REDD-PAC

REDD+ Policy Assessment Centre

Project under the International Climate Initiative of the Federal Ministry

for the Environment, Nature Conservation and

Nuclear Safety (BMU), Germany

PROJECT REPORT

POLICY CONSIDERATIONS FOR LAND USE MODELS IN BRAZIL

Report Date: 18 October 2012

Project number	10_III_028_Global A_REDD land use modelling
Ref	42206-6/28
Project Duration	Nov 2011 – November 2015 (4 years)
Coordinating Organization	International Institute for Applied Systems Analysis (IIASA)

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	
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	
5	Instituto de Pesquisa Economica Aplicada	IPEA	Brazil	**X**

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This project is supported by funding from the 2010 International Climate Initiative of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Germany.

REDD-PAC PROJECT
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Version: October 18, 2012

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SUMMARY

1. Introduction

In this document, we discuss some main policy issues to be considered in land use models for Brazil. The discussion includes policies to be evaluated by the REDD-PAC project, using the methodologies available in EPIC, GLOBIOM and TERRA-ME models. Our discussion is based mainly on the new forest code, on the low carbon agriculture program, on the Action Plan for Prevention and Control of Deforestation in the Amazon – PPCDAm, and on the Action Plan for Prevention and Control of Deforestation and Forest Fires in the Cerrado - PPCerrado. Even though, in our evaluation, these policies seem to be the main ones for evaluation by using land use models, we also discuss a series other issues to be taken into account, or that deserve further analysis, when performing numerical evaluations with economic models.

The idea is not only to consider the policies as they are now, but also to gain insights, so as we can propose some improvements, in terms of instruments to make these policies more effective. One of the instruments to be employed is in the form of tax incentives (tax breaks) for producers adopting some of the initiatives for emission reduction, for example. Other instruments may include payments for environmental services, extending command and control initiatives or focusing on more biodiversity endangered locations.

Section 2 of this document covers the new forest code, which has been the object of discussion by the Congress House, by the President's House and by other members of the international and domestic institutions. Section 3 discusses the low carbon agriculture program in Brazil, which encompasses six types of instruments to foster the adoption of modern technologies allowing a more intense soil recovery, a productivity gain, and the reduction of GHG. Section 4 presents a discussion on the PPCDAm program, which has been the main responsible for the drop o deforestation rate in Brazil in recent years, whereas Section 5 describes the PPCerrado program. Additional topics, such as payment for environmental services, biodiversity priorities, migration flows, which are also important for modeling land use change in Brazil, are discussed in Section 6[1]. Section 7 presents some synthesizes the main recommendations for land use models and concludes the document.

2. New Forest Code

The new Brazilian forest code was published as the Law, number 12.651, in May 25, 2012, by the Brazilian President, after several revisions and approval by the Chamber of Deputies and the Senate House. Nonetheless, for the first approved version by the Congress House, President Dilma Rousseff vetoed 12 articles. One of the main points of discussions for the veto was related to the recovery of permanent preservation areas by the margin of the rivers. For these 12 articles, the President House released a provisory measure (valid from its publication) for 120 days. The discussion returned to the Congress House, and a new Provisory Measure (PM), number 571, was approved, but in October 2012 the President vetoed 9 out of 84 items of the new PM. The veto

[1] The present document benefited greatly from the discussion during the workshop in September 2012, held at INPE, in São José dos Campos. All remaining errors are the author's responsibility only.

affected directly items related to deforestation close to water streams. It is possible that the lobby from the agriculture and beef producers sectors will still try to bring some of the vetoed topics back to discussion. In spite of all the current debate on the new forest code, its main topics will be maintained. Some of these topics are discussed in this section.

The new law treats two main points: (a) *permanent preservation areas* (APP[2]); (b) *legal reserves* (RL[3]). The permanent preservation areas correspond to critical sites, in both rural and urban regions. These areas, differently from the legal reserve, are intended to the preservation of water resources, landscape, geologic stability and biodiversity. Areas eligible for APP include:

(a) River margins – the preserved areas depend on the river width. For example, for width of 10 meters, the preserved areas correspond to 30 meters from the river margin; for width from 10 to 50 meters, the preserved areas correspond to 50 meters from the river margin; for width larger than 600 meters, the preserved area goes up to 500 meters from the river margin.
(b) Areas with inclination above 45%, on the side of mountains or hills.
(c) Areas around water springs, up to 50 meters from the margin.
(d) Hill and mountain tops.
(e) Any area 1.8 thousand meters above sea level.
(f) Wetlands and sandbanks.

The legal reserve corresponds to a percentage of the rural property which has to be preserved – this percentage depends on where the property is located. The idea of the legal reserve is to ensure the sustainable economic use of natural resources, to foster the conservation and rehabilitation of ecological processes, and to promote biodiversity conservation as well as providing shelter and protection for the native flora and the wildlife fauna.

The shares of legal reserve obey the following values:

(i) For the Legal Amazon: 80% for properties located in forest areas; 35% for properties located in the Cerrado biome; 20% for properties located in general fields.

(ii) Other regions in Brazil: 20%.

Several possible exceptions are described in the new forest code. For example, for municipalities with more than 50% of its land in the form of native indigenous protected area or some form of preserved forest, the percentage of legal reserve can be reduced down to 50%, instead of 80%. A similar rule exists at the state level.

The objectives for the legal reserves and for the permanent preserved areas are quite different, as described above. One of the main differences is related to the economic use that can be given for the legal reserves. For example, the RL's can be used for commercial forest, with plantation of pine

[2] APP – Área de Preservação Permanente.
[3] RL – Reserva Legal.

eucalyptus, and black wattle. Another use for the legal reserves is the commercial exploration of Brazilian nuts. One of the consequences of this difference is that an APP in a certain property can be counted as legal reserve, as long as the area is not used for commercial purpose.

Another instrument predicted in the new code is the use of *environmental servitude*. According to this instrument, when a certain establishment has a legal reserve above its requirement (say 90% in the Amazon region), it can transfer the additional legal reserve area to another establishment, not complying with the required percentage. This instrument already existed before the new code, but the new Law creates a new institute to empower the idea of transference of rights for land use.

The forest code creates the new instrument denoted *environmental reserve shares* (CRA[4]), which represents an area of existing native vegetation, or in process of recovery. The emission of CRA's is done under requested by the land owner, and is conditioned to the inclusion of the property in the new rural properties data base, also predicted in the new code. Each CRA corresponds to one hectare of: (i) primary native vegetation; (ii) secondary vegetation in any stage of regeneration; (iii) areas under recovery by reforestation with native species. The CRA can be used to compensate for legal reserve in another rural property located in the same biome.

In addition to the restrictions because of the permanent preservation areas and the legal reserve limits, the new Brazilian forest code also specifies restrictions to the denominated *areas of restricted use*. In swamplands it is permitted the exploration of ecological sustainable activities, following technical recommendations by the official research institutes. In these areas, it is not allowed to new clear cutting of original vegetation, except if there is official permission from the state environmental institution. For areas with inclination between 25% and 45%, it is allowed sustainable forest manure and systems integrating pasture, crops and forests. Conversion of new areas is not allowed, except in situations of public or social interest. For the simulation exercises in GLOBIOM and TERRA-ME, it is important to have a map of swamplands and areas with inclination between 25% and 45%, and specify them as restricted areas for further deforestation.

