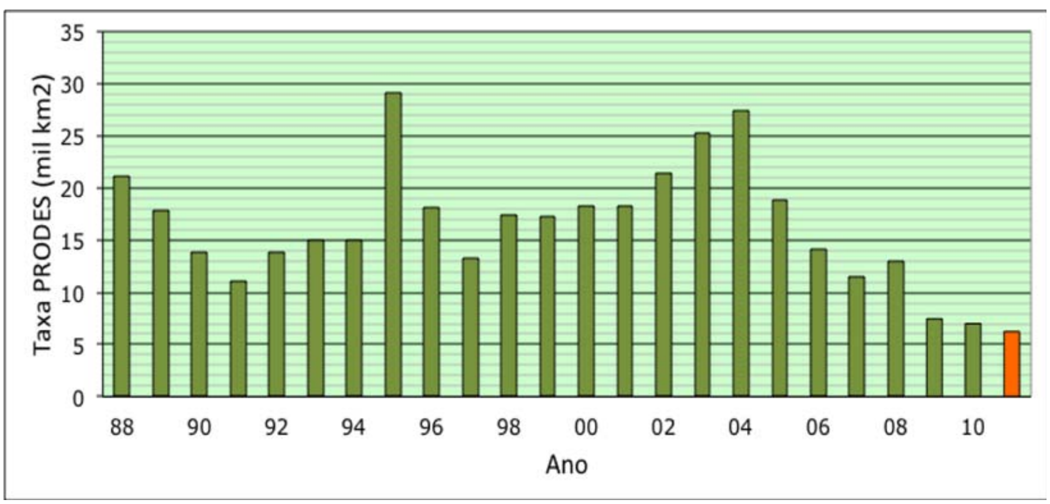

Figure 1: Yearly deforestation (clear-cuts) in Brazilian Amazon monitored by INPE (1988-2011)

Part of the private market and consumers also reacted to the external and internal pressure for action. Greenpeace and ABIOVE (Brazilian Association for Vegetable Oil) signed an agreement in 2006 (the "Soy Moratorium"), whereby ABIOVE member companies pledged not to trade soy originated after July 2006 in deforested areas within Amazonia. The "Soy Moratorium" has been renewed yearly since 2006. More recently, there has been growing pressure from Brazilian public attorneys to certify timber and beef products by the market chains.

During the period 2005-2010, when the deforestation rates fell significantly, there was also a variation in the national and international prices of soybeans and meat. These prices fell from 2004 to 2007 and recovered in the period 2007-2010. However, a recent study states that approximately half of the deforestation that was avoided in the Amazon in the 2005 through 2009 period can be attributed to conservation policies introduced in the second half of the 2000s (Assunção, Gandour et al. 2012).

These positive results led the Brazilian government to include ambitious deforestation reduction goals in the National Law on Climate Change, passed in 2009. The law uses the average rate for the period 1996-2005 as a baseline scenario for deforestation. It sets a target of 80% deforestation reduction in Amazonia for the period 2006-2020, relative to the baseline (Figure 2).

Figure 2: Brazil's projected reduction in deforestation (green bars) and actual rates (brown bars) measured in km² per year

2.2.2. Future challenges

Most of Brazil's success in reducing deforestation in Amazonia was brought about by a combination of monitoring and law enforcement. Most of Brazil's public opinion supports the government's actions, but there was a negative reaction in the rural areas. In Brazil's Congress, the rural areas have a disproportionate share of seats, a relic of the country's military dictatorship period (1964-1985). Given the skewed proportional representation in Brazil, environmentalists have much less power in Congress than they have in public opinion. This led to a legislative proposal to reform Brazil's Forest Code to reduce the rigour of the current legislation. The new Forest Code is under discussion on Brazil's Congress, and the resulting piece of legislation will have much influence on future environmental policy. Thus, one of the objectives of the REDD-PAC project in the Brazilian case is to examine the new policy scenarios after the new Forest Code becomes law.

The new Forest Code and resulting policies will have a significant impact on the design of REDD+ policies in Brazil. Brazil has already fixed its baseline and its targets for reduction until 2020 and the country has a reliable MRV system. It is important to discuss what policies are needed to meet the targets set by the Brazilian government. One of the aims of the project is to study whether REDD+ has a role to play in Brazil as an incentive system so that the targets can be met. Also, the REDD-PAC project will analyse the impact of REDD+ in Brazil for recovery of the areas already deforested.

Consider that 720,000 km^2 have been deforested in Amazonia, that 20% of this area (150,000 km^2) is now abandoned and that 345,000 km^2 are used for extensive cattle raising. Part of this area can be set aside as a carbon sink, under conditions to be set up by agreement between the government and private landowners. In a scenario in which 40% of all clear-cut areas is allowed to regrow without being cut again from 2015 onwards, Amazonia could become a net carbon sink by 2020 (Aguiar, Ometto et al. 2012).

We have also to consider an alternative scenario, where the new Forest Code reduces the government's capacity to act against deforestation practices. Therefore, the REDD-PAC project will consider what are the possible trade-offs and options for REDD+ public policies in Brazil, which could lead to different futures.

Finally, the analysis during the REDD-PAC project in the Brazilian case will have to keep track of the current discussion on the forms REDD+ strategies Brazil will adopt. For the voluntary market of carbon credit, the Brazilian government is not necessarily going to create restrictions. Therefore, carbon compensations between an international private entity, for example, and a community or a private entity in Brazil will probably be allowed.

For carbon compensations between countries, on the other hand, the Brazilian government is determined to keep the transactions at the Federal government level. It is likely that land use policies aimed at GHG emission reduction will be considered as REDD+ initiatives. A topic under discussion is whether the federal government will implement only directly the main REDD+ initiatives (in the form of policy instruments), or it will also foster more decentralized instruments, implemented by state governments, by municipality governments, or by communities or private entities. Nevertheless, the Brazilian REDD-PAC project has in its agenda taking into account the main government initiatives for forest-based GHG emission reduction; therefore, there is a perfect alignment between the project goals and directives and the Brazilian preliminary strategy for REDD+ implementation.

2.2.3. Biodiversity considerations for REDD+ in Brazil

As an active signatory to the Convention on Biological Diversity, Brazil has a number of biodiversity related commitments, including through the CBD's Aichi Biodiversity Targets and its own National Biodiversity Strategy and National Biodiversity Policy. It is in the process of agreeing new national biodiversity targets. Like the Aichi targets, these will include targets relating to ensuring areas important for biodiversity are adequately included within protected areas and reducing the rate of deforestation and other habitat loss, as well as avoiding extinctions and improving the status of threatened species. Exploring the potential for REDD+ implementation to affect the extent of forests and other ecosystems, as well as the status of their component species, is very relevant to ensuring that REDD+ supports the implementation of the National Biodiversity Strategy and the National Biodiversity Policy and the achievement of national and international biodiversity targets.

The Ministry of the Environment (MMA) has identified priority areas for biodiversity conservation in each of its six terrestrial biomes. REDD+ can support or impede the achievement of conservation objectives in these areas. The potential for displacement of land use pressure from forested zones, including the Amazon, to less forested but biologically important biomes such as the Cerrado is of particular concern. Identifying the degree to which different approaches to REDD+ may have such impacts can support the design of REDD+ policies that help to achieve and avoid compromising biodiversity conservation objectives in all biomes.

2.3. Congo Basin specific issues on REDD+

The Congo Basin countries have expressed strong interest in Reducing Emissions from Deforestation and Forest Degradation (REDD) since the Conference of Parties to the UNFCCC in Bali in December 2007, when the international community recognized the concept of REDD as a significant opportunity for climate change mitigation in developing countries. Because ecosystems of the Congo Basin forest have not yet suffered the damage observed in many other regions of the world, they are quite well-preserved along with an extraordinary biodiversity. This is due to a low impact of the development policies implemented for a long time and, since almost a couple of decades, the adoption and effective implementation of policies and practices for a sustainable forest management. The Congo Basin countries are therefore referred to as “high forest cover, low deforestation” countries. While the total forest of the 10 COMIFAC member’s countries is around 227 million ha (FAO, 2005), the rate of net deforestation in the Congo Basin is estimated at 0.17% per year during 2000 and 2005 (FAO, 2010).

However, the situation described above which is characterized by low historical rates of deforestation is most likely to change because of increasing pressure from a variety of forces, including oil and mineral extraction, road development, agribusiness, biofuels, in addition to agriculture expansion for subsistence and urbanization.

Congo Basin countries have a common position on REDD+ that other Parties involved in the REDD+ negotiations are well aware of. Although the REDD+ process is currently being implemented at a different speed in those countries, a regional approach is adopted in order to respond to strategic area 1 of the COMIFAC Convergence Plan[2].

[2] The Convergence Plan constitutes a common platform for priority actions, organized under 10 strategic areas, to be implemented at the sub-regional and national levels to ensure the follow-up of the Yaounde forest Summit resolutions. Strategic area 1 is related to “harmonization of forest and taxation policies” with three sub-areas: implementation of international agreements and conventions, harmonization of forest policies and harmonization of taxation systems.

Biodiversity considerations for REDD+ in the Congo Basin

All ten COMIFAC countries are signatories to the Convention on Biological Diversity and are therefore committed to contributing to the achievement of its Aichi Biodiversity Targets. The COMIFAC Convergence Plan also contains several axes of work on forests and biodiversity. REDD+ implementation could either benefit or hamper achievement of objectives under both these agreements, including Convergence Plan strategic areas 1 on the harmonisation of forest policies, 3 on management of ecosystems and reforestation, 4 on biodiversity conservation and 5 on 'sustainable valorisation' of forest resources. Exploring the implications of different REDD+ policies can support development of sound Congo Basin REDD+ policies that contribute to meeting these objectives.

An important biodiversity issue specific to the Congo Basin is the conservation of great apes. Most COMIFAC countries are also signatories to the Kinshasa Declaration on Great Apes, implemented through the UN-led GRASP (Great Apes Survival Partnership). The conservation of great apes is a pressing issue of global importance and the Congo Basin is a critical region for it, as it hosts all of the bonobo range and large parts of chimpanzee and gorilla ranges. Identifying potential impacts of REDD+ is critical to planning REDD+ activities that contribute to great apes conservation.

Beyond these regional agreements, the countries of the Congo Basin also have their own national biodiversity policies and objectives. The DRC recently completed its strategy for the conservation of biodiversity in protected areas, and is in the process of updating its national biodiversity strategy and action plan (NBSAP) in accordance with its commitments under the CBD. This multiplicity of national policy and legal contexts means that taking each country's objectives into account will be an additional challenge to the project in the Congo Basin.

3. Core project teams

3.1.1. IIASA

- **Michael Obersteiner**

Michael Obersteiner is leader of the Ecosystems Services and Management (ESM) Program at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria. He joined IIASA's Forestry Program (FOR) in 1993 and has been leading the Group on Global Land-Use Modeling and Environmental Economics since 2001. His background includes the fields of global terrestrial ecosystems and economics, specializing in REDD and REDD+ modeling as well as policy assessments with particular expertise on the tropical forest zones of South America, Africa and Asia. Michael Obersteiner's research experience stretches from plant physiology and biophysical modeling in the areas of ecosystems, forestry and agriculture to environmental economics, bioenergy engineering and climate change sciences as documented in his publications record. Since 2004 he substantially contributed to the developing, establishing and managing of the IIASA-ESM integrated modeling cluster which includes widely recognized global biophysical and economic models in the area of agriculture, forestry and land use (G4M, EPIC, GLOBIOM). During the past decade, Dr. Obersteiner has been the principle investigator at IIASA of more than 30 international projects covering diverse fields of different scales and numerous funding organizations. He has been the coordinator of three EU FP6/7. For the REDD-PAC project, M. Obersteiner will be the Project Coordinator.

- **Florian Kraxner**

Florian Kraxner has been Acting Deputy Program Leader of IIASA's ESM Program since January 2011. His background is in forestry with a specialization in mountain risk engineering and watershed management. Mr. Kraxner has been coordinator of IIASA's EU Projects for Carbon Sequestration Potentials, for Benefits through Global Earth Observation and for Climate Change & Terrestrial Adaptation & Mitigation in Europe. F. Kraxner will be helping to coordinate and manage the project.

- **Géraldine Bocquého**

Géraldine Bocquého is a Research Scholar at the ESM Program at IIASA. Her background is in life sciences and environmental and resource economics, with a special focus during her PhD on farmers' adoption of perennial energy crops under risk. Before joining IIASA, she was involved in the design and implementation of agricultural policies and programmes. For the REDD-PAC project, G. Bocquého will be responsible for the co-management of the project and will also contribute to the refinement of IIASA tools at the country level.

- **Aline Mosnier**

Aline Mosnier is a Research Scholar at the ESM Program at IIASA. Her background is in development economics with a special focus on trade policies and rural development. She has contributed to the development of the GLOBIOM model and to several GLOBIOM-related projects since 2008, in particular for Congo Basin countries. For the REDD-PAC project, A. Mosnier will work on the refinement of IIASA tools at the country level.

- **Steffen Fritz**

Steffen Fritz is a Research Scholar at the ESM Program at IIASA. He is the initiator and co-ordinator of Geo-Wiki.org, a global land cover validation tool based on crowdsourcing. He published in the field of earth observation, crowdsourcing, fuzzy logic, remoteness mapping, global and regional vegetation monitoring, crop yield and crop acreage estimations, and wild land research. For the REDD-PAC project, S. Fritz will be responsible for the improvement of the Geo-Wiki tool.

- **Petr Havlík**

Petr Havlík is a Research Scholar at the ESM Program at IIASA. He studied agricultural economics and developed specific skills in land use economics and spatially explicit optimization models. For the REDD-PAC project, P. Havlík will help with the development of the GLOBIOM model.

- **Hannes Boettcher**

Hannes Böttcher is a Research Scholar at the ESM Program at IIASA. He studied forest sciences and ecology, focusing on forest ecosystem modeling and information processing. Recently, Dr. Böttcher published research on the effects of different greenhouse gas accounting rules in the land use, land use change and forestry sector (LULUCF) with the help of land use models. He also assesses the potential of REDD and analyzes options for including it in a global climate agreement. He is currently a lead author of the IPCC Report "2013 Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol". In the REDD-PAC project, H. Boettcher will mainly help with forest management and carbon accounting issues.

- **Sylvain Leduc**

Sylvain Leduc is a Research Scholar at the ESM Program at IIASA. He is specialized in energy engineering and more specifically bioenergy systems. He is the developer of the BeWhere model, a techno-economic model which optimizes the geographical location of bio-energy production plants. For the REDD-PAC project, S. Leduc will help with the costing of GHG measures.

- **Mykola Gusti**

Mykola Gusti is a Research Scholar at the ESM Program at IIASA. He has a strong background in system analysis mathematics and experience in GHG inventory and REDD modeling. For the REDD-PAC project, M. Gusti will be responsible for the refinement of the G4M forest model.

- **Ian McCallum**

Ian McCallum is a Research Scholar at the ESM Program at IIASA. His background is in forest information and remote sensing. His current research interests include the use of geographic information and earth observation systems in terrestrial biospheric studies. In particular, issues related to greenhouse gases, the Kyoto Protocol, land cover and forest ecosystems. For the REDD-PAC project, I. McCallum will help with remote sensing issues.