2.1. Consolidated Activities and Permanent Preservation Areas

One of the main complications of the new forest code in Brazil is the treatment for consolidated areas. Specifically for the permanent preservation areas, there is a set of rules on how much area has to be recovered, in the case of previous usage (before the new law). These rules tend to benefit small properties. A further complication in this equation is how small property is defined, which depends basically on the definition on a *fiscal module*. A fiscal module is a measure of area, varying according to the municipality where the rural property is located.

The fiscal module, created by the Law number 6.746/1979, has the primary goal of determining a measurement unit at the municipality level, for application of the ITR[5] (rural property tax). The

[4] CRA - Cotas de Reserva Ambiental.
[5] ITR – Imposto Territorial Rural.

fiscal module is a multiple of a hectare, and it varies from 5 to 110 hectares. For example, in the state of Amazonas, the largest module has 100 ha whereas the smallest one has 10 ha. In average, a fiscal module in Amazonas has more than 90 ha.

According to the new forest code, for rural establishments with area up to one fiscal module, with consolidated areas, they have to recover an area of 5 meters from the river margin. For properties with area between 1 and 2 fiscal modules, with consolidated areas, they have to recover an area of 8 meters from the river margin. For properties with area from 2 to 4 fiscal modules, the area to be recovered by the river margin is located within a distance of 15 meters. For establishments with area greater than 4 fiscal modules, the area to be recovered depends on the river width.

Additionally to the recovery criteria for areas along river margins, there are also other criteria to benefit smaller properties. One of the articles allow that the recovered area do not exceed 10% of the total establishment area, in the case of properties with less than 2 fiscal modules, and with crop or pasture activities consolidated before July 22, 2008. For properties with area between 2 and 4 fiscal modules, this limit is increased to 20% of the total establishment area.

2.2. Consolidated Activities and Legal Reserves

Article 66 of the new law provides guidelines for the recovery of consolidated areas in legal reserves, with activities existing before July 22, 2008. For the general cases, the recovery can be done by: (i) recomposing the legal reserve – it can be done in up to 20 years; (ii) allowing for natural regeneration of natural vegetation; (iii) compensation for the legal reserve. If the rural producer opts for option (i), the legal reserve can be used for economic activities. The compensation in item (iii) can be done by using CRA's or environmental servitude, for example.

The new code also grants special treatment for small properties, when dealing with legal reserves. For rural properties with less than 4 fiscal modules of area, for consolidated areas with activities before July 22, 2008, there is no necessity of recovering of deforested areas. In these cases, no new deforestation can be done. For areas deforested after July 22, 2008, all economic activities in the legal reserve have to be immediately suspended, and the legal reserve areas have to be recovered within two years after the new code publication.

2.3. Challenges

The new forest code poses several challenges for the government in terms of implementation. There has been some discussion on how to check whether a certain area was deforested before July 22, 2008, of after this time point. Some suggestions include usage of dated satellite images, for example. Another problem is related to the proper mapping of locations eligible for permanent preservation areas. To overcome these difficulties, the government will probably have to invest heavily on proper equipment and personnel training. Both equipment and human resources may become a problem to manage given the great distances and the remoteness of most of the rural properties in the Amazon biome.

One of initiative that will certainly be of great aid in the implementation of the new code is the new data base on rural properties. Registering in this data base, denoted *rural environmental data base* (CAR[6]), is mandatory for all rural properties. After 5 years from the new code publication, only rural properties registered in the CAR will be eligible for official credit lines.

Probably an even bigger challenge will be raising resources for recovering the deforested areas. We do not know yet how much the whole recovery effort will cost. Besides, depending on the economic and financial health of the rural establishments, many of them will not have enough money to go through with the recovery requirements. There have been some discussion also on how to finance these producers, but no definitive idea has come up so far.

Finally, the new code has created several instruments to benefit small properties, and the definition of how a property has to depend on what municipality the establishment is located. It is difficult to anticipate how the economic agents will react to these incentives. In the recent years, for example, there has been some dismembering of large properties into smaller ones. Besides, it is expected that some pressure will exist to increase the defined size of a fiscal module, pushing the average size to 110 hectares (or even more than 110 ha). Certainly the discussions on the new code are far from over.

2.4. New Code into GLOBIOM and TERRA-ME

Simulations in GLOBIOM and TERRA-ME for the new code may not be easy to specify given the high level of complexity of the many articles in the law. It is up to the REDD-PAC project team to decide how far in terms of details they want to go. For example, at the less detailed level, the team may decide to simply consider the overall limits for legal reserves (80% in the Amazon biome, 35% for Cerrado biome etc.). These limits can be easily input into GLOBIOM and TERRA-ME as land use change restrictions. Therefore, we know *a priori* that, in the Amazon biome, only up to 20% of the total land can be transformed into pasture or crop production. The other 80% or more have to be used for native forest products or for commercial forest, for example.

More details can be input into GLOBIOM and TERRA-ME by considering permanent preservation areas as binder restrictions for land use change. In this case, we can consider initially only eligible areas 1,800 meters above sea level and areas with inclination above 45% since they are probably the easiest to map. The great difficulty here is to delineate river margins where the preserved areas depend on the river width. Intensive GIS work will have to be employed to map these areas. The geo-localization of establishments of different sizes would also require some work. In a conservative analysis, we can disregard the special treatment given to small establishments (below 1 or 2 fiscal modules, for example) and assume that the restriction will be the maximum specified in the code.

In terms of financial incentives for forest conservation and recovery, chapter 10 in the new code anticipates the possibility of using different instruments. For example, there can be tax deductions in the purchase of equipments and inputs for the maintenance and recovery of legal reserve and permanent preservation areas. Besides, activities for maintaining legal reserves and permanent

[6] CAR – Cadastro Ambiental Rural.

preservation areas are eligible for payments or incentives due to environmental services. In these cases, certificates for GHG emission reduction in both national and international markets can be used. For our REDD-PAC project this discussion is important because environmental services instruments can be included in some of the policy evaluation scenarios.

Finally, one can enhance the analysis by considering the sizes of establishments in different municipalities. In this way, it will be possible to include also information on more relaxed restrictions, due to benefits granted to small properties. The data used in this analysis can be extracted from the Brazilian agriculture census.

One important hypothesis is that the instruments of recovery transference, such as CRA's or environmental servitude will be used. These instruments will not affect the overall land use change in each biome, but they may affect the location (downscaling) of production within the biome. For example, it may be the case that it will be more efficient to concentrate all production close to the main roads, and use CRA's or environmental servitude so as the recovered areas are located in more remote sites. For GLOBIOM scenarios, using this hypothesis simplifies the analysis, because we would not have to worry about properties maps. For further discussion, see Section 6 on implementation notes.

3. The Low Carbon Agriculture Plan in Brazil

In the last COP 15, on climate change, held in Copenhagen, Brazil has committed voluntarily to reduce its GHG emission between 36.1% and 38.9% considering the total emission projected till year 2020 (considering trend scenarios, based on recent historic growth for emissions). This commitment was formally assumed with the Law number 12.187, sanctioned in December 2009, which launched the National Policy on Climate Change (PNMC). According to the Article 11th, it will be established sector plans to mitigate and adapt to the global climate change.

Considering a baseline trend scenario, with no policy for emission reduction, by 2020, Brazil would emit around 2.7 billion of tons of CO2. According the country's commitment, the reduction would be somewhere between 975 and 1,052 million tons of CO2. The PNMC establishes important economic instruments to be used by the policy implementation institutions: (i) fiscal and tax incentives; (ii) special credit and financing products for public and private agents; (iii) development of a domestic market for emission reduction, using carbon credits as financial assets negotiable on the stock market.

The Ministry of Agriculture, together with other ministries, created the plan for low carbon agriculture7 (ABC), in order to search for alternatives for low carbon emission. With the ABC plan, the government intends to foster the adoption of modern technologies allowing a more intense soil recovery, a productivity gain, and the reduction of GHG. The plan was officially created by the Decree number 7.390, in December 2010. Its initial term is till 2020, with periodic revisions every two years.

[7] ABC – Agricultura de Baixo Carbono.

3.1. ABC Directives for 2010/2020

The ABC plan[8] is intended to reach rural producers individually, or through their cooperatives. The main goals for the program are listed below.

1. Recovery of 15 million hectares of degraded pasture, with proper techniques and green manure, allowing for a reduction of 101 million tons of GHG, or carbon equivalent;

2. Adoption of an integrated system of pasture-crop-forest in 4 million hectares, resulting in the reduction of 20 million tons of GHG, or carbon equivalent;

3. Increasing the use of direct planting system in 8 million hectares, going from 25 million hectares nowadays to 33 million, resulting in a possible reduction of 16 to 20 million tons of GHG, or carbon equivalent;

4. Incentives to the biological nitrogen fixation in the soy production, going from 11 million hectares to 16.5 million (an additional of 5.5 million), allowing for a reduction between 16 to 20 million tons of GHG, or carbon equivalent;

5. Increasing the plantation of economic forests in 3 million hectares, resulting in a sequestration of 10 million tons of GHG, or carbon equivalent.

6. Treatment of animal waste, in a total of 4.4 million m^3.

There is little data on the amount of degraded area in Brazil. According to the 2006 agriculture census (IBGE, 2006), there would be around 9.8 million hectares of degraded pasture and 0.7 million degraded land. However, this information does not account for degraded areas not in interviewed rural establishments; therefore, from the 2006 Census, we have an underestimation for the total degraded area in Brazil. The Brazilian Company of Agriculture Research[9] (EMBRAPA), through the GEODEGRAD project, has been collecting more information on the level of pasture degradation in Brazil, from satellite images. The first published work, analyzing the state of Goiás, has shown that 27% of the total pastures present some degree of degradation (see Andrade et al, 2011).

In general, soil in tropical areas as more susceptible to degradation than the soil in colder areas. In Brazil, degradation is accelerated by the common usage of fires to open new pasture areas. Besides, simple practices indicated to avoid soil degradation, such as direct planting and culture rotation, are not well disseminated among Brazilian farmers. Therefore, the ABC plan directive for recovery of degraded pasture seems to be an important component in the inventory of government instruments for reducing CO2 emissions.

[8] There is a difference between ABC Plan and ABC Program. The plan corresponds to all initiatives combined, whereas the program corresponds specifically to the credit line. The especial credit line is the most advanced initiative in the Brazilian ABC effort.

[9] Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA.

3.1. The ABC Program

The main instrument in the ABC plan is a special credit line, denoted ABC Program, aiming at the crops for 2010/2011. The Brazilian government directed a total amount of R$ 2 billion, in 2011, for the ABC program, to be passed as loans to the agriculture sector. In 2012, the total amount available was raised to R$ 3.15 billion. These loans have a limit of R$ 1 million, per producer, per year, independent on other credit the individual or the cooperative have received. The annual interest rate is 5.5%, with up to an eight-year grace period, and a total payment period of up to fifteen years, and will be granted to rural producers who adopt the solutions mentioned above.

The grace period and the total payment period will depend on the type of solution implanted. For example, for the development of commercial forests, the grace period can be up to 8 years and the payment period up to 15 years. For the development of forest-tree nurseries, the payment period is 5 years and the grace period is 2 years. The borrower has to provide guarantees for the loans. The main type of item to be used as collateral is the rural property itself.

3.2. Production Methods and Technologies Covered by the ABC Program

There are six lines of methods and technologies covered by the ABC Program in Brazil. These lines are:

1. Direct planting system (DPS) as a practice that retains more carbon in the soil, increases the amount of water and organic matter (nutrients) in the soil and decreases erosion.

2. Crop-livestock-forestry integration systems.

3. Recovery of degraded areas and pasture.

4. Forest plantation, based for example on the production of pines, eucalyptus and black wattle, which are fast growing species.

5. Biological Nitrogen Fixation (BNF), by using micro-organism and bacteria.

6. Treatment of animal waste, producing energy and organic material.

Several institutes in Brazil are continuously doing research to propose enhanced techniques, with higher productivity and lower environmental damage, reducing, for example, GHG emissions. EMBRAPA is the leading institute in this joint effort. On the other hand, researchers in different institutes having been performing experiments to access attractiveness, in terms of productivity gains, for low carbon agriculture techniques. The reader can refer, for example, to Macedo (2009), Baggio and Schreiner (1988), Rodigheri (1997, 1998), Oliveira et al. (2008), Dossa et al. (2000), Mello et al. (2002), Borghi et al. (2008), Pereira et al. (2007), Perin et al. (2004), Hungria et al. (2001), Kuss (2006), Campos et al. (2001). One of the issues for the experiments conclusions is the fact that productivity may vary considerably from one area to another. Therefore, not necessarily a technique suited for one specific region will perform as well in other areas.

Even when new techniques improve land productivity (total yield per hectare), not necessarily they will incur in profit gains; required inputs may be more expensive when compared to more traditional techniques. Moreover, new techniques will require proper training and proper technical assistance, which not always is easily available. These issues have to be taken into consideration when evaluating ex-ante the true effectiveness of the low carbon policy. In the next section, we present a discussion on agriculture technology adoption.

3.3. Challenges

The heterogeneity in technology adoption across the rural establishments in Brazil is well documented. According to the 2006 agriculture Census (IBGE), in the South region, the percentage of properties with some use of fertilizer is 72%, while in the Northeast, this percentage is 20%. The percentage of establishments that had used soil pH correction in the South region is 39%; this percentage in the Northeast is only 3%. An important question that arises is what determinants affect rural producers' decision on whether they will adopt or not new techniques available. Understanding these factors is crucial for better designing public policies to foster the adoption of techniques such as the ones covered by the ABC program.