3.1.2. UNEP-WCMC

- **Valerie Kapos**

Valerie Kapos is a Senior Programme Officer with the Climate Change and Biodiversity programme at UNEP-WCMC. She has expertise in tropical forest ecology (especially fragmentation), biodiversity indicators climate change policy and multiple benefits, and measures of the effectiveness of conservation action. With UNEP-WCMC she has worked extensively on development and use of biodiversity indicators, including spatial indicators derived from land cover data and indicators derived from national forest assessments, to support policy and decision making at international and national scales. This work has included contributions to the *World Atlas of Biodiversity,* FAO Forest Resource Assessments in 2000 and 2005, the GEF-funded Biodiversity Indicators for National Use (BINU) project, and the Biodiversity Indicators Partnership

(BIP). Most recently she has worked on the relationship between climate change policy, including REDD+, and biodiversity,. She has worked on analyses of the role of protected areas in securing carbon and on spatial analyses at national and international scales of the potential for multiple benefits, including biodiversity conservation and ecosystem services, from actions to secure terrestrial carbon stocks. For the REDD-PAC project, V. Kapos will be coordinating and managing the biodiversity elements of the project.

- **Rebecca Mant**

Rebecca Mant is a Programme Officer with the Climate Change and Biodiversity programme at UNEP-WCMC. Her background is in ecology and since joining UNEP-WCMC has focused on the understanding and monitoring of the biodiversity and ecosystem services impact of climate change adaptation and mitigation measures including REDD+. For the REDD-PAC project, R. Mant will be helping to coordinate the biodiversity elements of the project.

- **Monika Bertzky**

Monika Bertzky is a Senior Programme Officer with the Climate Change and Biodiversity programme at UNEP-WCMC. Her work focuses on supporting countries in the planning for biodiversity and ecosystem service benefits from REDD+. She leads the collaboration with countries in Latin America, Africa and Asia. She is also leading the development of an online tool demonstrating the spatial relationship between carbon stocks and biodiversity at global scale, and has experience in sustainability standards for bioenergy. Before joining UNEP-WCMC in January 2009, Monika completed a PhD in Human Geography in Germany, working for more than four years with a research group on success and failure factors of protected areas. For the REDD-PAC project, M. Bertzky will be coordinating work with the additional countries (China, Ecuador, Peru, The Philippines, Uganda and Viet Nam) on multiple benefits of REDD+.

- **Corinna Ravilious**

Corinna Ravilious is a Senior GIS Officer within the Climate Change and Biodiversity Programme at UNEP-WCMC. She has worked within the GIS team at UNEP-WCMC since 1991, and so has a deep familiarity with the range of biodiversity data available, the types of analysis feasible and the presentation of outputs to suit either both technical and lay audiences. She has worked upon a number of UNEP flagship products, including the *World Atlas of Coral Reefs*, *World Atlas of Biodiversity* and the earlier

Conservation Atlas of Tropical Forest series. Corinna also supervised the Centre's work on the EC-funded Enrisk (Environmental Risk Assessment of European Agriculture) project, in which the risk of biodiversity loss from agriculture was evaluated, including through the compilation and analysis of spatial data. For the REDD-PAC project, C. Ravilious will be carrying out the spatial analysis and mapping of biodiversity and multiple benefits of REDD+.

- **Jörn Scharlemann**

Jorn Scharlemann is a Senior Scientist at UNEP-WCMC. His main research interests are in quantitatively assessing the impacts of environmental changes on biodiversity and identifying strategies to reduce the effects of human impact. He joined UNEP-WCMC as Senior Scientist in July 2008 to be involved in statistical analyses and advise on scientific publications across all programmes within the Centre. He has investigated the impacts of agriculture on biodiversity, focusing on theoretical models of agricultural expansion and testing these with data from birds collected in São Paulo state, Brazil. He has extensive experience of statistical and spatial analyses using geographic information systems and remote sensing data, gained while modelling the distributions and abundance of ticks, deer and lions under different land use/climate change scenarios. For the REDD-PAC project, J. Scharlemann will provide guidance on the biodiversity modelling.

- **Lera Miles**

Lera Miles is a Senior Programme Officer with the Climate Change and Biodiversity programme at UNEP-WCMC. She has worked on climate change and biodiversity issues since 1997, joining the UNEP-WCMC in 2002. Over the past three years, her work has concentrated on the potential impacts of climate change policy on biodiversity and ecosystem services, such as reducing emissions from deforestation and forest degradation (REDD, now REDD+), and biofuel development. Previously, she has worked on the regional impact of climate change from the Amazon to the Arctic; and on various scenario exercises, including as part of the GLOBIO3 biodiversity modelling group. For the REDD-PAC project, L. Miles will be working on the biodiversity impacts of REDD+, biodiversity indicators development and the biodiversity modelling work.

- **Lucy Goodman**

Lucy Goodman is a Programme Officer with the Climate Change and Biodiversity programme at UNEP-WCMC. Her work aims to bring biodiversity and ecosystem services benefits to the Reducing Emissions from Deforestation and Degradation

(REDD) mechanism. Since joining UNEP-WCMC in 2012, she has also been working on policy advice for protected areas and biofuels. Previously Lucy worked in Mozambique, Zambia, South Africa, Tanzania and Kenya giving technical input to community conservation projects. For the REDD-PAC project, L. Goodman will be working on the spatial analysis of multiple benefits of REDD+ and on biodiversity indicator development.

- **Ulf Narloch**

Ulf Narloch is a Programme Officer with the Climate Change and Biodiversity programme at UNEP-WCMC. He leads on the economic work within the programme. His work focuses on the valuation and costing of ecosystem service provision in various countries under REDD+. Before joining WCMC, Ulf worked on projects for Bioversity International, UN-FAO and the Kiel Institute for the World Economy on payment for ecosystem services, agricultural biodiversity and rural development in Bolivia, Burkina Faso, Ethiopia, India and Peru. Ulf completed his PhD in Environmental Economics at the Department of Land Economy at University of Cambridge. For the REDD-PAC project, U. Narloch, will be involved with environmental economics analysis.

3.1.3. INPE/IPEA

- **Gilberto Câmara**

Gilberto Câmara is a Senior Researcher at the Earth Observation Directorate at Brazil's National Institute for Space Research (INPE). He lead’s INPE's R&D team on Geoinformatics and Environmental Modelling. He has published over 100 research papers on his areas of expertise. Gilberto advised 24 PhD dissertations and 18 MSc thesis and serves on the editorial board of the journals *Earth Science Informatics*, *Journal of Spatial Information Science and Computers*, *Environment and Urban Systems*. He was a member of the Scientific Steering Committee of Global Land Project from 2006 to 2011. From December 2005 to May 2012, he was INPE's general director. He established a free and open access policy for INPE's data and guided INPE’s team to achieve big advances in forest monitoring by satellite. In the REDD-PAC project, G. Câmara will work on producing land change data for Brazil, on data and software integration for the project, on establishing future scenarios for land policy in Brazil, and on linking between IIASA models and INPE modelling tools.

- **Fernando Ramos**

Fernando Ramos is a senior researcher of the Computing and Applied Mathematics Laboratory at INPE. His background includes scientific computing, time-series analysis, inverse problems, complex systems modelling and simulation, in applications that range from Meteorology to Remote Sensing and Geophysics. During the past decade, Dr. Ramos has been the principal investigator at INPE of several national and international research projects and represented Brazil, as seconded expert, at the Group on Earth Observations (GEO), in Geneva. In the REDD-PAC project, F. Ramos will work on the adaptation of the GLOBIOM, G4M and EPIC models for the Brazilian case.

- **Giovana Espindola**

Giovana Espindola is the Executive Officer of the Global Land Project (GLP), a core-project of the International Geosphere-Biosphere Program (IGBP) and the International Human Dimensions Programme on Global Environmental Change (IHDP). Her background covers cartography, remote sensing and geoinformatics. She has a PhD in Remote Sensing from INPE. Her focus is on how human activities on land are affecting the earth system and on the responses of the human-environment system to global environmental change. G. Espindola investigates land processes broadly in developing countries as well as focusing specifically on the case of tropical forest-agriculture frontiers in Brazil and in the Brazilian Amazon. In the REDD-PAC project, G. Espindola will work on the production of land change data for Brazil, on the analysis of the drivers of land change, and on adapting IIASA's G4M and EPIC models for Brazil.

- **Pedro Andrade**

Pedro Andrade is a researcher at the Earth System Science Center (CCST) at INPE. He is a geoinformatics expert, with a PhD on Applied Computer Science. He is in charge of the integration between TerraLib library and R statistics toolbox (the aRT package). He is also one of the leading developers of the TerraME modelling software. In the REDD-PAC project, P. Andrade will work on data and software integration for the project, on linking between IIASA models and INPE modelling tools, and on adapting IIASA's G4M and EPIC models for Brazil.

- **Ricardo Cartaxo Modesto de Souza**

Ricardo Cartaxo is a senior engineer at the Earth Observation Directorate at INPE. He has a 30 year experience is remote sensing image processing and geospatial software development. He is the chief architect of INPE's geospatial technologies. In the REDD-PAC project, R. Cartaxo will design the geospatial databases and develop new software for time series analysis of land change data.

- **Alexandre Xavier Ywata Carvalho**

Alexandre Xavier Ywata Carvalho has a Bachelor's Degree in Mechanical Engineering from ITA, a Master's Degree in Statistics from University of Brasilia, and a Ph.D. in Statistics from Northwestern University. He is currently Head of the Econometrics Group at IPEA, and is responsible for a large project aiming at the organization of government socio-economic Brazilian data bases at IPEA. He is a former Head of Regional and Urban Studies at IPEA, and former member of the NSF panel for computational intelligence. He was a assistant professor of Statistics at University of British Columbia, Vancouver, and a forecast analyst for UBS, Chicago. In the REDD-PAC project, A. X. Ywata Carvalho will work on establishing future scenarios for land policy in Brazil, and on adapting the GLOBIOM and EPIC models to Brazil.

- **Aline Soterroni**

Aline Soterroni has a PhD in Computer Science (2012) from National Institute for Space Research, Brazil. Her background is in applied mathematics and computing with a special focus on optimization techniques for global optimization. For the REDD-PAC project, A. Soterroni will work on the adaptation of the GLOBIOM model for Brazil.

- **Victor Wegner Maus**

Victor Wegner Maus has a MSc in Computational Modelling (2011) and is PhD Student in Earth System Science from National Institute for Space Research, Brazil. His background is in mathematical modelling and computer simulation with special focus on numerical methods. For the REDD-PAC project, V. Wegner Maus will work to develop new software for time series analysis of land change data.

3.1.4. COMIFAC

- **Martin Tadoum**

Martin Tadoum has been since 2008 the Deputy Executive Secretary of COMIFAC in charge particularly of the technical coordination of projects and programmes under

COMIFAC. He was during 2004 and 2008 the technical adviser at the COMIFAC secretariat office. He holds a MSc on natural resources planning and management and is also an Engineer in forestry sciences. M. Tadoum has coordinated a lot of projects and studies funded by different partners (World Bank, AfDB, UNEP, FAO, France, GIZ, KFW, WWF, …) in the central Africa region about sustainable forest management and the environment. For the REDD-PAC project, M. Tadoum will lead the implementation of the project in the COMIFAC region.

- **Michel Ndjatsana**

Michel Ndjatsana is the current COMIFAC Environmental Expert. With a dual training as forester and agronomist, he is in charge of the activities related to UNFCCC within the COMIFAC secretariat. He has been the COMIFAC focal point for the one-year project funded by the World Bank about the impact of development trajectories on the Congo Basin forest cover by 2030. This project was carried out by IIASA in 2010 and yielded the first version of the CongoBiom model. For the REDD-PAC project, M. Ndjatsana will be in charge of the relation with the experts and researchers at the country level and the organization of regional meetings.

- **Chouaibou Nchoutpouen**

Chouaibou Nchoutpouen has been the officer in charge of biodiversity in the COMIFAC secretariat since 2008. He has a Master degree in forestry sciences and agroforestry. He is working on all biodiversity issues in the central Africa region and has participated to many regional workshop on biodiversity safeguards in the REDD+ context. For the REDD-PAC project, C. Nchoutpouen will ensure the follow-up of the analysis on biodiversity safeguards.

- **Valerie Tite Tchuante**

Valerie Tite Tchuante is the monitoring-evaluation expert within the COMIFAC secretariat since 2007. He is a forestry Engineer and has a professional degree in environment. He is in charge of the follow-up of regional projects and initiatives related to the COMIFAC convergence Plan. For the REDD-PAC project, V. Tchuante will work closer with his colleagues in charge of biodiversity and climate change in order to follow the implementation of the project in the Congo Basin.

4. Description of data and tools

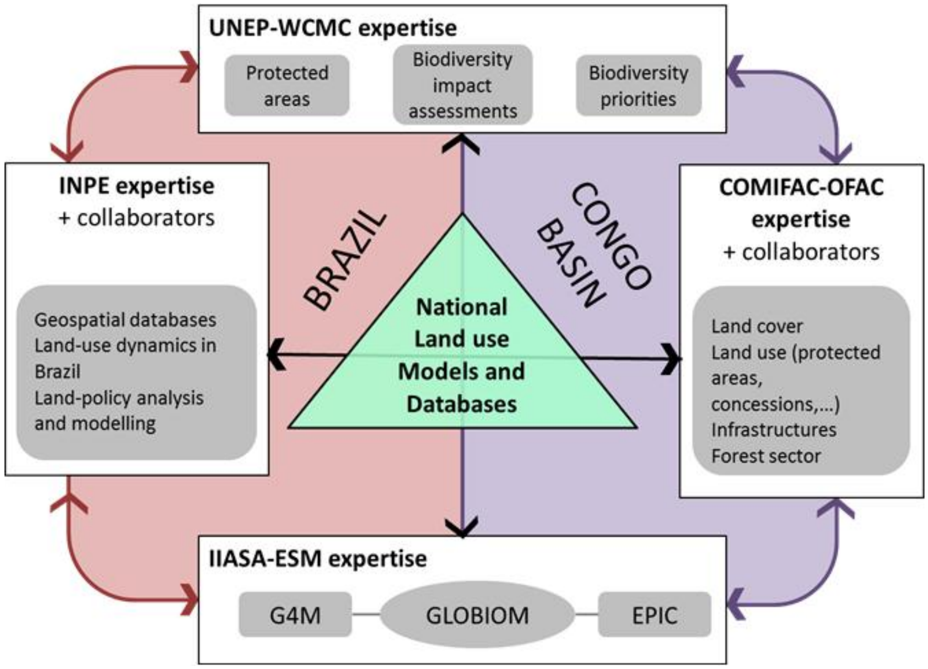

Figure 3: General organization:

partners and collaborators, existing data and tools, final output, data flows

4.1. Available data and tools relevant for REDD-PAC

4.1.1. IIASA: data, tools, approaches

4.1.1.1. Presentation of the modelling cluster

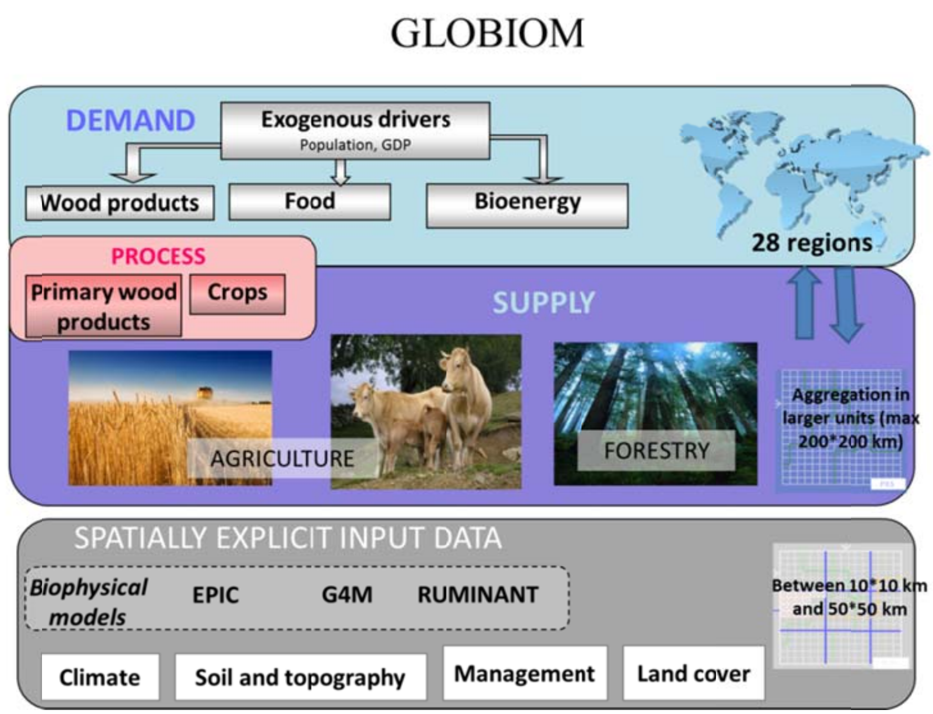

Figure 4: GLOBIOM structure

The **Global Biosphere Management Model (GLOBIOM)** (http://www.globiom.org) was developed by and is used at the International Institute for Applied Systems Analysis (IIASA). A global recursive dynamic partial equilibrium model, GLOBIOM is designed to aid policy analysis of land use competition among the major land-based production sectors, particularly agriculture, forestry, and bioenergy. It provides for a detailed representation of each sector, accounting for about 20 of the most globally important crops, a range of livestock production activities, major forestry commodities, and multiple bio-energy transformation pathways (Appendix A).