A survey on conditioning factors for technology adoption in rural establishments can be found in Filho et al. (2011). Among these determinants, one can mention: property size, risk and uncertainty, human capital, property contract (lease, partnership, and property rights), credit availability, labor force, infrastructure, market proximity, proper technical assistance, soil characteristics, . Several studies, for Brazil and international, show evidence that lower schooling and experience may affect negatively technology adoption. It may be one of the important reasons explaining the lower observed innovation adoption in the Northeast region, as compared to the South region. Property size can affect, for example, the adoption of technologies that depend on a minimum scale; in these cases, small producers can alleviate this problem by forming collaborative schemes. Besides, property size is high correlated to other factors, such as credit availability and human capital.

Infrastructure also plays an important role because it will impact the attractiveness of investments for increasing productivity. Establishments better served of roads network connections will more likely have sufficient capital to spend in production improvements. On the other hand, some new techniques require usage of ingredients (for example, chalk for pH correction, among other benefits) demanding more transportation efforts. If the infrastructure available is deficient, the establishment may have difficulty incorporating the new techniques.

The credit lines, such as the ABC program, made available by the Brazilian government to quicken the diffusion of techniques for sustainable agriculture, address one of the many determinants pointed out in the literature. Another important factor, provided in part by the government programs, is technical assistance. Increasing technical assistance coverage may be expensive though, especially for remote areas in the country.

Several challenges have then to be taken into account for the success of the ABC program in Brazil. One can list, for example:

(a) Provision of proper training and technical assistance for the adoption of the new technologies;

(b) Support for research and development to improve the existing techniques;

(c) Provision of proper training for the financial agents and the rural technicians, so they can analyze appropriately the ABC projects to be financed;

(d) Mechanisms for easier credit access, with less bureaucracy and fewer warranty requirements;

(e) Implementation of policies of payment for environmental services generated from the adoption of these new technologies;

(f) Implementation of tax and fiscal incentives for the produces adopting the new technologies.

Even though the annual interest rate of 5.5% may sound attractive (for Brazilian standards), we have to keep in mind that the overall program incentives may not be enough; there are other incentive programs for rural producers, also with low interest rates and good credit conditions. One example is the PRONAF[10] (National Program for Family Agriculture), available for small rural establishments. The PRONAF offers lower interest rates than the ABC Program.

Another issue that has to be considered is property rights for the rural establishments. As found in Börner et al. (2010), around 67% of endangered forest areas in Brazilian Amazon contain rural establishments with ill-defined or non-clarified tenure. Tenure problems may affect negatively ABC program penetration, because normally the rural property is used as collateral in the credit contracts. Therefore, rural producers without proper land ownership may not fulfill the proper requirements for ABC credit.

According to data from Banco do Brasil (see Sambuishi, 2012), from June 2011 to July 2012, there were 3,552 contracts in the ABC Program credit line, totalizing R$ 1.2 billion. Most of the contracts were directed to rural establishments in the South and the Southeast regions (66% of all contracts). Therefore, we observe that less than half of the total available amount in the program was actually taken as loans. Besides, a regional heterogeneity was observed.

These figures on the ABC Program dissemination may be explained by the lack of enough technical assistance to the potentially interested producers. Besides, more advertising seems to be needed. Nonetheless, a more thorough evaluation of the program is necessary so as to better pin point the main weaknesses, allowing future improvements. As discussed above, land tenure and other issues influencing technology adoption may also be investigated, so as to speed the diffusion of

[10] PRONAF – Programa Nacional de Agricultura Familiar.

ABC techniques among producers in all Brazilian regions. We believe that for the program to be successful, more instruments have to be used, along with the special credit line. One way to proceed is to provide tax incentives, as discussed in the next section.

3.4. Brazilian Low Carbon Agriculture in GLOBIOM, TERRA-ME and EPIC

Simulations for the ABC Program evaluation for our REDD-PAC project can be developed combining EPIC, GLOBIOM and TERRA-ME. Because there are six lines of actions covered by ABC in Brazil, maybe some of these lines can be chosen to start with. As mentioned above, one of the downsides of the program is that the interest rates provided may not be that attractive; consequently, the program may not have the intended impact. In this case, there is an opportunity for our project not only to study the impacts of the ABC program, but also to propose some modifications so as to make it more attractive. Our initial suggestion is to investigate the impact of tax incentives[11] for the producers adopting ABC techniques. We can build on the simulations which have already been done with GLOBIOM on pasture intensification measures.

The general activities for simulation can be put as follows:

1. Choose some of the six lines of ABC to simulate. Maybe we can start with Biological Nitrogen Fixation (BNF) and Direct Planting System (DPS). The feasibility depends on the capacity of EPIC to provide estimates of BNF and DPS impacts on crop yields, input requirements and soil carbon. Such estimated parameters will be used as inputs for the simulations in GLOBIOM.

2. For implementing (1), we can initially map the areas with crop production[12], eligible for BNF and DPS. We can also map the sizes of properties and assume that larger properties will be more prone to adopt the ABC initiatives, without tax incentives (small properties have access to PRONAF). We can assume a percentage of properties which will adopt the ABC without tax incentives, according to size group. For example, small producers will not adopt ABC at all. For large producers, we can assume scenarios of maybe 20% or 40% will adopt BNF and DPS[13]. A more economically based strategy would be to differentiate production parameters between small properties and large properties and let the model decide when it will be profitable for them to adopt new technologies. In any case, it is important to consider region heterogeneity, assuming a higher adoption on the South, Center-West and Southeast regions of Brazil, compared to the North and Northeast regions.

[11] Tax reduction.

[12] Data on crop production is readily available from www.ipeadata.gov.br. Data on properties size can be tabulated from the IBGE Agriculture Census.

[13] Ideally, we should have an estimate of how much the total production cost is reduced because of the reduced interest rates, and compare this reduction with the additional cost of implanting the new systems. I guess that would be extremely difficult.

3. We can then include scenarios of tax incentives in GLOBIOM but we first need to define how they could affect production costs and/or agricultural outputs.

4. After running the model, we could have the usual outputs by GLOBIOM, including emission reduction compared to the baseline scenario (business-as-usual). One interesting variable to be calculated is the total tax break, so as we have an estimate of how much this will cost for the National Treasury.

In all simulations, it is important to consider the restrictions for land use change imposed by the new forest code. For the Amazon biome, for example, we have to keep in mind that only 20% of the total land can be used for crop or pasture. For the Cerrado biome, this limit is 65%.

4. Action Plan for Prevention and Control of Deforestation in the Amazon - PPCDAm

The main existing initiative of the Brazilian REDD policy is the Action Plan for Prevention and Control of Deforestation in the Amazon (PPCDAm). Established in early 2004, this program integrates forest cover monitoring, land use planning and land titling, inspection and enforcement, and promotion of sustainable use of natural resources. The PPCDAm is also the operational program, which puts into concrete operations the goals stated in the Sustainable Amazon Plan[14] (PAS). So far, PPCDAm has worked mainly for deforestation reduction, and it has been quite successful in doing so. The main results observed since its creation include:

(a) Creation of more than 25 million ha of conservation units, located mainly nearby conflict zones.

(b) Consolidation of more than 10 million ha of indigenous land.

(c) Inhibition of more than 60 thousand illegal rural property titles.

(d) Creation of the DETER system and improvement of the PRODES system. These systems are used for deforestation detection and measurement.

(e) Intensive law enforcement by IBAMA (Brazilian environmental police), with planed operations in critical areas, together with the Brazilian Army, the Federal Police and the Federal Highway Police, resulting into expressive apprehension of illegal wood and equipment, and resulting into many issued fines.

(f) Combat to corruptions, with more than 600 public employees arrested.

(g) New law for public forest management (Law number 11.284/2006), giving more transparence to identification of public forest and expediting the process of forest concession.

[14] PAS – Plano Amazônia Sustentável.

(h) First public forest concession (Flona Jamari, state of Roraima).

One of the main pillars of PPCDAm has been the support by the monitoring systems implemented and run by INPE. The official estimate of deforestation is calculated with the Amazon Deforestation Monitoring Project (PRODES). These estimates consider changes in clear cutting of forests between July in one year and August of the following year. Additionally, INPE has developed the 'DETER' system (Detection of Deforested Areas in Real Time System) in parallel to PRODES, with the objective of generating deforestation alerts for intervals less than 15 days, indicating the approximate location and area, where the clear cutting activities have been registered, so as to direct enforcement operations.

PPCDAm is the program responsible for the great drop of deforestation rate in the Amazon region in the last years. In this process, a great role has been played by INPE, responsible for the monitoring system. The collaboration between INPE and law enforcement agencies has proved to be extremely effective. An external evaluation was carried on jointly by the Institute of Applied Economic Research (IPEA), by the Economic Comission for Latin America and the Caribbean (ECLAC) and by the Deutsche Gesellschaft für Internationale Zusammenargeit (GIZ) GmbH, between November 2010 and October 2011. The general conclusion was that PPCDAm was fundamental to decrease illegal deforestation, establishing a new framework to be replicated in other regions.

4.1. Participation of Municipalities in the PPCDAm

One of the reasons for PPCDAm success was the integration of efforts from federal, state and municipality agents. For municipality participation, it was determined by the Decree 6.321/2007, which determines that the Ministry of Environment will periodically update a list of municipalities responsible for the greatest percentage of deforestation in the biome. Once included in the list, the municipalities will the special focus of surveillance and control by state and federal institutions. Moreover, these municipalities become prohibited from acquiring new deforestation authorizations (exceptions are anticipated in the decree).

Nowadays, the list has 48 municipalities; 12 more municipalities than the initial list with 36 in 2008, when the list was created. In 2010 and 2011 two municipalities were removed: Querência, in the state of Mato Grosso; Paragominas, in the state of Pará. To be excluded from this list, the municipality has to have its deforestation reduced by some criterion updated yearly, and also has to have 80% of its areas (except public conservation areas and indigenous land) registered into the rural environmental database (CAR).

4.2. PPCDAm in GLOBIOM and TERRA-ME

The PPCDAm has focused mainly in reducing deforestation in the Amazon biome by a strong scheme of surveillance and control. The main actions include an intensive policy work, supported by INPE's monitoring systems. Besides, the creating and expansion of public conservation areas and of indigenous land has played an important part in limiting the amount of clear cutting of

forests. Specifically for model implementation, PPCDAm characteristics can be taken into account in several ways:

(a) The enforcement of rules to avoid deforestation is important to guarantee that the new forest code will obeyed in the Amazon biome. Besides, we can consider that the indigenous land and the conservation units will also be binding restrictions in the model.

(b) It is important to have updated maps (geo-referenced information) on the location of conservation units and indigenous lands. This information will be used as restrictions for GLOBIOM and TERRA-ME in different scenarios.

(c) The model may also consider special treatment for the list of municipalities responsible for the greatest percentage of deforestation in the biome, as they have permission for new deforested areas suspended temporarily. We can consider, for example, some form of 'soft' or transient restrictions within these municipalities.

Even though the sustainable economic use of deforested areas and infrastructure are somehow part of both the Sustainable Amazon Plan (PAS) and PPCDAm, these topics have not had any expressive concrete action up to now. No specific initiative has been put into practice so as to improve productivity, for example, or to foster more sustainable forms of agriculture, within the PPCDAm umbrella. Actions for low carbon agriculture, for example, had been the focus of the ABC program, discussed above.

In any case, we can keep in mind that PPCDAm may include policy initiatives more related to economic activities, which are the focus of our simulations GLOBIOM and TERRA-ME. Therefore, for the case the REDD-PAC team project come up with new policy proposals for Brazil, for the Amazon biome specifically we can try to include these proposals under the PPCDAm umbrella. Some of the ideas we can think of in the future:

(i) Infrastructure improvements, which may reduce transportation costs[15]. We could use the techniques developed by Ana Paula for the GPM (general proximity matrix) or technique used at IIASA to compute the market accessibility index. A good source of additional data for this activity would be the PNV and the SNV (National Road Plan and the National Road System[16]). Internal transportation costs already used in GLOBIOM for Brazilian simulations could be checked and updated using information from PNV and SNV.

(ii) Productivity improvements, especially for beef production[17]. Some figures show that Brazilian livestock productivity is extremely low, around 1 animal per ha. Besides, beef

[15] See http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=1802276 and http://www.planejamento.gov.br/secretarias/upload/Arquivos/seain/Custos_Transporte.pdf for transportation costs on Brazilian exports.
[16] PNV – Plano Nacional de Viação; SNV – Sistema Nacional de Viação.
[17] This productivity gains for beef production could be related to programs not necessarily on the current agenda – we could propose some new instruments, if we see appropriate.

production is the main cause of deforestation. Therefore, we could think of policies to enhance productivity, by using tax breaks or special credit lines.

5. PPCerrado

The Brazilian Cerrado is the second largest biome in Brazil, with approximately 2 million km2. It corresponds to 24% of the total Brazilian territory (Amazon biome corresponds to 49%) and is considered the most biodiverse savanna in the world. Many of the nation's large hydrographic basins are formed in the Cerrado, so as this biome plays a very import role in guaranteeing water supply to many large cities. By 2008, more than 48% of the original vegetation had been cleared (for the Amazon biome, the percentage of remaining original vegetation was 82% at that same year). Figure 1 has a map of the Brazilian biomes.

The Cerrado area contains 30% of Brazilian cattle herd (54 million hectares of pastures and 72 million head of cattle). It also contains 21 million hectares of croplands, producing 60% of Brazilian soy, 60% of Brazilian coffee, 44% of Brazilian corn and 84% of Brazilian cotton. One important ecological aspect of the Cerrado biome is its high allocation in belowground biomass (root/shoot ratio is between 2.6 and 7.7).