GLOBIOM is an optimization model wherein market equilibrium is determined by choosing land use and processing activities to maximize social welfare (i.e., the sum of producer and consumer surplus) subject to resource, technological, and policy constraints. Countries are assigned to 1 of 30 regions (Appendix B). Prices and international trade flows are endogenously determined at the level of these regions. This analysis includes both tariffs and transportation costs differentiated among products and trading partners.

The supply side of the model reflects a detailed spatial resolution that accounts for land heterogeneity. The model draws from a global database with information on soil types, climate, topography, land cover, and crop management (Skalsky et al. 2008). These data have been harmonized at the simulation unit level, which is defined by the intersection of country boundaries, altitude, and slope and soil classes within a 50 x 50 km grid. GLOBIOM disaggregates available land into several land cover classes, which can (or cannot) be used for production. Forest land is made up of two categories (unmanaged forest and managed forest); the other categories include cropland, short-rotation tree plantations, grasslands (managed grasslands), and “other natural vegetation” (including unused grasslands). The model allows land cover/use conversions, but the total land area spanning all categories remains fixed. The model is recursive dynamic in the sense that changes in land use made in one period alter land availability in the various categories in the next period.

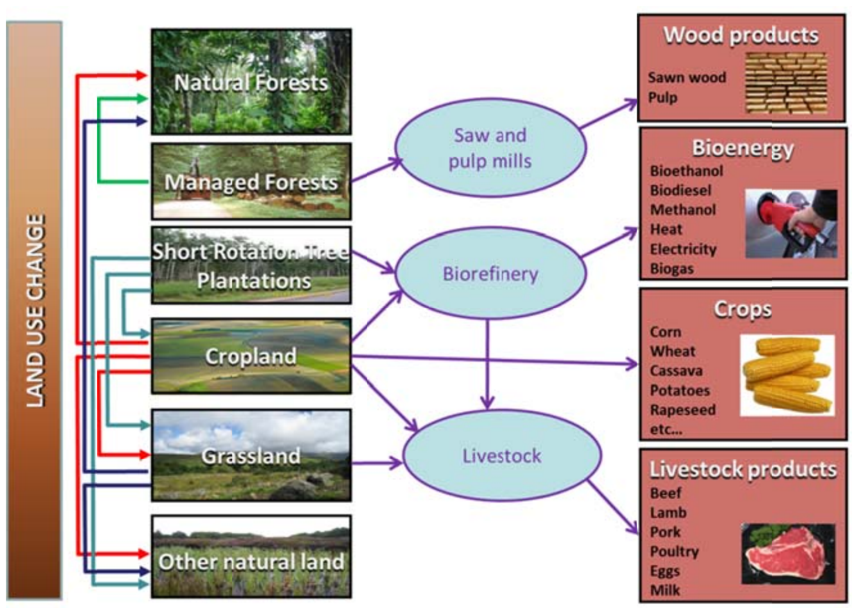

Figure 5: Land transition matrix and representation of the supply chain

GLOBIOM accounts for the major GHG emissions and sinks related to agriculture and forestry, particularly emissions related to crop cultivation, land use, livestock, and fossil fuel substitution. GHG accounts of land use change activities are based on the carbon contents in equilibrium states of the different land cover classes. Carbon content in above- and below-ground living forest biomass is taken from Kindermann et al. (2008), and carbon content in the biomass of short-rotation plantations is calculated on the present study's estimates of the plantations' productivity. For parameterization of carbon in grasslands and in other natural vegetation, the biomass map of Ruesch and Gibbs (2008) is used. CO_2 coefficients for emissions and sinks due to land use change are calculated as the difference between the carbon content of the initial land cover class and that of the new class. Only carbon in the above- and below-ground living biomass is considered, because no reliable data on soil organic carbon are available.

The analysis distinguishes four crop management systems—subsistence agriculture, low-input rain-fed agriculture, high-input rain-fed agriculture, and high-input irrigated agriculture—and allows for switches among them (You and Wood 2006). Spatially explicit yields for each crop and each management system as well as input requirements have been estimated using the biophysical crop growth model EPIC described later. For livestock, management systems have been defined according to the livestock production systems classification developed by the International Livestock Research Institute and the Food and Agriculture Organization (updated Seré and Steinfeld 1996). Input-output coefficients have been computed with the RUMINANT model for ruminants (Herrero et al. 2008) and derived from a literature review for monogastrics (pigs, poultry, and other livestock with one stomach). The productivity of managed forests at the 0.5 degree grid level is shared with the G4M forest model described later, and relies on forest growth equations estimates.

The principal exogenous drivers are gross domestic product (GDP) and population change as well as bioenergy demand. The analysis also relies on the FAO-projected demand for agricultural product aggregates, including per-capita calorie consumption (Alexandratos et al. 2006), as a lower bound for agricultural demand.

The **EPIC (Environmental Policy Integrated Climate) model** integrates a large number of terrestrial biophysical processes allowing for global environmental impact assessments of alternative land use management systems (Williams, 1995; Izaurralde et al., 2006). The major components in EPIC are weather simulation, hydrology, erosion-sedimentation, nutrient and carbon cycling, pesticide fate, plant growth and competition, soil temperature and moisture, tillage, cost accounting, and plant environment control. EPIC operates on a daily time step and is capable of simulating hundreds of years if necessary.

The new carbon cycle (Izaurralde et al., 2006), which is based on the CENTURY approach (Parton et al., 1993) is included as well as the new nitrogen cycle. The new nitrogen cycle allows tracing N2O more precisely and includes microbial processes (i.e. nitrification and de-nitrification) which are the major sources of N-based GHG emissions in managed lands. The new N-cycle combines consolidated findings in microbiology as well as chemical reactions and physical processes regarding the formation of oxidized nitrogen products during the nitrification process.

EPIC is used to compare land use management systems and their biophysical impacts on crop yields and biomass growth, hydrology, nitrogen emissions, soil organic carbon sequestration, sediment transport and on greenhouse gas emissions. The management components (e.g. latest crop maps from IFPRI) that are currently analyzed include crop rotations, legume/grass mixes, agro-forestry, tillage operations, fertilization and irrigation scheduling. The EPIC model is already operational on global and European scales and is continuously improved.

The **Global Forest Model (G4M)** is applied and developed by IIASA and estimates the impact of forestry activities (afforestation, deforestation and forest management) on biomass and carbon stocks. By comparing the income of managed forest (difference of wood price and harvesting costs, income by storing carbon in forests) with income by alternative land use on the same place, a decision of afforestation or deforestation is made. G4M is spatially explicit (currently on a 0.5° x 0.5° resolution which is brought down to 30"x30" for Europe already).

To initialize forest biomass the forest biomass map compiled by Kindermann et al. (2008) was used. Increment is determined by a potential Net Primary Productivity (NPP) map (Cramer et al. 1999) and translated into net annual increment (NAI). At present this increment map is static but can be changed to a dynamic growth model which reacts to changes of temperature, precipitation or CO2 concentration. Age structure and stocking degree are used for adjusting NAI. If stocking degree of forest modelled with a given age structure (country average) in a cell is greater than 1.05 age structure of the modelled forest is shifted iteratively by a few age classes towards older forest. If stocking degree of forest modelled in a cell is smaller than 0.5 age structure of the modelled forest is shifted iteratively by a few age classes towards younger forest. It is required that the shifts are symmetrical to keep country average age structure close to statistical value. If the age structure shift distribution within a country is skewed towards older forest, the country's average NAI is increased iteratively. If the age structure shift distribution within a country is skewed towards younger forest country NAI is decreased iteratively.

Geo-Wiki (http://www.geo-wiki.org) is a crowdsourcing tool whose aims are (i) to increase the amount of in-situ land cover data available for training, calibration and validation, and (ii) to create a hybrid global land cover map that provides more accurate land-cover information than any current individual product. It is a geospatial tool based on the Google Earth platform. Volunteers are asked to indicate the land-cover type of a given area based on what they can see on Google Earth. Their input is recorded in a database, along with uploaded photos, to be used in the future for the creation of a new and improved land-cover product.

Once in the system, the user can rotate the Earth to zoom into any land surface to begin land cover assessment, plot any of the global land cover maps (GLC-2000, MODIS, GlobCover) on top of Google Earth, or display the disagreement maps between any pair of land cover products . These disagreement maps highlight the critical areas where further validation is needed.

4.1.1.2. Application of IIASA tools to the Congo Basin and to Brazil

IIASA-ESM has already started to adapt its tools to the Congo Basin region in 2010 during a one-year project funded by the World Bank about the impact of development trajectories on the Congo Basin forest cover by 2030. This has been the starting point of the collaboration between IIASA-ESM and the COMIFAC. The CongoBiom model has been created using the GLOBIOM model framework and regional specificities of the Congo Basin region. The main objectives of the project were to a) build a regional model to assess GHG emissions resulting from land use change over the next 20 years b) support the climate focal points of the Congo basin region in the national discussions and international negotiations through the realization of key documents and c) to train local experts to modelling tools. The main improvements to the model have been:

- The inclusion of internal transportation costs
- Spatial demand for fuel wood according to the population density by 50x50 km grid
- Protected areas
- Forest concessions

Simulations have been run by 2030 testing for the impact of new roads development, higher crop productivity, lower fuel wood demand, higher global biofuel demand and higher global meat demand on forest cover and related GHG emissions in the Congo Basin and globally. Impact of a global agreement on GHG emissions reduction from deforestation was also investigated with side effects of such a policy on food prices and food imports being emphasized.

IIASA-ESM has also started to refine the representation of land use activities in Brazil since 2010. The main improvements to the model have been:

- The inclusion of internal transportation costs
- Improvement in the spatial grassland productivity assessment
- Display of the results at the state level

The main objective was to investigate the effects of a tax or a subsidy for pasture intensification on global GHG emissions by 2030. We have investigated the effect of different levels of tax and subsidy, the role of international trade and the role of internal demand.

Geographical scope

- COMIFAC includes the 10 member countries: Burundi, Cameroon, Congo, Gabon, Equatorial Guinea, Central African Republic, Democratic Republic of Congo, Rwanda, Sao Tomé & Principe and Chad. The first version of the CongoBiom model has been established for 6 countries only: Cameroon, Central African Republic, Equatorial Guinea, Gabon, Congo and Democratic Republic of Congo.

- Moreover, if the regional analysis has proven to bring some advantages in terms of strengthening a common strategy of the Congo Basin countries in the REDD+ negotiations, the need to build national tools to support national policies and planning strategy has been strongly expressed.
- Brazil is already singled out as a separate region in GLOBIOM. Since Brazil encompasses a large territory, the challenge will be to take into account the diversity inside Brazil by implementing different policies at the regional/local scale and to provide the results at sub-national units (biome/state/municipality for instance).

4.1.1.3. Limitations

Subsistence agriculture and fuel wood: subsistence agriculture is currently the first cause of deforestation and forest degradation in the Congo Basin region. In the forest area, slash-and-burn agriculture dominates with long fallow period following the cultivation period. If slash-and-burn agriculture leads to deforestation depends on the length of the rotation. We observe that when the population density increases the rotation time tends to decrease thus limiting the natural regrowth of the forest and the soil nutrients repletion. Moreover, the main objective of subsistence agriculture is to provide food and fuel wood to the households which cannot access markets (physically or economically). Consequently, the dynamics of subsistence agriculture are not well represented in the current framework of the model where subsistence farming is fixed to the initial area and the rest of the agricultural sector only reacts to market incentives. The complementarity of agriculture and fuel wood is also not represented in the current version of the model. In Congo Basin, fuel wood is the main energy source and it is mainly provided by the informal sector through non controlled withdrawal of wood. Fuel wood is estimated to be a major contributor to forest degradation or deforestation around large urban centers. The dynamics of fuel wood supply and demand and the way it changes ecosystems has to be improved in the model.

Coffee, cocoa and palm oil: Perennial crops are also a challenge for our modeling framework. Coffee, cocoa and palm oil are the main perennial crops in the region. To the contrary to annual crops, these crops require waiting several years before harvesting. The yields also vary from one year to the other due to the aging of the plantations. Finally they could be combined with other crops.

Forest management: Congo Basin countries have pushed for the recognition of the forest degradation and the enhancement of carbon stocks in the REDD+ international negotiations arena in order to valorize the recent improvements in forest management. Recent implementation of the FLEGT (Forest Law Enforcement and Trade) agreement with the European Union to fight against illegal logging and the increase in certified forest concessions will for sure have some impact on the forest management in the next decades. However, we currently represent only one forest management which is the sustainable rate of harvest. To improve this side of the model, it would require to have better data on the forest structure i.e. species composition, age classes and commercial species availability.

Land cover maps: current land cover is a crucial input layer in the model. However, many uncertainties are related to the land cover maps, especially in the tropics where the presence of clouds require a large number of images to be processed. However, a lot of efforts have been made during the last years to improve the quality and the availability of land cover maps both in Brazil and in the Congo Basin. We have to investigate how the currently available land cover maps compare and how does it match the other production statistics available (e.g. FAOSTAT, national statistics) to select the best available land cover map. Furthermore, some deforestation map for Brazil and for DRC is also available for 2000-2005 and 2005-2010. These maps could be used to improve model predictions for the period 2000-2010.

Livestock productivity: Low cattle productivity in Brazil and especially in the Amazon has been often highlighted as a significant driver of deforestation. Low stocking rate per hectare could be, in some cases, explained by degraded pastures. However the definition of degraded pasture could be very different from one biome to another varying fom natural vegetation regrowth to soil erosion. More generally, to address this issue, one would need to have better data on pasture management in Brazil and the pasture productivity. Another factor that could affect the cattle sector productivity is the spread of diseases. For instance the to be abl to export, a certificate of foot and mouth disease free area is required. In the Congo basin, the presence of tse tse flies undermines the development of the sector. We currently lack this information in GLOBIOM.

Mining: We have to think about the variables that we have in the model that could be influenced by mining and through which mechanisms (new infrastructures, new settlements, GDP, governance, etc.).

Farm classification and production costs*:* farm typology and characteristics such as machinery, fertilizer and resources use and cost, investment costs, storage capacity and costs.

Database and user interface

- Access to a unique database where the user could access all the input data in a table or visualize them in a map with the corresponding documentation about the source, the year and how the data have been processed
- Inclusion of explicit causality chains for key variables in the user interface would also be a plus
- Possibility for the user to run new simulations with different assumptions on selected parameters, and quickly visualise the changes in the model outputs, would be a must.

4.1.2. UNEP-WCMC: data, tools, approaches

The data, tools and approaches that UNEP-WCMC brings to the REDD-PAC project derive largely from its work on using mapping to raise awareness and support decision making on multiple benefits of REDD+. The mapping enables users to visualise the spatial distribution of biodiversity, carbon and other ecosystem services, as well as other land use considerations such as the location of protected areas and mining. It can help in understanding the potential impacts of different REDD+ policy options. In carrying out this work we have used, and have access to, data on protected areas, biodiversity priority areas and species ranges, and have developed specific approaches and tools for analysing them.

Protected areas are internationally recognised as major tools in conserving species and ecosystems, and up-to-date information on protected areas is essential to fully enable conservation and development planning. Since 1981 UNEP-WCMC has been compiling data on protected areas worldwide making it available to the global community. The resulting **World Database on Protected Areas (WDPA)** is the most comprehensive global spatial dataset on terrestrial and marine protected areas (Figure 6). The WDPA is a joint project of UNEP and IUCN, produced by UNEP-WCMC and the IUCN World Commission on Protected Areas (WCPA), and contains crucial information from national governments, non-governmental organizations, academic institutions, international biodiversity convention secretariats and many others.

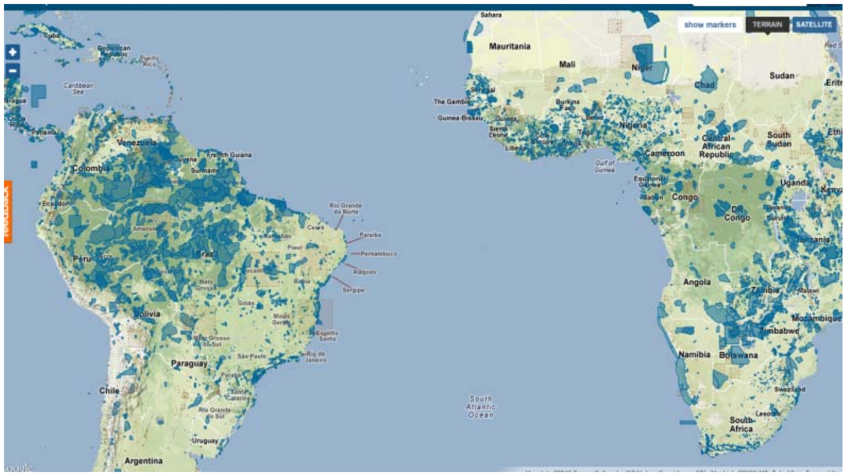

Figure 6: Sample geographic data on protected areas from the WDPA

A wide range of options exists for identifying areas of high priority for biodiversity conservation, and UNEP-WCMC's mapping work has drawn on many of them, as well as on spatial data on species ranges. Among the datasets that can be drawn on for REDD-PAC are:

Important Bird Areas (IBAs): Developed by Birdlife International, IBAs are areas that (a) hold significant numbers of one or more globally threatened bird species, (b) are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species or (c) have exceptionally large numbers of migratory or congregatory species.

Key Biodiversity Areas (KBAs): Extend the IBAs to cover a wider range of species groups. They are identified nationally using simple, standard criteria, based on their importance in maintaining species populations. KBAs provide one of the most detailed global designations of biodiversity priority areas.

Species Distribution Data: The locations of individual species and species groups can also be important for identifying biodiversity priorities, and certain threatened species, such as the Bonobo or Gorilla, may be biodiversity priorities for a country. UNEP-WCMC has compiled detailed mapped data on the distributions of great ape species, and mapped distributions of other vertebrate species are available from the extent of occurrence information compiled in IUCN's global assessments of mammals, birds amphibians and reptiles under the auspices of the IUCN Red List Programme. Combining such data with data on terrestrial carbon stocks (Figure 7), can help to identify areas with potential for biodiversity conservation benefits from REDD+.

UNEP-WCMC has developed a customised **GIS mapping toolbox** (ArcGIS 9.3.1) for REDD+ multiple benefits analyses. It provides both novice and experienced GIS users with a series of raster analysis tools to help identify, map and understand the spatial relationship between ecosystem carbon stocks, other ecosystem services, biodiversity, land-use and pressures on natural resources. The resolution of the analysis is defined by the user. The toolbox is flexible, providing a set of tools that can be used interchangeably whilst using a consistent and efficient methodology that will decreases the time required to undertake such analyses.

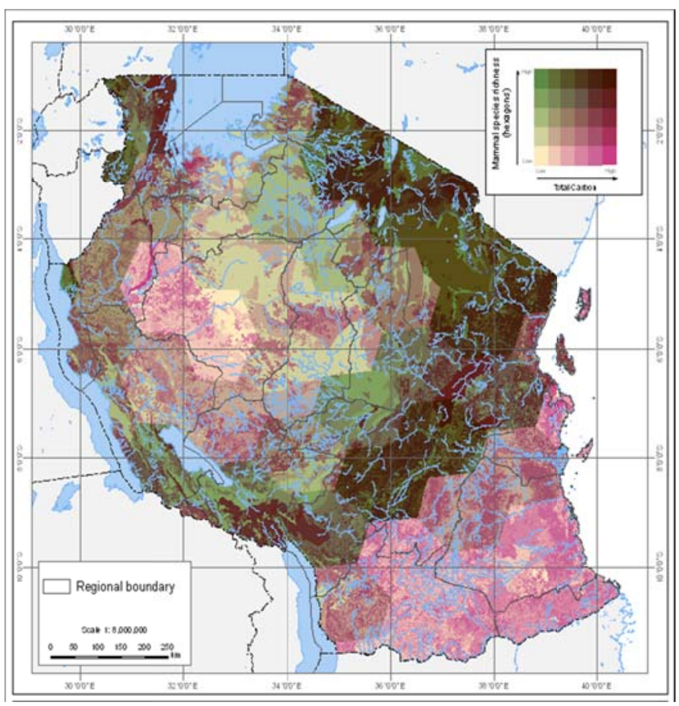

Figure 7: Potential mammal species richness in Tanzania derived from extent of occurrence data and overlaid with carbon stock data

Alongside its work on mapping multiple benefits, UNEP-WCMC has carried out work related to REDD+ and biodiversity policy issues. This has included detailed analyses of the implications of the Cancun safeguards for REDD+, contributing to the development of the UN-REDD Social and Environmental Principles and Criteria, and assisting countries in developing their understanding of the implications of the REDD+ safeguards for national REDD+ policies. The policy work has also involved work to develop indicators for the achievement of REDD+ safeguards.

Additional perspectives on biodiversity and on useful indicators for policy and impact assessment come from UNEP-WCMC's experience in leading the Biodiversity Indicators Partnership (BIP). The BIP assisted the CBD in tracking progress towards its 2010 Biodiversity Target, and is continuing this support in relation to the CBD Aichi Biodiversity Targets. These approaches for identifying and implementing biodiversity indicators are further supplemented by experience in supporting countries in developing their national biodiversity strategies and action plans (NBSAPS), a process which includes identifying national biodiversity targets and priorities.

Within the REDD-PAC project UNEP-WCMC will also be drawing on experience from other work involving valuation of ecosystem services, scenario development and modelling. UNEP-WCMC's valuation work is seeking to demonstrate economic values of ecosystem services and biodiversity benefits that could be achieved under REDD+. The work has involved reviewing existing valuation studies and applying benefit transfer methods to derive a range of potential values.

UNEP-WCMC has been integrally involved in a wide variety of national and international scale assessments that have included development of scenarios that may provide useful input to the development of scenarios for REDD-PAC.

UNEP-WCMC is involved in a range of biodiversity modelling projects, the experience from which will help to inform the REDD-PAC project work, particularly in relation to developing biodiversity models as a basis for impact assessment. In the 'Madingley model' project UNEP-WCMC, in collaboration with Microsoft Research Cambridge, are developing a global biosphere model that captures the ecological processes and human pressures shaping biological communities in terrestrial and marine environments. The aim is to use the model to examine the effect of human pressures on ecosystem structure and vulnerability, make quantitative predictions about the future health, stability and composition of ecosystems, and explore a variety of scenarios about future trends. UNEP-WCMC also works with GLOBIO, which is a tool to assess past, present and future impacts of human activities on biodiversity. Using spatial information on environmental drivers as input, the model estimates the impacts on terrestrial biodiversity through time of land use change, climate change, fragmentation, infrastructure and nitrogen deposition based on cause-effect relationships derived from the literature.

Limitations

Although the World Database on Protected Areas (WDPA) is the most comprehensive global spatial dataset on terrestrial and marine protected areas, it does not include all areas that are relevant to the retention and conservation of forest cover. The WDPA does not include private reserves, indigenous reserves and community management areas, all of which can play an important role in protecting natural habitats, including forest, from conversion. The data within the WDPA are furthermore only as good as the information that is reported by countries; not all of the protected areas within the data base have complete information associated with them. Some protected areas are missing precise geographic boundaries and others do not include information on their management (and associated IUCN category).

The priority area data is limited by the fact that most priority areas are identified by using only four vertebrate groups (birds, mammals, amphibians and reptiles), with birds being particularly dominant. They take little or no account of invertebrates or of conservation needs for specific ecosystem types, including aquatic ecosystems. There is no single set of biodiversity priorities that is globally accepted and the internationally identified biodiversity priorities do not always tie in with specific national priorities and locally identified priority areas.

As well as limitations in the protected area data and the biodiversity priority area data, another limitation of the multiple benefits mapping is limitations in the carbon data used. One large challenge with carbon data is that carbon distribution is not static; seasonal and yearly variations in vegetation cover will cause variations in carbon distributions. Additionally, there are challenges in accurately calculating carbon distributions especially for below ground carbon. Understanding carbon distributions can help in understanding the relative carbon impact of land conversions in different areas. However, the interpretation of the carbon maps is also limited by available understanding of the impact of land use change on emissions. For example, the conversion of forest to another land use will release some but not release all of the carbon in the forest, however the precise impact is presently not fully understood, even where accurate estimates of the present carbon are available.

The spatial analysis of multiple benefits is also limited by the resolution of the available land use/cover data in terms of habitat and land use classifications. Limited data is available on habitat sub-types and ecosystem condition. The identification and mapping of degraded areas is very challenging and so often lacking, for example the identifications of degraded forests that still retain their forest cover. Another limitation is that there is presently little or no assessment of land tenure and capacity. Land tenure and capacity, including financial capacity, will impact on likely land use changes.

4.1.3. INPE/IPEA: data, tools, approaches

Brazil´s National Institute for Space Research (INPE) is the country´s main research centre in space and environment. INPE builds satellites, manages ground receiving and control stations, develops remote sensing applications, study global change and provide weather forecasts. INPE has a research and development team that has extensive experience in building geospatial and environmental software.

IPEA, Institute of Applied Economics Research (www.ipea.gov.br), is part of the Secretary of Strategic Affairs of the Brazilian Federal Government. The institute evaluates of government programs, aids on budget planning, and supports actions in infrastructure, environment, regional and urban development. It also studies macroeconomic policy, and social protection and inequality reduction. One of its main products is the portal IPEADATA (*www.ipeadata.gov.br/*), with much socioeconomic data available. IPEA will take part on the REDD-PAC project on the basis of a scientific agreement signed with INPE for joint research on land use policy in Brazil.

4.1.3.1. Remote sensing data and products at INPE

INPE has developed many applications on Remote Sensing. Given the scope of the REDD-PAC project, we describe INPE’s Amazonia monitoring program. INPE runs three complementary remote sensing-based systems (PRODES, DETER, DEGRAD) to monitor wall-to-wall deforestation and forest degradation in the Brazilian Amazon.

PRODES reports yearly deforestation by clear cuts in the Brazilian Amazon since 1988. PRODES uses medium-resolution (20 to 30 meters) imagery from Landsat, CBERS (see Appendix A) and DMC satellites to map deforestation areas larger than 6.25 hectares.

DETER is a real time deforestation detection system launched in 2004 (www.obt.inpe.br/deter/). DETER uses 250 m-resolution images from NASA's MODIS sensors to map clear-cuts and forest degradation on a *daily* basis. While lower in spatial resolution compared to the images used for PRODES, DETER is essential for surveillance and deforestation control. DETER enables more efficient law enforcement that is crucial to reduce deforestation (Banerjee, Macpherson et al. 2009).

Figure 8: INPE's website for disseminating DETER data.

DEGRAD was launched in 2008 to produce yearly maps of forest degradation. DEGRAD uses the same Landsat, CBERS and DMC images to monitor partial removal of trees through burning and logging in areas larger than 6.25 ha.

The Brazilian law enforcement agencies use data from PRODES, DETER and DEGRAD to curb illegal forest cuts. IBAMA (Brazil's Environmental Protection Agency) has about

15,000 officers equipped with cars, helicopters and boats and works closely with public prosecutors to impose fines on lawbreakers. PRODES, DETER and DEGRAD maps are available freely to the public on the internet. INPE's reports have become the foundation for public policy on land use in Amazonia. The combination of effective monitoring and strong law enforcement reduced the yearly rate of deforestation from a peak of 27,700 km^2 in 2004 to a 20-year low of 6,450 km^2 in 2010 (INPE 2010). All maps are available openly, transforming the way Brazil and the World looked at Amazonia. Nature has called this decrease to be "the biggest environmental success story in decades".

INPE's Amazon forest MRV systems seek to be transparent, accurate, comparable, verifiable, consistent and credible. They have contributed to real action on the ground (law enforcement, policy development, and results-based carbon financing). Brazil has offered to make these data and monitoring systems (TerraAmazon, PRODES, DETER, DEGRAD) available to other countries to help them advance their own forest monitoring.

The Amazonia database has Landsat TM-based 1997-2012 deforestation maps produced under the Amazon monitoring program of the Brazilian National Institute for Space Research (INPE 2011). The figure below shows some cumulative deforestation maps for the Brazilian Amazon in selected years from 1997 to 2008.

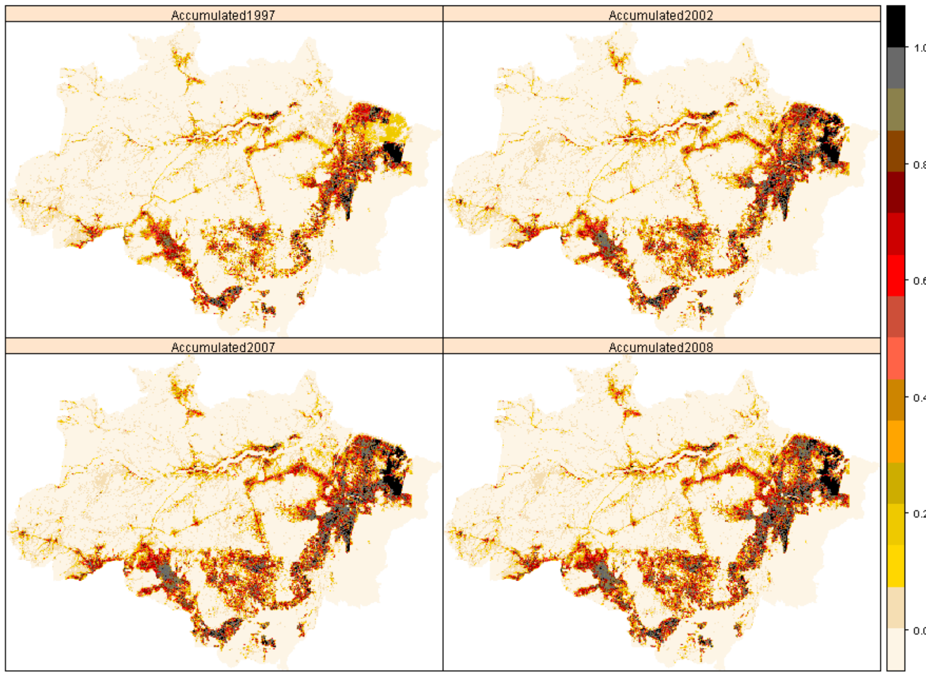

Figure 9: Proportion of cumulative deforestation for each grid cell in 1997, 2002, 2007 and 2008.