In 2010, the government launched the PPCerrado, the Action Plan for Prevention and Control of Deforestation and Forest Fires in the Cerrado. The main goal of PPCerrado is to reduce greenhouse gas emissions from deforestation in the biome in 40% by 2020. Inspired by PPCDAm, the PPCerrado encompasses 151 actions, divided in three main axes: (a) monitoring and control; (b) protected areas and land use planning; (c) fostering sustainable activities.

Figure 1 - Brazilian Biomes

Source: Brazilian Institute of Geography and Statistics - IBGE, 2004.

When the program was launched, 8.24% of the total Cerrado biome corresponded to conservation units, whereas 4.39% corresponded to indigenous land. For properties in the Cerrado biome, within the legal Amazon, the minimum legal reserve percentage is 35%; outside the legal Amazon, the minimum percentage is 20%. Between 2002 and 2008, the Cerrado biome had suffered a more severe relative deforestation than the Amazon biome: Cerrado had 4.1% of its territory deforested during this period, whereas Amazon biome had 3.2% of its total area deforested. In the Cerrado biome, a significant part of deforestation is done by human-caused fires (although natural fires are also very frequent).

The PPCerrado raised an initial list of priority areas to direct it is actions for deforestation control. These areas were selected according to:

(a) Recent deforestation pressure;
(b) High priority for biodiversity;
(c) High relevance for hydrological resources.

Important information for simulation projects on land use change is the location of protected areas. According to the PPCerrado, in addition to the existing conversation units, the total federal conservation units are expected to be increased in 2.5 million hectares. It is possible that conservation units at the state level are also expanded or created. For indigenous land, the National Indian Foundation will homologate 300 thousand hectares of indigenous land and specify 5.5 million additional hectares for the indigenous population.

Finally, as the program also has as one of its axes fostering sustainable activities, PPCerrado has several actions focusing mainly on reforestation and recovery of degraded land. Credit lines will be available for the recovery of more than 8 million hectares of areas, including: degraded pasture, legal reserve, permanent preservation areas. Special credit will also be available for large commercial reforestation projects. Some other lines of action will support the production based on agroextractivism[18] and on biodiversity.

5.1. PPCerrado in GLOBIOM and TERRA-ME

The same way PPCDAm has focused specifically on actions for deforestation control, it is likely that PPCerrado will also follow the same path, leaving the support to sustainable activities for a second stage. In terms of modeling implementation, PPCerrado could be taken into account in the following ways:

[18] Agroextractivism is used in Brazil for when activities of agriculture, fishing, and fruit plantations are combined with extractivist activities. Economic attractiveness of the agroextractivism depends heavily on commercialization opportunities, which varies according to the products explored. Government policies include technical assistance, credit lines, and research for improved technologies. One way to add value to the agroextractivist systems is to process locally products such as açaí fruit, Brazilian cashews, moriche palm fruit (*buriti*), and oil collected from the kerosene tree.

(d) The enforcement of rules to avoid deforestation is important to guarantee that the new forest code will obeyed in the Cerrado biome. Besides, we can consider that the indigenous land and the conservation units will also be binding restrictions in the model.

(e) The Plan includes the creation or expansion of conservation unit areas and indigenous lands. Therefore, the simulation models have to consider these units as new restrictions into the land use change scenarios. As discussed in the implementation section, a detailed data collection will have to be done so as to get information on the geo-referenced location of the conservation units.

(f) The model may also consider especial treatment for the priority areas, specified in the PPCerrado, based on relevance for hydrological resources, relevance for biodiversity and recent deforestation pressure. Similarly to what happened in PPCDAm, these areas may have, for example, permission for new deforested areas suspended temporarily.

Similarly to PPCDAm, PPCerrado may also include policy initiatives more related to economic activities, which are the focus of our simulations GLOBIOM and TERRA-ME. Therefore, for the case the REDD-PAC team project come up with new policy proposals for Brazil, for the Cerrado biome specifically we can try to include these proposals under the PPCerrado umbrella. These proposals may address productivity improvement and infrastructure enhancements, for instance.

6. Other Topics

It appears that REDD implementation in Brazil is likely on the one hand to build on the country's previous success in limiting deforestation through improved monitoring and enforcement, and on the other to develop at least some component of transmitting financial benefit to landowners, through some form of payment for environmental services (PES). As discussed previously, Brazil has an impressive record in the reduction of deforestation over the past decade, which has been achieved through a combination of regulation and enforcement (Command & control). A key element for this success has been the PPCDAm, which has focused on definition of property rights, monitoring and enforcement of existing regulations (including the previous versions of the forest code). It is likely that a great part of REDD implementation in Brazil will be through investment of REDD funds in intensification of these efforts.

On the other hand, several proposals have been made for the development of a system of incentives, such as payment for environmental services, which enables landowners to benefit from the services that are provided if they manage ecosystems well. Another possibility is for incentives to be provided through tax breaks. Both of these options have been included in existing draft legislation, and pilot systems of PES are in operation in the Atlantic Forest region.

There is also an existing "Bolsa Verde" (green grant – see box below), which provides grants to communities that are closely associated with or depend on forests, but does not require specific actions or results in return. Some have suggested that such payments could in future be linked to community-based monitoring activities. Another possibility for enhancing the "Bolsa Verde"

program is by taking advantage of the CRA's (discussed in section 2). Bassi (2012) suggests using CRA's or legal servitude, so as farmers in other areas would pay for extra deforestation rights to families living in poor settlements within the Legal Amazon. Therefore, when constructing scenarios for policy evaluation in REDD+ in Brazil, especially when considering PES instruments, the social dimension should also be considered.

BOX 1. THE "BOLSA VERDE" PROGRAM

The program was created by the provisory measure, number 535, in June 2, 2011. It corresponds to payments for environmental services, paid basically for biodiversity preservation functions. Its focus are families in extreme poverty (per capita income of less than US$ 35 per month), living in areas considered important for preservation of Brazilian biomes, operating mainly in the following areas within the Legal Amazon:

- National forests
- Extractive federal reserves
- Federal reserves for sustainable development
- Projects of differentiated settlements in the Legal Amazon

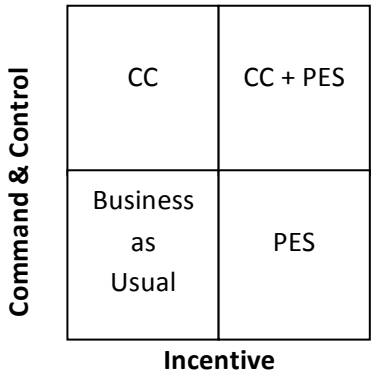
The first three items above correspond to conservation units. In December 2011, the areas listed above totalized 11.3 million hectares.

The "Bolsa Verde" program pays quarterly amounts of US$ 150 per family. The initial period is of two years, but can be extended. Until March 2012, according to information from the Ministry of Environment, the total amount paid summed up to US$ 6.2 million; more than 23 thousand families benefited from the program. The state of Pará has the majority of benefiting families (more than 17 thousands), followed by the states of Acre (1 thousand families) and Amazonas (560 families).