The cumulative deforestation is divided into the main agricultural uses – pasture, temporary and permanent agricultures – combining deforestation maps with agricultural census. In fact, given the huge size differences between municipalities in Brazil, all the data from census surveys need to be disaggregated spatially to capture geographical variations (Figure 10). INPE has developed tools to convert municipality-based census data from polygon-based information to grid cells, considering native forests, urban areas and rural occupation.

The total agricultural area for each municipality comes from the deforestation maps; the proportion of each agricultural use comes from the census data. The proportion of land use types is uniformly distributed over the deforested areas of each municipality.

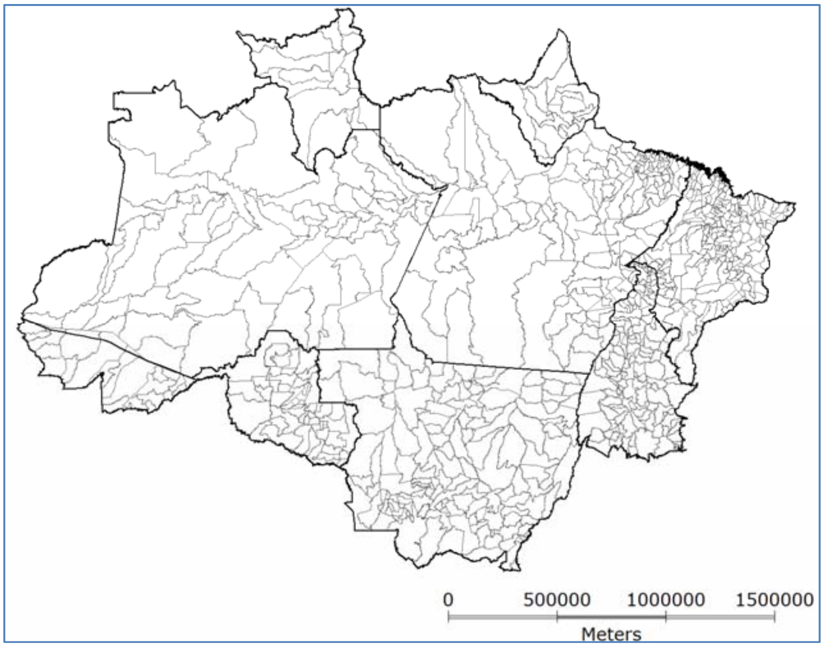

Figure 10: Spatial extent of municipality polygons within the states of the Brazilian Amazon.

Besides information extracted from satellite images and census data, the Amazonia database contains information from hydrological and climate maps, as well as information on the main deforestation drivers (see below).

Variables

a) **Deforestation:** Maps of cumulative deforestation and maps of annual deforestation from 2002 until 2012.
b) **Agricultural land uses**: Deforested areas will be decomposed into primary agricultural uses (pasture, temporary agriculture and permanent agriculture).
c) **Agrarian structure:** Land distribution indicators, such as the proportion of small (less than 200 ha), medium (200 ha to 1000 ha) and large (greater than 1000 ha) farms.
d) **Land tenure and planning:** conservation units, settlements, and specific rules of land use.

e) **Public policies:** Governmental laws and plans and command and control programs that define local arrangements of territory use.
f) **Commodity prices:** Prices and production of agrarian commodities and demand from internal and external markets.
g) **Accessibility to markets:** Distance to roads, rives and urban centers, connection to national markets and ports.

4.1.3.2. Geospatial technology at INPE

The International Council for Science has recently published a "visioning" paper that calls for new technologies that support better decision-making. They ask for methods and tools to *"combine data and knowledge gathered over centuries with new observations and modelling results to provide a range of integrated, interdisciplinary datasets, indicators, visualizations, scenarios, and other information products"* (ICSU 2010). These datasets are geospatial, having a geographical location and a temporal reference. Geospatial data comes from many sources, such as mobility data from phones and GPS devices, in-situ data from geosensors, land cover and land use data from remote sensing images. Thus, handling geospatial data is crucial for global change research, especially in the case of nature-society interactions.

INPE wants to contribute to the effort of developing tools for better decision making in global change research. The aim is to build a set of geospatial software tools that deal with large and downscaled environmental data sources and support global change research focused on nature-society interactions. The basis for INPE's tools is the **TerraLib** open source software library. A library is not an executable program. Libraries provide code that can be used by different programs. A library allows different applications to share the same basic functions and services, helping code sharing and reuse.

TerraLib supports development of custom-built geographical applications using spatial databases. The library supports open source data managers such as MySQL and PostgreSQL. Its vector data model is compatible with OGC (Open Geospatial Consortium) standards. The TerraLib project started in 2002. Currently, TerraLib version 4.0 provides all support needed to handle geospatial data on databases created with MySQL and PostgreSQL managers.

The next generation of TerraLib (version 5.0) is being designed to work with different data sources on the web and to be able to combine their information. This will allow moving from centralised data server to a set of distributed databases. The programming interface of TerraLib 5.0 provides four main services. The *Presentation* part has tools to convert data into graphics, text and images. The *Data Discovery* functions find remote servers that contain the data needed by the user. The *Data Access* component has functions to retrieve data from the remote servers. The *Data analysis part* has tools to extract information from geospatial data.

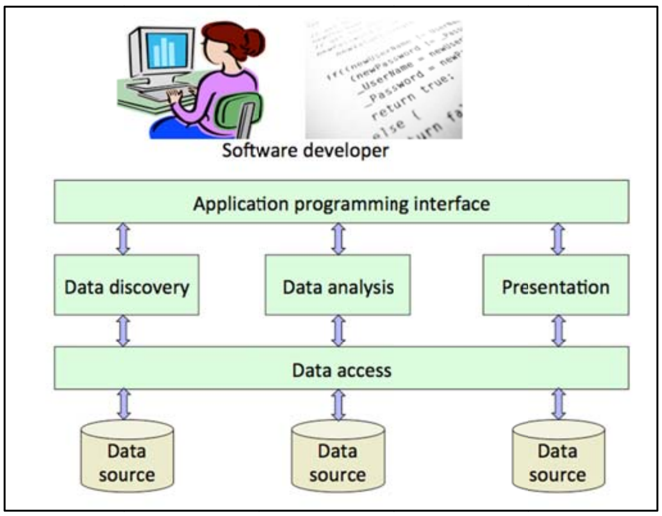

Figure 11: Architecture of the TerraLib software library

A key part of TerraLib's architecture is the concept of a *data source*, which is any organized collection of geospatial data. Data sources range from large data sets stored in a database system to individual files. In the context of REDD-PAC, a data source can be an output of the GLOBIOM, EPIC or G4M model, a result from a biodiversity model from WCMC, or a map produced by COMIFAC.

TerraLib is a software library and as such, provides a basis for the development of different applications, each dedicated to a specific task. This strategy allows modular development. Based on the TerraLib software library, INPE is building different systems that are relevant to the REDD-PAC project: TerraView, TerraAmazon, TerraME, aRT, and GEODMA.

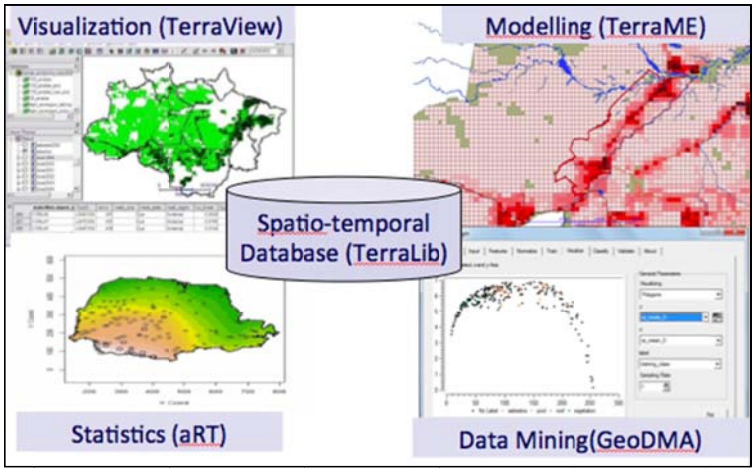

Figure 12: INPE’s portfolio of geospatial technologies

TerraView is an open source application for spatial data visualisation. It performs data conversion, display, spatial statistics, image processing, and spatial and nonspatial queries. Many Brazilian public institutions use TerraView for public policy making, including studies in spatial epidemiology and crime analysis. Figure 13 shows TerraView’s user interface.

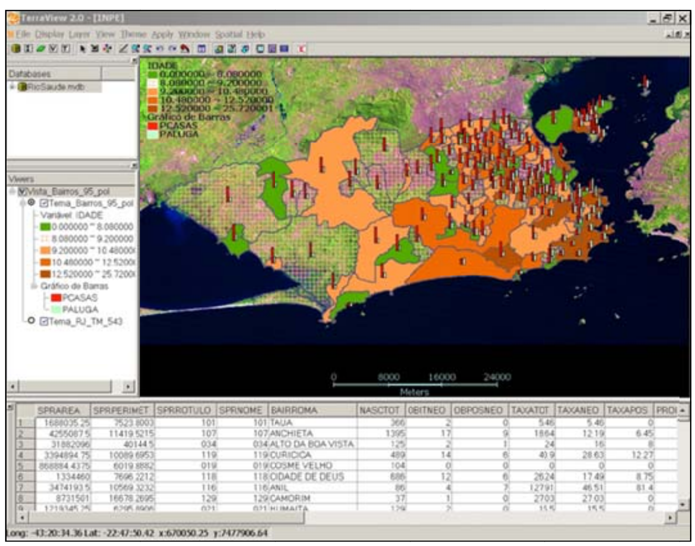

Figure 13: User interface for the TerraView product

TerraAmazon is Brazil's national database for monitoring deforestation in Amazonia, developed by INPE and its partners. The application manages all data workflow, gathering satellite images, pre-processing, segmenting, and classifying these images for further human interpretation, in a concurrent multi-user environment. The database stores about 5 million complex polygons and has about 20 Tb of satellite data. A Web site allows seamless display and analysis of full resolution data, using TerraLib's OGC WMS server.

INPE and the United Nations Food and Agriculture Organization (FAO) have set up an agreement to make the TerraAmazon available to all other tropical nations, in support of the UN-REDD program. FAO considers that the TerraAmazon software allows tropical forest nations to replicate Brazil's MRV (monitoring, reporting and verification) system. Technology transfer will be carried out at the premises of INPE Amazonia in Belém, Brazil. FAO UN-REDD will be responsible for the in-country implementation and operationalization of the forest monitoring systems at national level. FAO and INPE will adapt the monitoring systems to other countries' needs.

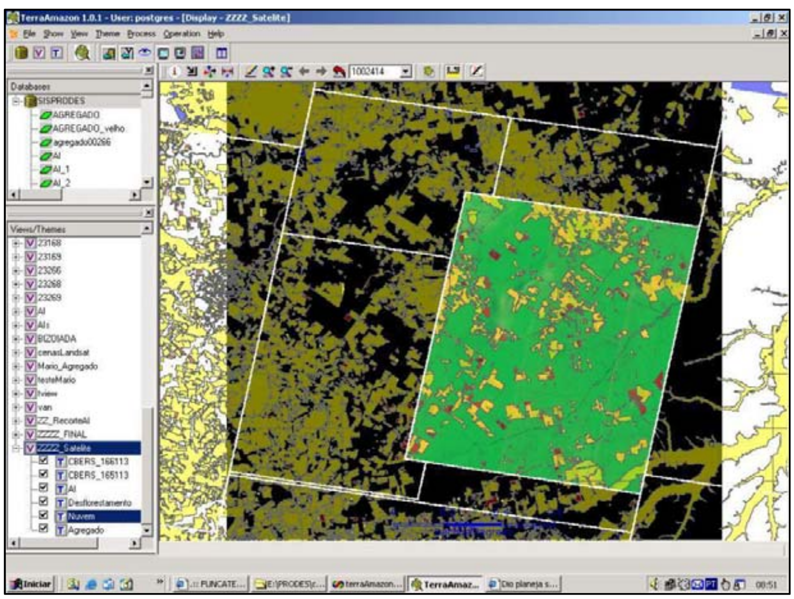

Figure 14: User interface for TerraAmazon

TerraME is a toolbox for spatially explicit modelling integrated with geospatial databases. It offers integrated functionalities for multiparadigm and multiscale modelling of the coupled human-environmental system. The outcomes of its models are maps that depict the spatial distribution of a pattern or of a continuous variable. TerraME supports models that use cellular automata, agents and system dynamics, or a combination of these methods. Using TerraME, INPE's group developed a model to account for farmer's behaviour in an area of 200,000 km^2 in Amazonia, which is a hotspot of deforestation (Figure 15). The model captures large-scale land change from the 1990s to the 2000s.

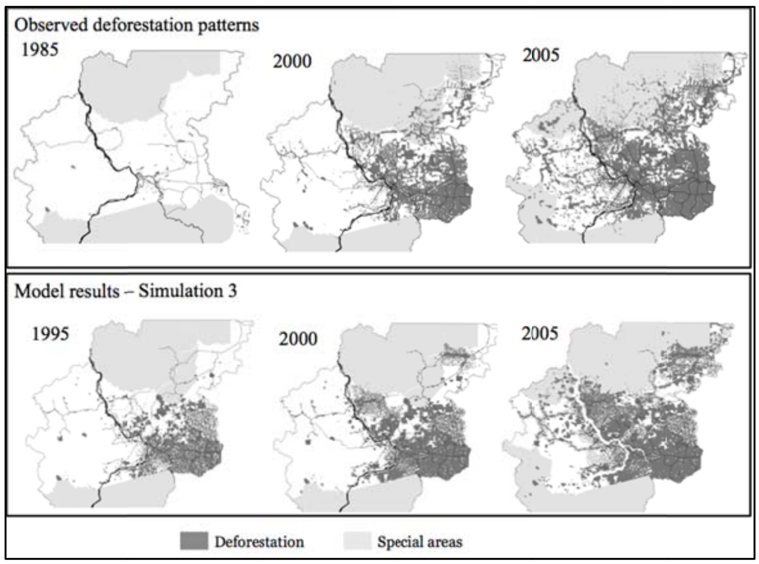

Figure 15: Observed and simulated deforestation in São Felix do Xingu (Amazonia)

The **aRT** package provides a direct link between a TerraLib database and the R programming language. R is an open source programming language for statistical computing and graphics and has become a *de facto* standard for developing statistical software (Ihaka and Gentleman 1996). R has contributors from all over the world, with continuous improvement that incorporates cutting-edge statistical methods. Packages in R relevant to REDD-PAC include: (a) *sp* - general support for spatial analysis (Bivand, Pebesma et al. 2008); (b) *spacetime* – methods for spatio-temporal data analysis (Pebesma 2011); (c) *dtw* – methods for dynamic time warping in R (Giorgino 2009).

The *aRT* API performs spatial queries and operations in R. It encapsulates TerraLib functions into R objects, and enables R users to read data from a TerraLib database. Figure 16 shows an example of the R-TerraLib coupling (Andrade-Neto and Ribeiro 2005). The base data is a set of point samples stored in a TerraLib database. This data was interpolated into a grid using the *geoR* package (Diggle and Ribeiro 2007) and the result stored as a TerraLib layer and displayed using the TerraView GIS application.

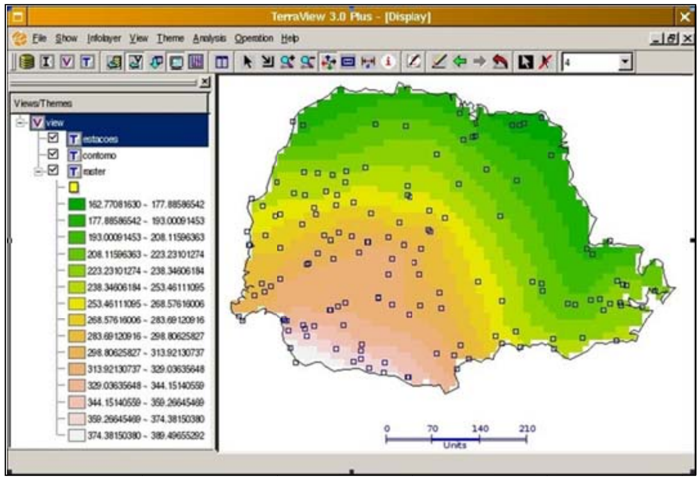

Figure 16: Plotting the result of an R geostatistical package in TerraView

GeoDMA (Geographic Data Mining Analyst) is a tool for data mining of remote sensing data. The toolbox provides algorithms for object-based image analysis and for change detection using landscape ecology metrics. The aim of GeoDMA is to be able to find objects in remote sensing images and to classify them using data mining methods. GeoDMA provides exploratory data visualization, to help the user select the best parameters for data analysis.

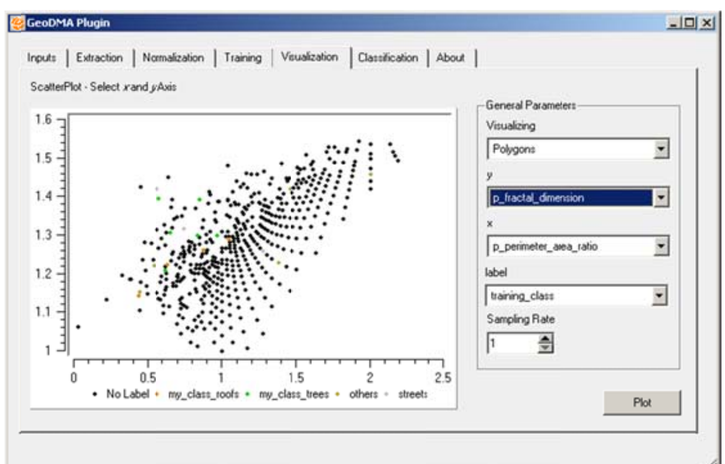

Figure 17: Visualization of training data in GeoDMA

4.1.3.3. Econometric and public policy modelling and products at IPEA

The Institute of Applied Economic Research (IPEA) is a public foundation affiliated to the Secretariat of Strategic Affairs of the President's Cabinet. IPEA's planning and research activities provide technical and institutional support to governmental actions for the formulation and reformulation of public policies and Brazilian development programs. As a result of its relevance, the Institute came to be known, throughout its existence, as the entity that has the mission to "think Brazil”.

IPEA's institutional mission is a goal IPEA seeks to fulfill in its every-day activities through the following strategies for action:

- Developing and disseminating studies and applied research.
- Performing prospective applied studies.
- Aiding the elaboration of government plans, policies and programs.
- Keeping track of and evaluating government plans, policies and programs.
- Aiding decision -making processes of government institutions.
- Carrying out training activities for the qualification of public management staff.
- Cooperating with governments and national and international agencies in their fields.

4.1.3.4. Limitations

Data challenges for the REDD-PAC project

Currently, INPE's land use data is restricted to the Brazilian Amazon. We lack such data for the rest of Brazil. With support from the REDD-PAC project, INPE will produce a full land use database for Brazil to feed GLOBIOM and other models.

Another challenge for land use data is its level of aggregation. As mentioned before, INPE has developed tools to downscale census data. In this project, the aim will be to match the data to the spatial resolution of the simulation models.

To face these challenges, INPE will improve its geospatial technologies and develop new methods to determine the land uses in each Brazilian biome. The next generation of INPE’s tools will work with very large databases that could be stored in different data sources and follow heterogeneous data formats. INPE’s software will be improved to support spatiotemporal data. Its interface with the R software will allow using statistical methods to classify, analyse and interpolate geospatial data.

Producing land-change data for Brazil

Most of the current global land use maps are based on data sets with a single time references. These maps include products such as GLC2000, MODIS and GLOBCOVER. However, there are many inconsistencies between these global data sets. A recent study for Africa points out that agreement between these land cover products is only about 60% (Kaptué Tchuenté, Roujean et al. 2011). This shows that global land cover datasets need much improvement.

In this project, one of the aims of INPE's team will be to use a time series of vegetation indexes derived from MODIS data to produce a database of land change for Brazil. Currently, the MODIS vegetation index time series is the only data set that allow us to identify different types of land use in large areas (Zhang, Friedl et al. 2003; Sakamoto, Yokozawa et al. 2005). Below, we show a MODIS time series for one cell in Amazonia, which shows a transition from forest to agriculture. Deforestation started in the last quarter of 2003 and ended in the last quarter of 2004. After land clearing, temporary agriculture (soybeans) started in 2005 and continues until 2011. Thus, different types of land use can be detected using the MODIS time series.

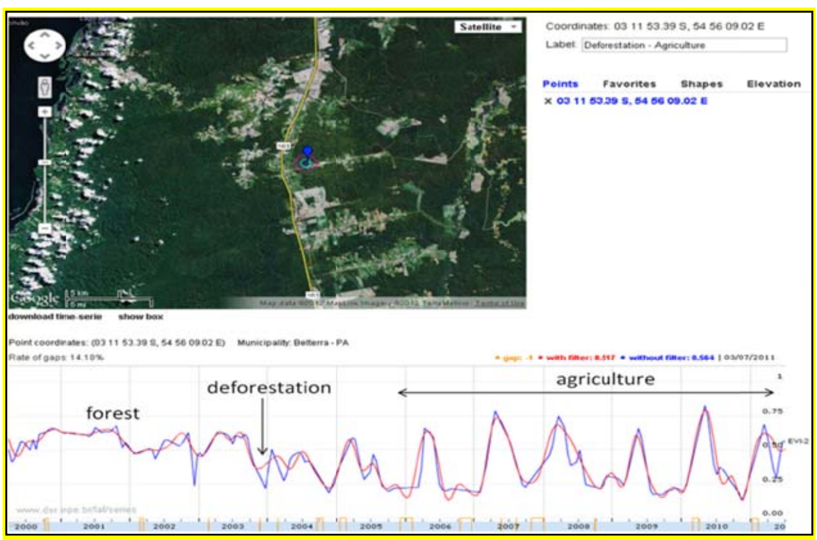

Figure 18: The EVI MODIS time series representing a cell in Amazonia (blue balloon).

There are some proposals in the literature for extracting information from MODIS time series. However, there are no proven methods to extract land use trajectories for large areas. Based on INPE's extensive experience with remote sensing, geoinformatics and statistics, we will develop new techniques for extracting land use maps from MODIS time series. The aim is to produce land use maps for Brazil in the end of 2013. If INPE is successful in producing these maps, we will work to produce better maps for tropical and subtropical Africa to be delivered by the end of 2014.

4.1.4. COMIFAC: data, tools, approaches

CongoBiom model

In 2010, the CongoBiom model was created by IIASA-ESM. Although only six out of the ten COMIFAC member countries were involved, it constitutes obviously a strong base for the REDD-PAC project.

COMIFAC's technical unit (OFAC)

Nowadays, the importance of the Congo Basin forests is unanimously recognized. Nevertheless, many questions and uncertainties persist on the services those forests provide, their spatial evolution, the opportunities they represent and the threats they face.

To overcome the lack of reliable information, numerous stakeholders in the region and beyond, from government departments, non-governmental organizations, the private sector and the scientific community initiated the development of a State of the Forest (SOF) report under the coordination of the Observatory for the Forests of Central Africa (OFAC), a permanent body under the auspices of COMIFAC.

Through that report, the Observatory allows COMIFAC and the Congo Basin Forest Partnership (CBFP) members have at their disposal an essential steering tool and knowledge-sharing system for improved governance and sustainable management of forest ecosystems.

During the two-year process that leads to the final report, the first year is dedicated to data collection by national groups consisting of six to ten members, all of whom working for public administrations dealing with forest issues. Data collected are validated during national workshops for public administration officials, environmental NGO representatives, the private sector and development projects. Finally, a State of the Forest sub-regional workshop is organized for a reasonable number of participants

(100) working in forest management, comprising representatives from the ten COMIFAC member countries and several of its partners.

The process to elaborate the SOF 2012 has been launched and will be extended to all ten COMIFAC member countries.

Other initiatives

Under the auspices of COMIFAC or some of its partners, a number of regional projects are planned, ongoing or already implemented (CIRAD EFBC 2040, FAO (UNREDD)/INPE MRV project, GEF institutional strengthening project on REDD+, CBFP). All those initiatives with a regional approach are likely to yield useful data for the REDD-PAC project.

Limitations of the CongoBiom model

The current version of the CongoBiom model involves six COMIFAC member countries out of ten. There is a strong need to feel the gap by enlarging it to the four remaining in order to let COMIFAC has a complete picture of its area of competence.

Furthermore, REDD+ is one of the points of great interest for the Congo Basin. The mastering of all its components/segments by the negotiators of COMIFAC member countries is crucial for their voices to be heard and their position adopted. For that to happen, the REDD-PAC project has to yield strong and unshakable arguments concerning in particular “conservation”, which concerns also biodiversity.

Finally, COMIFAC member countries need to start the construction of their reference levels (RLs). As a consequence, they need to develop scientifically credible estimates of their historic emissions and removals, based on data collected according to commonly accepted standards. Moreover, methodologies to adjust RLs for projections based on historical estimates have to be mastered.

Limitations of OFAC’s database

The deforestation rates are computed from satellite time series, at the Congo Basin level by the European Joint Research Centre and the Catholic University of Louvain, and at the RDC level by the South Dakota University and the OSFAC (Observatoire Satellital des Forêts d'Afrique Centrale). Very few Congo Basin countries assess forest cover and deforestation using satellites images. When they do, methodologies vary between countries. In addition, the information reported by the National Groups is somewhat inconsistent with the information given by the satellite images. In particular, some deforestation rates refer to old studies and FAO data, which are not very precise. Moreover, technical capacities in remote sensing are scarce in the Congo Basin area. When satellite images are available, the quality can be poor (due to problems with cloud cover).

The Congo Basin countries have numerous protected areas. However, inventory data for the flora and fauna are missing. The species dynamics over time is unknown. Furthermore, little is known about the management of protected areas. We hope that the signing of the OFAC-RAPAC convention will increase the collection of data about protected areas. Very few data exist on the threats to biodiversity in forest concessions in general, and on biodiversity conservation measures in those which are certified. This last activity was financed for a few months by WRI on a voluntary basis.

Most of non-timber forest products are sold on the informal market. Thus, no information is available on the quantities produced and traded. For now, only a few specific projects can provide information on some of the traded non-timber forest products.

4.2. Collaborations and on-going projects relevant for REDD-PAC

4.2.1. IIASA

International Center of Tropical Agriculture (CIAT), Cali, Colombia

- Oriana Ovalle, Peter Läderach: Global suitability maps of coffee and cocoa and impact of climate change on the suitable area of production by 2050
- Christian Bunn, Peter Läderach: Integrated Climate Change Impact Modelling of the Coffee Sector

National Coordination REDD (CN-REDD) DRC

- Bruno Hugel, workshop in Kinshasa in March 2012 where IIASA, UCL and Millenium Institute have been involved. A second modelling workshop in

Kinshasa is planned for October 2012. Documents and statistics which have been collected by the CN-REDD are shared in a common Dropbox folder.

Centre International de Recherche Agronomique pour le Développement (CIRAD)

- Jean-Noel Marien, Nathalie Bassaler: Analyse prospective sur les écosystèmes forestiers du Bassin du Congo EFBC 2040
- COFORTIPS project: the objective is to foster a better management of the Congo Basin forests through a better understanding of the dynamics, regime shifts and tipping points of biodiversity and a better definition of the conditions of resilience of social and ecological systems.

British Columbia University

- Yu Huang, Gary Bull and Steven Northway: Incorporating illegal logging into GLOBIOM

4.2.2. UNEP-WCMC

Biodiversity Indicator Partnership (BIP)

- UNEP-WCMC is the official Secretariat of the BIP. The CBD-mandated Biodiversity Indicators Partnership (BIP) is a global initiative that has operated since 2007, promoting and coordinating development and delivery of biodiversity indicators in support of the CBD and related Conventions, national and regional governments and a range of other sectors. Initially established to assess progress towards the CBD 2010 Biodiversity Target, the BIP has realigned itself to assist with implementing and monitoring progress towards the Strategic Plan for Biodiversity 2011-2020, as well as the work of other biodiversity related Conventions.

Convention on Biological Diversity (CBD) Secretariat

- Mr. Johannes Stahl, is presently the main contact point in the CBD Secretariat for the Climate Change and Biodiversity Programme within UNEP-WCMC. UNEP-WCMC has close collaborations with multiple people within the CBD

Secretariat on many issues and projects, especially in relationship to indicator development and policy targets.

UN-REDD global programme

- Tim Christopherson, Programme Officer at UNEP. He is head of the UNEP part of the UN-REDD programme. A key contact for UNEP-WCMC'S global and regional work within the UN-REDD programme

UN-REDD programme DRC

- Rubin Rashidi, UNEP UN-REDD programme contact point for UNEP-WCMC'S work on REDD+ safeguards within the DRC. Danae Maniatis, FAO UN-REDD programme contact in the DRC.

CN-REDD DRC

- Bruno Hugel, in contact with regard to our UN-REDD project in the DRC on the valuation and mapping of REDD+ multiple benefits.

MECNT, DIAF (Ministry of Environment, Nature Conservation and Tourism, Directorate of Forest Inventory and Management), Democratic Republic of Congo

- Christophe Musampa, collaboration on previous report on REDD+ in the DRC, and likely collaboration on the second phase on mapping and valuation of REDD+ multiple benefits.

MECNT, Direction du Développement Durable (Ministry of Environment, Nature Conservation and Tourism, Directorate of Sustainable Development), Democratic Republic of Congo

- Vincent Kasulu, Director and his colleagues in charge of biodiversity policy (Mike Ipanga and Chantal Nkey), with whom we are engaging with on this and other work on REDD+ multiple benefits.

Observatoire par Satellite des Forêts d'Afrique Centrale (OSFAC)

- Collaborated on the development of a REDD+ multiple-benefits mapping report.

SNV Viet Nam

- Steve Swan, Coordinator of the ICI-funded High-Biodiversity REDD+ project, co-implemented by SNV and the Vietnam Administration of Forestry (VNFOREST) through which an initial spatial analyses of carbon and biodiversity was conducted by national partners.

Viet Nam REDD+ Office

- Dr. Pham Manh Cuong, Director of the national government-endorsed ICI-funded High-Biodiversity REDD+ project, Chair of the Sub-Technical Working Group on Safeguards (STWG-SG); Director of the national REDD+ Office; UN-REDD Phase I co-ordinator.

Chinese Research Academy of Environmental Sciences (CRAES)

- Prof. Dr. Junsheng Li, Li Guo, Dr. Hu Lile and Dr. Zhao Zhiping. CRAES was collaboration partner in the initial spatial analyses conducted for the province of Jiangxi in 2010 and will be collaborating with us on a further spatial analyses in the province of Guangxi in 2012/2013.