There have been also discussions on the opening of a national market for carbon credits in Brazil, which would similarly provide an incentive-based mechanism for REDD+ implementation. Nonetheless, this option does not seem to be well accepted by several important policy makers in the Brazilian government. The majority of professionals involved in decision making for environmental matters in the government seem to be in favor of intensifying command and control actions as form of extending REDD in the country.

As it is likely that REDD+ implementation in Brazil will depend on expansion of command and control actions and on the development of some form of payment services (although the last item is likely to happen in lower intensity), it is possible to approach the development of scenarios for REDD+ based on these two main axes, as represented in the figure below.

Figura 2. Axes for REDD+ Scenarios in Brazil



In terms of the modeling, each of these components has different implications for scenario building. Based on the axis in figure 2, the main scenarios can be described as below:

Business-as-usual scenario (BAU): The business as usual scenario will need to include both the existing policies and some representation of their effectiveness, e.g. assessment of actual RL implementation and conversion rates for protected areas of different classes (potentially available from the agricultural census, from PRODES/DETER, and from studies by IMAZON, SOS Mata Atlantica and in the Cerrado), which can be applied as restrictions at SIMU scale. Therefore, instead of considering a hard restriction of 80% no deforestation in the Amazon biome, for example, one can consider a lower percentage, which will depend on command and control effectiveness. Policy instruments ineffectiveness is illustrated, for example, by data from the agriculture census; in 2006, the total non-forest land use on private establishments were higher than the regulatory limit in 749 out of 760 municipalities.

Command and Control Scenario (CC): At SIMU scale this could be represented by restricting land availability in proportion to the APP (identified with finer scale GIS analysis) and RL requirements incorporating a degree of enforcement effectiveness greater than the current incorporated in BAU. It could also include improved effectiveness of protected areas existing relative to BAU levels that are not absolute protection.

Payment for environmental Services Scenario (PES): PES can presumably be represented as a price per ton of carbon stock (as emissions avoided), but this will need to be assessed in terms of rates currently applied where PES schemes are in operation and the prices likely to operate in any national carbon market that develops (given government lack of interest in participating in international markets). One may also implement PES in the form of extra income for poor communities (see discussion on "Bolsa Verde" above), based on the legal reserve shares and on legal servitude.

Problems with policy instruments inefficiency, and possible alternatives, are discussed in Börner et al. (2011). The authors based their discussion on an economic decision model, according to which

land users make the decision of deforesting or not, beyond legal limits, depending on: the profit obtained per hectare deforested; the probability of being detected and effectively sanctioned; and the fine for illegal deforestation. Once detected the illegal deforestation, land users may be fined; however, increasing fine values not necessarily will have the desired impact. Due to poor institutional environment, high fines may increase propensity to defaults and to bribes. Non-payments may be punished by property confiscation, but given the problems with tenure rights, common in the Amazon biome, confiscation instruments may also not be very effective.

As found in Börner et al. (2010), around 67% of endangered forest areas in Brazilian Amazon contain rural establishments with ill-defined or non-clarified tenure. Tenure problems may affect negatively not only the effectiveness of command and control policies, but also PES instruments. In fact, for REDD payments to be effective instruments, it is necessary that environmental service providers have the right to avoid others from deforesting the land area under conservation agreement. Therefore, tenure problems will also limit how much impact PES policies will be effective.

Araújo et al. (2008) analyze specifically the impacts of property rights on deforestation. The authors focus on the consequences of ownership insecurity on deforestation in the Brazilian Amazon. As a consequence of the Brazilian legal system, which does not provide a complete bundle of rights to land, property insecurity prevails resulting in violent land conflicts and expropriation procedures. Additionally, title holders face a risk of losing their rights to the land as a result of land reform policies. In this risky set up, deforestation becomes a rational choice. As part of a risk management strategy, agents convert forests into pasture or agricultural lands. Therefore, among several other negative consequences, insecure property rights are expected to favor forest clearing.

As pointed out by Börner et al. (2011), land tenure uncertainties are not the only factor affecting command and control policies effectiveness. Remoteness in the Amazon biome is another important attribute to be considered when analyzing REDD+ instruments. Establishments further to law enforcement headquarters, in principle, are less susceptible to be visited by the authorities. This happens because the authorities also face an optimization problem, in which they have to optimize their operations subject to a given amount of resources. On the other hand, land productivity and proximity to markets incur in higher land profitability, increasing deforestation pressure.

The attributes impacting C&C instruments effectiveness may vary significantly in space. Because of this variation, PES instruments may be more appropriate for deforestation reduction than C&C policies. Therefore, a mix between C&C and PES should in fact be taken into consideration by government authorities, what makes the upper-right quadrant in figure 2 a reasonable scenario to be investigated.

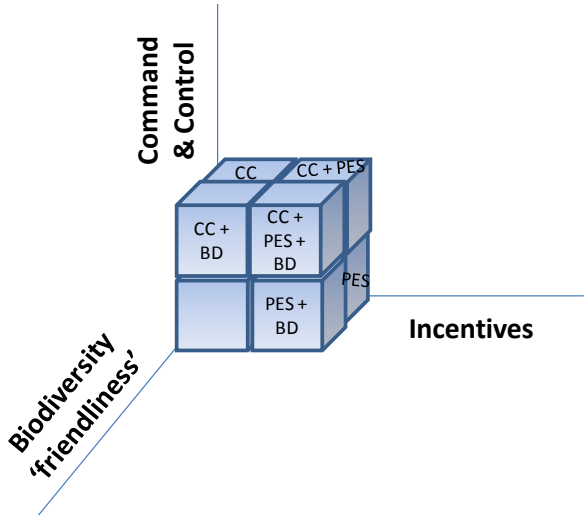
One of the issues to be taken into consideration when implementing PES policies is additionality, especially because of the significant regional variation present in the Amazon biome. There is a strong question in Brazil about whether remuneration should relate to stocks or to fluxes of

carbon. To achieve additionality, compensation would be allocated to land owners in areas of high flux, and there would be no compensation for those who are already managing stocks well. If resources are allocated on the basis of stocks, then they have little impact on emissions (this is a microcosm of the discussions that have taken place at global level). The solution being discussed in Brazil has been that a hybrid approach would be best in which payments are higher in areas of high pressure or flux, but there is some payment in other areas as well.

Considering Biodiversity in REDD Scenarios

There is as yet little (if any) discussion of considering biodiversity in the implementation of REDD+ in Brazil. Nonetheless, a few individuals consulted have recognized the potential for including biodiversity conservation priorities as one basis for directing REDD+ implementation, and increasing the effectiveness of existing protected areas has been specifically mentioned as one relatively un-contentious way of making progress on REDD+ (MMA staff, in conversation). Therefore, given that the overarching objective of the REDD-PAC project is assessing the potential of REDD+ to contribute to achieving biodiversity conservation objectives, it will be important to explore scenarios in which the 'biodiversity-friendliness' of REDD implementation is enhanced to determine whether this is likely to make a difference in the ultimate biodiversity-related outcomes.