Ministry of Environment, Ecuador (Ministerio de Medio Ambiente del Ecuador, MAE)

- MAE was collaboration partner in previous spatial analyses conducted in 2010 and will remain first contact point for any further work with the country.

4.2.3. INPE

Land Use Change in Amazonia: Institutional Analysis and Modelling at multiple temporal and spatial scales (LUA/IAM)

- This project aims to understand and model the social processes that contribute to large-scale deforestation in Amazonia. The project wants to develop land change models and data analysis tools that capture how land use systems function in different contexts in Amazonia. The project is partly funded by FAPESP ("Fundação de Amparo à Pesquisa do Estado de São Paulo"), and by INPE. Total funding is US$ 2,500,000.
  The project's principal investigator is Gilberto Câmara, and Pedro Andrade-Neto is one of the team members.

Global Land Project: International Program Office (GLP/IPO)

- The Global Land Project is a joint research project for land systems for the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme (IHDP). The focus of GLP is largely "land-centric" which includes the people, biota, and natural resources (air, water, plants, animals, and soil). Its science plan emphasizes changes in the coupled human and environmental system. The GLP science plan was published in 2005. The International Project Office (IPO) was set in Copenhagen from September 2006 to the end of 2011. From the 1st January 2012 the IPO is funded and hosted by INPE, at an annual cost of US$ 500,000.
  Gilberto Câmara and Giovana Espindola from INPE are currently staff members of the GLP IPO, and they are responsible for conducting most of its initiatives.

TerraLib and associated technologies

- The development of the open source software TerraLib and associated technologies (described in section 4.1.3.3) is being funded directly by INPE, under its budget received from Brazil's Ministry for Science, Technology and Innovation (MCTI). INPE spends about US$ 2,000,000 yearly to maintain these projects. Gilberto Câmara and Ricardo Cartaxo are principal investigators of this project.

4.2.4. COMIFAC

CIRAD

- Jean-Noël Marien, Nathalie Bassaler: Analysis of the future of the Congo Basin forest ecosystems at the term 2040 (EFBC 2040)

World Bank / Global Environment Facility (GEF)

- Hervé Maidou: Regional Project on institutional capacities reinforcement on REDD+ for SFM in the Congo Basin.

FAO (UN-REDD)/INPE

- Danae Maniatis: National MRV systems with a regional approach for the Congo basin countries.

OFAC

- Hiol Hiol François: The forests of the Congo Basin – State of the Forest.

Congo Basin Forest Partnership (CBFP)

- Gaston Grenier and Dany Pokem, Facilitator and Communication officer for the Canadian facilitation.

Programme d'appui pour la Conservation des Ecosystèmes du Bassin du Congo (PACEBCo)

- Bihini Wa Won Musiti and Anne-Marie Tiani: Programme on Congo Basin ecosystem conservation and project on synergies between adaptation and mitigation in the Congo Basin

5. Strategy for tool development

The output of the project will be a jointly developed cluster of fully integrated land-use models focusing on Brazil and the Congo Basin region. Data about land cover, land use, and biodiversity will be combined with physical and economic models in a globally consistent way so as to provide a spatially-explicit and multi-criteria assessment of a set of REDD+ policy options. In this section, we describe each of the components that will be produced by the project: the input database, the land-use models, and the scenario analysis.

It should be noted that information exchanges are important to the project as no single partner has all of the required skills and data to fully address the aims of the project. Hence, information will need to be passed amongst project partners. The central GLOBIOM model will be run at IIASA in a first step, thus other partners will have to pass to IIASA existing data and knowledge that could improve the model. However, the modeling tasks will be progressively transferred to local partners with the support of IIASA team. In particular, IIASA will train regional partners on the use of IIASA models. The first REDD-PAC school session will focus on GAMS software language, simplified partial equilibrium land-use models, and GLOBIOM applications. It will take place at IIASA on November 5-9, 2012. More training sessions will follow during the project. Analysis of model outputs, including for scenario assessment, will be carried out by all partners. Hence model outputs will need to be passed to all partners.

5.1. Consistent database on land use, land-use change drivers and biodiversity in Brazil and the Congo Basin

REDD-PAC will act as a global forum for sharing and improving global data on forests and deforestation drivers. The priority will be to use what is already available at INPE, COMIFAC, UNEP-WCMC, IIASA and from other collaborators to the project, especially for Brazil and the Congo Basin region, but also globally. Additional data collection and data production will be carried out, with priority given to covering identified modelling and data gaps.

Land-use databases produced by the project will be disseminated using the applicable international standards for geospatial datasets. These standards are defined by the Open Geospatial Consortium (OGC) and include both specifications for direct access to the data and for dissemination via the internet. The project will leverage INPE's experience with TerraLib database to build the joint REDD-PAC database.

5.1.1. Land use

The land-use data will come from global maps adapted to the IIASA model cluster format and resolution. In a first step, INPE will provide IIASA with the Amazonia deforestation database (full list of variables already available at: http://www.redd-pac.org/amazonia-database.html). In a second step, the database will be extended to other Brazilian biomes. INPE will also use a time series of vegetation indexes derived from MODIS data to improve the land-use information. COMIFAC will provide OFAC/OSFAC maps for the Congo Basin.

The geo-wiki information platform (see section 4.1.1.1) may be leveraged to improve land-use data. We anticipate mobilizing a large number of individual contributors.. We will also build a global network of interested parties from international organizations and NGOs that will help to validate the database.

Land can also have political designations that impact on its use including designations such as protected areas, indigenous reserves and, within Brazil, areas designated under its forest code. Data on these different land designations will be included into the land use database using existing geospatial databases ormethodologies to identify the areas under different rules. Land use designations will be linked to specific usage rules in accordance with legal constraints and, where possible, observed patterns. UNEP-WCMC will work with IIASA to develop classification rules related to different types of protected areas. Remote-sensing data and local knowledge will be used to provide an assessment of the actual effectiveness of existing designations that can be used to improve the way they are treated in the model.

5.1.2. Land-use change drivers

The information on actual and future land-use change drivers will come from various sources. It will include information on:

Population and GDP- The population dynamics as well as the level and distribution of wealth among the population will influence the future demand and the resulting land use dynamics. For instance, larger populations usually require more food and wealthier people often consume more meat. Moreover, consumption patterns differ from one region to another due to cultural differences, and diets may vary inside a country between rural and urban people. People living remote from markets, may depend more on subsistence agriculture, i.e., the distribution of population is the best indicator for agriculture production.

Connectivity- Numerous studies have highlighted the crucial role of transportation infrastructures in past deforestation. The connectivity structure is especially critical for a country of the size of Brazil or to a lesser extent of the Democratic Republic of the Congo. We will use data on the road network, including road quality,distances and transportation costs. Infrastructure development projects will also be included in the database and taken into account in the freight costs for the next decades. We will also gather information on ports tariffs.

Agriculture and Forestry- Most of the data currently used in GLOBIOM come from FAOSTAT (production, harvest area, cattle heads, prices, average crop yields, consumption...). Agricultural and forestry statistics at sub-national levels as well as additional statistics related to management (fertilizer use, machinery use, water use...) will be collected in each country and added to the database. One particular challenge is to get a better information on production costs in land based economic activities in Brazil and in the Congo Basin. In addition, productivity potentials estimated by EPIC for agriculture and G4M for forestry will be validated using sub-national statistics and expert knowledge.

Mining- Gold, copper, diamonds, oil, and other important mineral resources are found in rainforests around the world. The extraction of these resources can be directly destructive of forests and also brings in migrants who place additional demands on surrounding land. The Amazon is considered to have great potential for copper, tin, nickel, bauxite, manganese, iron and gold. The Congo Basin has some of the world richest mineral deposits, including oil, iron, copper, manganese, uranium as well as diamonds and gold. Mining operations are poorly monitored and are contributing to conflicts in the Eastern Congo.

Bioenergy- The global bioenergy demand is expected to increase in the near future, and a the same time the need for land to produce the feedstock. Brazil is already the largest producer of sugarcane-ethanol in the world and the second largest producer of bioethanol. It is also one of the largest exporter of bioethanol. Congo Basin countries have also the potential to contribute to the global supply of bioenergy or bioenergy feedstock. For the moment, fuelwood is the most common source of household energy in the Congo Basin. Fuelwood alsorepresents a significant share of the energy portfolio in Brazil.

5.2. Spatially explicit land-use models for Brazil and Congo Basin countries

Spatially explicit land-use models are relevant tools to help with planning for multiple benefits from REDD+. First, it is important to understand the state of knowledge on the spatial relationship between the carbon stored in ecosystems, biodiversity and other ecosystem services, and pressures exerted on ecosystems both at local and international levels. Second, it is crucial to account for international trade in a global assessment of REDD+ benefits because REDD+ activities will increase the pressure on low carbon forests and other ecosystems, including those valuable for biodiversity conservation (geographic leakage). Third, land-use models have the potential for broader benefits, including helping to generate national capacity for improved land-use planning and integrated policy development. Land use models can support intersectoral coordination, including amongst policies for agriculture, forestry, nature conservation and bio-energy.

In the project, the spatially explicit land-use models will in fact be a cluster of models centered on an updated version of GLOBIOM, and run at the regional and national scale. For the Congo Basin and Brazil, a regional version will include the standard features of GLOBIOM, but the representation of land-use will be improved for all the countries in the region. In the Congo Basin, three national versions will also be made available for 3 pilot countries. Their selection will rely on the tangible and transparent criteria listed in Appendix D.

The regional partners will be instrumental in co-developing the land-use models in collaboration with IIASA and WCMC teams, increasing their technical detail and applying them at finer geographic scales. Improvements to the GLOBIOM model will be made through refining the model components, developing improved input data, and validating the model through comparison with empirical data on land use change and with results of other regional studies. Results from econometric studies may be used to better understand the past dynamics in land-use change and provide estimates of key parameters. Regional partners will also contact technical staff in research institues and/or government institutions.

The main **outputs** of the regional land-use models will be for each scenario and each 10-year period:

- Land-use change at a 50x50km resolution
- GHG emissions from land-use change and agriculture
- Crop production at a 50x50km resolution by crop and management system
- Livestock production at a 50x50km resolution by animal type and management system
- National prices
- Bilateral trade flows
- National demand level

Econometric, cellular automata and agent-based models will be possibly coupled to GLOBIOM to downscale GLOBIOM results and increase their quality. Downscaling is valuable for public policy in Brazil, given the specific attention turned to regional inequality issues.

The **integration of data and tools** will again leverage INPE's experience in information technologies. It will initially affect IIASA and INPE's tools, and may be extended to WCMC and COMIFAC's tools at a later stage. The interface between IIASA and INPE's tools will be developed in two steps. First, a loose coupling will be implemented. Import and export functionalities for INPE's tools will read and write data compatible with IIASA models, so these models can use the data manipulated by INPE's tools. This strategy is straightforward, but it provides enough functionality to allow modellers to start using INPE's data for the next deliverable of this project.

The second step will be a strong integration. INPE will develop new software drivers for TerraLib to read and write directly to the formats used by IIASA models. This will provide an easy-to-use environment that keeps data updated in a single database. Figure 19 shows a preliminary scheme of the two steps related to the integration between TerraLib and G4M. The integration with other IIASA models will follow a similar strategy.

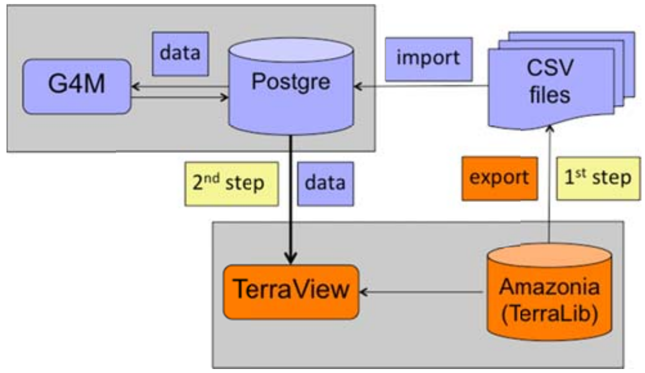

Figure 19: Integration between TerraLib and G4M

5.3. Policy assessment and scenario development

5.3.1. Policy scenarios

One important objective of the project is the assessment of the impacts of several REDD+ policy options on land-use change, economy, emission reduction and biodiversity by 2030 or 2050. These policy options will be included in different forward-looking scenarios. A 'No Additional Policy Scenario' (NAPS) will be designed to account for current policies and their actual effectiveness, as well as their implementation as anticipated for the next decade. The NAPS scenario will include projections of important parameters (drivers) over the next decades such as population, GDP, infrastructure network, or technological change. The selection of the most realistic assumptions will be based on i) the collection and comparison of the available information and ii) a broad consultation of stakeholders, national and international experts. A set of alternative scenarios will account for new policy instruments, especially in relation to REDD+, and taking account of biodiversity priorities. The drivers will most likely be similar to those defined in the NAPS scenario.

All partners will contribute to the definition of plausible policy options for REDD+ within the different regions, and to the assessment of the different policy scenarios. A range of stakeholders will also be involved (see section 5.3.2). In this project, IIASA will lead the assessment of the economic impacts and UNEP-WCMC the assessment of the biodiversity impacts.

5.3.2. Interaction with stakeholders

For a maximum policy impact of the work undertaken within the project, close cooperation and consultation with national experts, including REDD focal points and decision makers interested in climate change and biodiversity conservation, is crucial. The interaction with experts will follow several stages.

We will first organize small technical workshops with second-level policy advisers who have a detailed understanding of policy design and implementation and analysts who have a very good knowledge of REDD+ mechanisms. The latter will also contribute on how to bring REDD+ into a wider policy framework. The objective is threefold: (i) to acquaint national stakeholders with REDD-PAC and the modelling approach used to assess policies, (ii) to build a credible NAPS, (iii) to investigate how REDD+ could be integrated into the current policy framework. In a second step, we will present first tentative results to higher-level policy makers. We will follow-up on how to implement adjustments with the technical group from the first stage.

In Brazil, the first workshop is planned on September 11, 2012 with Brazilian stakeholders from the Ministry of Environment (MMA), the Agricultural Research Agency (EMBRAPA), the Pontifical Catholic University of Rio (PUC-Rio), IPEA and INPE. As discussed in Section 2.2, the federal government is the most influential actor and will determine much of the land change in Brazil. Issues such as land ownership, ecological zoning, creation of environmental protection areas, quality control for crops and cattle, infrastructure construction, are dependent on federal actions. As a result, most of the simulations that will be run in the project will consider policy options that are available to the federal government. Therefore, we will focus on policy makers within the Brazilian federal government when interacting with stakeholders. We will meet officials in the Ministries of Environment, Agriculture, Agrarian Reform, Science and Technology, Planning, and Foreign Relations. We will also contact decision makers in the private sector, especially those involved in the soybean, cattle, forestry and biofuel markets.

In the Congo Basin, the first workshop will be held in DRC in the first week of October. Appropriate resource persons from relevant ministries and other state institutions will be identified to provide domestic information on various sectors (agriculture, transport, forestry, mining, etc.). Project partners will also interact with decision makers from the private sector (logging, mining, agro-industry). It is planned that other workshops will be organized at both national (pilot countries) and regional levels in order to discuss and validate the data needed for the scenario-building process, and disseminate results.

5.4. Multiple benefits assessment in additional countries

In addition to the tool development work within Congo Basin and Brazil, the REDD-PAC project will assist six other countries with work on multiple benefits from REDD+.. The work will cover capacity building in Peru, Uganda, Philippines and China on spatial analyses of the relationship between carbon, biodiversity, ecosystem services and drivers of change. Such analyses are essential to underpin REDD+ scenario analyses and the development of biodiversity indicators. Further targeted support will also be provided to Ecuador and Viet Nam, where initial spatial analyses have already been completed, but where results have not yet been applied to their full potential. For example, support may be provided in developing biodiversity indicators and monitoring systems and in broader spatial planning for climate change.

Collaborations will be established with relevant stakeholders (including UNFCCC and CBD national focal points) in each of the countries to agree on the modalities for the capacity building and targeted support. For Peru, Uganda, Philippines and China, relevant spatial data will be gathered and their suitability for inclusion in the analyses assessed in collaboration with national partners. With all countries working sessions with a technical and or policy focus will be organised either in the countries or at the Cambridge offices of UNEP-WCMC, depending on the countries' facilities and preferences. Based on the outcomes and outputs of the working sessions, collaboration will continue remotely to finalise the results. The output for each country will be a report summarising the results of the spatial analyses and targeted support and discussing the relevance of the work in the light of national land use planning processes, including REDD+ planning, and national biodiversity monitoring and reporting.

6. Project implementation

The management team for the project is based at IIASA and consists of: M. Obersteiner, F. Kraxner, and G. Bocquého. IIASA will be the only contact point with the funding organization BMU-ICI.

IIASA is responsible for reporting expenses to BMU-ICI basing on the financial reports prepared quarterly by each partner. However, each partner is responsible for collecting and classifying the corresponding receipts, and for justifying the expenses to BMU-ICI when required.

IIASA will also monitor the progress of the project, and ensure the overall quality control of methods and results. In particular, IIASA will coordinate the deliverables, which includes distributing milestones and assignments, reviewing and assessing quality before sumission, compiling and submitting on time the final documents to BMU-ICI. A REDD-PAC account was created in the project-management tool 'Mavenlink' (https://www.mavenlink.com/login) to track deliverables. The full list of the project deliverables is presented below (in chronological order, the due dates are indicated as initially scheduled, but will be slightly postponed because of the delay in the effective beginning of the project):

1) D.1.2.1. Assessment strategy report (August 1, 2012)
2) D.2.1.4. Description of model-ready inputs (August 1, 2012)
3) D.2.1.1. Launch of driver and forest-resources geo-wiki tools (November 1, 2012)
4) D.2.2.1. Launch of integrated model cluster (August 1, 2012)
5) D.2.1.3. Report/Atlas featuring carbon, biodiversity and priority areas for conservation (May 1, 2014)
6) D.1.2.2 Evaluation report on the overall assessment strategy (August 1, 2014)
7) D.2.3.1. Report on impact assessment of REDD+/CBD policies (February 1, 2015)
8) D.2.1.2. Driver and forest resources product report (May 1, 2015)
9) D.2.1.5. Final policy-scenario background document (May 1, 2015)
10) D.2.2.2. Technical description of model cluster (August 1, 2015)
11) D.2.3.2. Policy paper on institutional requirements (November 1, 2015).

The main versions of the deliverables and related documents will be uploaded in Mavenlink. Intermediate versions and other topic-specific documents will be exchanged through 'DropBox' accounts.

Data and information about important events will be exchanged mainly through the project internal website (www.redd-pac.org). A list of past and upcoming events is provided in Appendix E. The website will be hosted by INPE but IIASA will be responsible for its content.

IIASA will also organize the activities under the REDD-PAC research school, and coordinate the project meetings in collaboration with the hosting partners.

7. External communication and dissemination

The REDD-PAC website (www.redd-pac.org) will be used for both internal and external communication. The public website will contain general project information, public deliverable documents, a scenario portfolio and a set of assessment results. Furthermore, project-relevant country data will be possibly made available.

Supplementary communication material will be created depending on project needs. A one-page leaflet (see Appendix F) and a logo (see front page) are already available.

Research results will be disseminated in scientific community through participation to international conferences and other high-level workshops. Academic journal articles will be produced and submitted for publication to high-quality peer-reviewed journals and academic open access journals.

Results will be disseminated to policy makers through participation in side events at the UNFCCC and CBD COP and SBSTA meetings. In addition, country-specific results will be presented to national policy makers in special workshops.

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Appendix

A. List of products in GLOBIOM

AGRICULTURE	FORESTRY
Crops	**Primary wood products**
Barley	*Sawnwood Biomass*
Dry Beans	*Pulp wood Biomass*
Cassava	*Other Industrial wood Biomass*
Chickpeas	*Fuel wood Biomass*
Corn	*Other energy wood biomass*
Cotton	**Final wood products**
Groundnut	*Sawnwood*
Millet	*WoodPulp*
Ooil Palm	
Potatoes	**BIOENERGY**
Rapeseed	**1st generation biofuels**
Rice	*Ethanol 1st Generation*
Soybeans	*Biodiesel*
Sorghum	**2d generation biofuels**
Sugarcane	*Ethanol 2d Generation*
Sunflower	*Methanol*
Sweet Potatoes	**Heat**
Wheat	**Bioelectricity**
Meat	**Biogas**
Beef	**Stove**
Lamb and goat	
Pork	
Chicken	
Milk	
Eggs	

B. List of regions in GLOBIOM

GLOBIOM's 30 regions:

ANZ: Australia, New Zealand; **Brazil; Canada; China; Congo Basin**: Cameroon, Central African Republic, Congo Republic, Democratic Republic of Congo, Equatorial Guinea, Gabon; **Eastern Africa**: Burundi, Ethiopia, Kenya, Rwanda, Tanzania, Uganda; **EU Baltic**: Estonia, Latvia, Lithuania; **EU Central East**: Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia; **EU Middle West**: Austria, Belgium, Germany, France, Luxembourg, Netherlands; **EU North**: Denmark, Finland, Ireland, Sweden, United Kingdom; **EU South**: Cyprus, Greece, Italy, Malta, Portugal, Spain; **Former USSR**: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan; **India; Japan; Mexico; Middle East and North Africa (MENA)**: Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, Yemen; **Pacific Islands**: Fiji Islands, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Tonga, Vanuatu; **RCAM**: Bahamas, Barbados, Belize, Bermuda, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Netherland Antilles, Panama, St Lucia, St Vincent, Trinidad and Tobago; **RCEU**: Albania, Bosnia and Herzegovina, Croatia, Macedonia, Serbia-Montenegro; **ROWE**: Gibraltar, Iceland, Norway, Switzerland; **RSAM**: Argentina, Bolivia, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela; **RSAS**: Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan, Sri Lanka; **RSEA OPA**: Brunei Dar-es-salaam, Indonesia, Singapore, Malaysia, Myanmar, Philippines, Thailand; **RSEA PAC**: Cambodia, Korea DPR, Laos, Mongolia, Viet Nam; **South Africa; South Korea; Southern Africa:** Angola, Botswana, Comoros**,** Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Reunion, Swaziland, Zambia, Zimbabwe; **Turkey; United States of America (USA); Western Africa:** Benin, Burkina Faso, Cape Verde, Chad, Cote d'Ivoire, Djibouti, Eritrea, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Somalia, Sudan, Togo**.**

C. Remote sensing satellites at INPE

INPE’s main remote sensing satellite program is the China-Brazil Earth Resources Satellites (CBERS). In Brazil, INPE designs half of the subsystems, and contracts them to the Brazilian space industry. In China, CAST (Chinese Academy of Space Technology) is responsible for designing and building half of the satellites. The satellites are launched in China by a Long March 4B rocket. Data reception, processing and distribution in China is done by CRESDA (China Center for Resources Satellite Data and Application) and in Brazil by INPE.

Currently, the CBERS program includes five satellites. CBERS-1 worked from October 1999 to July 2003. CBERS-2 functioned from October 2003 to June 2008; CBERS-2B worked from September 2007 to May 2010. CBERS-3 is planned to be launched in late 2012 and CBERS-4 in late 2014. CBERS-3 and CBERS-4 have four cameras with bands in visible, near-infrared, middle and thermal infrared (Table 1).

Table 1: Sensors onboard the CBERS-3 and CBERS-4 satellites

Camera	Spatial resolution (m)	swath (kw)	Spectral bands
PANMUX	5/10	60	3 visible, 1 near infra-red
MUXCAM	20	120	3 visible, 1 near infra-red
IRMSS	40	120	1 near infra-red, 2 mid infra-red, 1 thermal
WFI	70	860	3 visible, 1 near infra-red

Brazil and China were the first nations in the world to offer free medium resolution satellite data, an example now followed by the United States and the European Union. As of August 2012, INPE has delivered more than 1,000,000 CBERS images to 15,000 users, proving the economical and social benefits of the free data. In China, CRESDA delivered more than 2,000,000 images to its users since 2008.

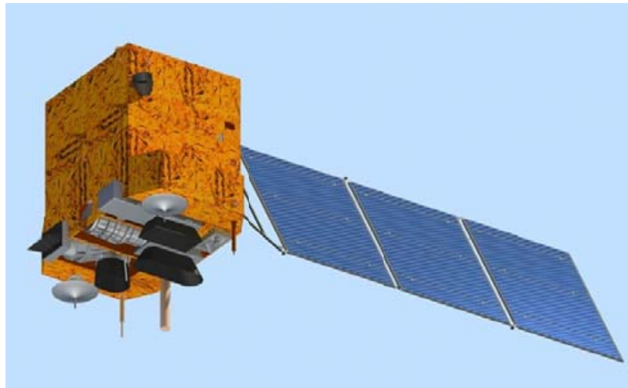

Figure 1: Artistic depiction of the CBERS-3 satellite

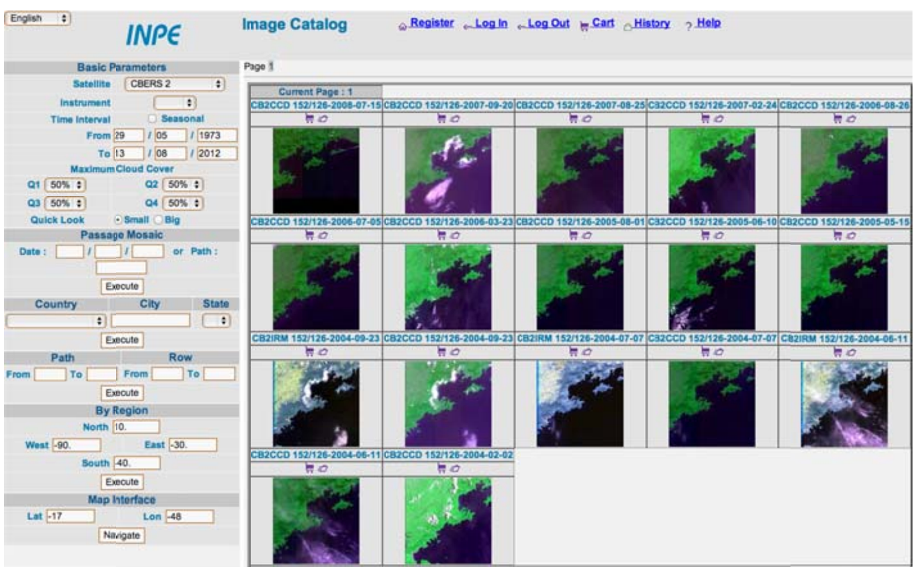

Figure 2: Webpage for image selection and downloading at INPE's Remote Sensing Data Centre

Figure 3: CBERS-2B image of Manaus in Amazonia

The open data policy adopted internally in Brazil and China has now been extended worldwide. CBERS images will be available to developing nations in all continents. China and Brazil have also agreed on a joint strategy for international access to remote sensing data in Africa. From 2013 onwards, African ground stations in South Africa, Canary Islands, Egypt, and Gabon will receive and freely share CBERS data.

D. Criteria for selecting Congo Basin pilot countries

A. Availability of information/statistics
  - Agriculture statistics (availability of time series, of sub-national statistics…)
  - Forestry statistics (availability of time series, of sub-national statistics…)
  - Household surveys
  - Biodiversity statistics
  - Drivers of deforestation

B. Potential of the country for REDD+
  - Total forested area
  - Share of the forested area in total land
  - Total carbon stocks

C. Pressures on ecosystems
  - Historical deforestation rate over 1990-2010
  - Evolution of the deforestation rate
  - Biodiversity loss
  - Population density and population growth rate
  - Agriculture growth rate
  - Fuel wood consumption
  - Timber harvests

D. National interest
  - Involvement in REDD+ initiative
  - Other ongoing projects on land use change and REDD+
  - Success of data collection for IIASA in phase 1
  - Continuity of experts involved in IIASA workshops in phase 1
  - Diffusion of the IIASA study nationally (REDD+ strategy)

E. List of events

WORKSHOPS

NAME	DATE	PLACE	PARTICIPANTS	FOCUS
Kick-off meeting	May 22-24, 2012	INPE (Sao José)	IIASA / UNEP-WCMC / INPE	Kick-off of the project
Workshop No 1	June 28-29, 2012	IIASA (Laxenburg)	IIASA / INPE	Strategy for tool integration
Workshop No 2	Sept 11, 2012	INPE (Sao José)	IIASA / INPE	Policy scenarios and technical coefficients
Workshop No 3	Oct 4-5, 2012	(Kinshasa)	IIASA / UNEP-WCMC / COMIFAC	Kick-off and policy scenarios
Workshop No 4	Oct 29-31, 2012	IIASA (Laxenburg)	IIASA / UNEP-WCMC / INPE / COMIFAC	Data exchanges and policy scenarios

REDD-PAC SCHOOL

NAME	DATE	PLACE	PARTICIPANTS	FOCUS
Session No 1	Nov 5-9, 2012	IIASA (Laxenburg)	IIASA / UNEP-WCMC / INPE	Partial equilibrium models in GAMS and application to GLOBIOM

F. One-pager

REDD-PAC project: Land-use modelling at global and regional scales to support national and regional REDD+ policies. More information is available at http://www.redd-pac.org.

Goal: Identify REDD+ policies that are economically efficient and socially fair and can safeguard and enhance ecosystem values and help meet the goals of the Convention on Biological Diversity (CBD).

Background: Policies for achieving REDD+ goals (Reducing Emissions from Deforestation and Forest Degradation plus conservation of forest carbon stocks, sustainable management of forests and increase of forest carbon stocks) under the UNFCCC will have major impacts on land use. Land-use in turn affects economic returns and ecosystem services. Thus, understanding how different policies could influence land use and its effects is essential to support informed decision-making.

Methods: The REDD-PAC project will develop novel models, data and analysis that can show the multiple effects of land use policies. These models and tools will help to identify ways of achieving a balance between the multiple goals of REDD+ for each specific regional case.

Global land-use model: A global land use model (GLOBIOM), developed by IIASA, will be used to support high resolution REDD+ planning. GLOBIOM projects land use change by spatially modelling supply and demand for competing agricultural, bioenergy and forest commodities. The project will use GLOBIOM for analysis of different land use policies (including those addressing biodiversity priorities), with a focus on Brazil and the member countries of the Central African Forests Commission (the Congo Basin). Results of GLOBIOM will be used to assess the economic and biodiversity impacts of different REDD+ policy options, and their potential contribution to achieving the CBD's Aichi Targets, economic growth or food security.

Regional partners: Regional partners will lead in identifying and defining policy options for REDD+ and land use. The partners will develop regional versions of GLOBIOM and will improve the models through comparison with land use data and results of other regional studies.

Global policy analysis forum: The project will provide a global forum for sharing and improving global data on forests and deforestation drivers and developing best practices for national REDD+ and land-use planning. Novel data, tools and analysis will be provided in the project's website.

Related work with other countries: The project will also support work on multiple benefits from REDD+ with national partners in further six countries (China, Ecuador, Peru, the Philippines, Uganda and Vietnam). The work will be tailored to the specific needs of each country.

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