As discussed previously with IIASA, options for incorporating biodiversity considerations into REDD scenarios within GLOBIOM include (a) application of restrictions within the model in relation to areas of high priority for biodiversity, (b) increasing costs of conversion in these areas through penalties or other means, (c) increasing the value of standing forest in these areas, or (d) using a phased approach to REDD+ implementation to prioritise these areas in time, so that any of these other approaches are first implemented in areas important for biodiversity (e.g. in the first 10 year cycle in GLOBIOM) and are implemented elsewhere only later. Our previous discussions have suggested that option b above is arbitrary and has economic implications that make interpretation of other aspects of GLOBIOM results problematic. Options a and c correspond roughly to the enforcement and incentive axes discussed above, i.e. restrictions and enforcement effort (investment) could be concentrated (or not) in areas deemed important for biodiversity conservation, and/or a premium rate of incentive could be applied for effective management that maintains forest in ways that support conservation of biodiversity in such areas. Therefore, consideration of biodiversity effectively forms a 3rd axis in the REDD+ scenario space for Brazil, and we have the potential for 8 scenarios (though we may not wish to assess all 8):



Nationally, a set of priority areas for conservation of biodiversity has been identified for each major biome in Brazil. These are currently being updated, and the project should watch for the emergence of the new version. In the meantime, the existing version will provide an appropriate basis for applying the approaches discussed above and will also be one important basis for assessing biodiversity impacts of the land use change projected by GLOBIOM.

Incorporating value of forest used for extractive purposes

Costa (20011 e 2012) presents evidence on the importance of forest products, other than timber. The author studies different technology trajectories, in which he identifies a specific group of rural establishments that obtain income from exploiting the natural forests. The total income from these activities can be up to 20% of gross product value for landowners in the Brazilian Amazon. In GLOBIOM, at present, these activities are not captured for the natural forest class. Taking account of this value added value will require sub-setting natural forest according to the potential for exploitation (e.g. access, proximity to population & markets). Besides, the trajectory for forest products also competes with other activities, such as pasture and soy, for example. Therefore, land use models should take into account the income from the forest, which may induce forest conservation, incurring also in poverty alleviation.

Migration movements

Another important issue to be considered to understanding land use dynamics in Brazil is the migration movements, due to public policies, construction of new infrastructure, such as new energy plants, or salary differential, among other factors. When new plants are built, there is a migration movement to the construction site, which results in urban growth for areas nearby. Together with migration, comes enhanced network connections, what incurs in more attractiveness for agriculture and pasture in the region, affecting land use change. Nowadays, there is a new power plant, named Belo Monte, being built in the state of Pará. Even though this area has been a recent focus of incoming migration, it is possible that Belo Monte will speed up migration to the Pará, and eventually surrounding states. Understanding how big infrastructure

constructions affect migration and how migration affect land use change, may be an interesting topic to be addressed with land use models, such as GLOBIOM.

A series of different factors can induce migration flows, other than infrastructure construction. According to the 2010 IBGE Census, the North region is the one with the highest recent incoming migration, possibly because of the expansion of the agriculture and pasture frontier in the region. Oliveira and Jannuzzi (2005) present a discussion of factors affecting migration flows in Brazil. In any case, whenever modelers decide to incorporate migration components into land use models, it is important to understand causality directions: land use causing migration, migration causing land use or both. The direction will depend heavily on the type of cause affecting migration in the first place. If migration is caused by exogenous events, such as government incentives to occupy a new area or infrastructure construction, the causality is expected to occur from migration affecting land use change. If migration is caused by more economic related variables, such as salary differential, causality may occur in both directions.

Regional variation within Brazil

Taking into account regional variation is particularly of interest in relation to the role potentially played by forest restoration (of high importance in e.g. Sao Paulo, Mato Grosso, where long and intense use has finished off legal reserve areas, whose restoration is now required by the forest code). PES schemes are already functioning in the Atlantic Forest region, and some states (Paraná) have developed their own approaches to PES in relation to biodiversity importance. Furthermore, one could in theory consider implementation of REDD through different approaches in different locations, as for example studied by Börner et al. (2008, 2010, 2011) in their discussion of application of enforcement versus incentives according to location and circumstances.

Minimum Prices Policies

The minimum price policy is an instrument established by the Brazilian federal government to guarantee a minimum income to the rural producer, so as to cover production costs, when there is supply excess in the market at the harvest time. The agricultural products are bought by the federal government and transfer to stocking areas, avoiding significant price drops in the market. Yearly, the government does a survey on production costs in different regions, considering both summer and winter products. The products considered in the minimum price policy are: garlic, coffee, canola, cashew nuts, silk cocoon, oats, barley, wheat, triticale, sunflower, guarana, milk, castor oil, sisal, grapes, cotton, peanuts, rice, natural rubber, Brazil nuts, carnauba wax, beans, cassava, corn, soybeans, sorghum, jute. Prices for each product are available at the National Supply Company (CONAB) website. The documents released by CONAB are also a good source of production costs for each of the products covered.

Considering the Brazilian minimum price policy when running simulations in land use change models may be important, because market prices affect directly the decisions on future production. On the other hand, it is important to take into account the mechanism used to determine minimum prices for the next harvest. In principle, these prices are calculated to as to

cover production costs, incurring in risk mitigation for the producers. Nonetheless, if there is a perspective that a substitute product will be more profitable in the future, not necessarily decision to switch to this other product will be affected by the minimum price policies.

Productivity Gains

Another important issue to be taking into consideration in land use change models for Brazil is the productivity gains. The table below illustrates the increase in productivity for some the most important products in the agricultural sector in Brazil, according to the agricultural census. Between 1975 and 2006, corn and wheat had a productivity gain of more than 150%. After 2006, the Brazilian Institute of Geography and Statistics (IBGE) has productivity statistics obtained from the Municipality Agricultural Production Survey[19] (PAM). According to the PAM, from 2006 to 2010, productivity for rice, sugarcane, bean, corn and soy has increased in 6.4%, 5.2%, 7.6%, 29.1% and 23.9% respectively. Therefore, the main agriculture products in Brazil had a great increase in productivity in the last 25 years.

Average Productivity (Kg / hectare) For Selected Products

Census year	Coffee	Sugar cane	Corn	Soy	Wheat	Beans
1975	729	42.979	1.335	1.542	679	410
1980	571	53.618	1.521	1.639	914	397
1985	926	60.525	1.476	1.773	1.519	377
1995	1.034	62.086	2.442	2.334	1.701	507
2006	1.399	68.876	3.606	2.602	1.737	718
Productivity gains from 1975 to 2006	92%	60%	170%	69%	156%	75%

Source: www.sidra.ibge.gov.br.

Models such as GLOBIOM run simulations for 40 years in the future (of even further). Therefore, even in the business as usual scenario, it would make sense to consider continuously increasing productivity gains to a total of more than 200% after 40 years. Besides, given all the pressure on global productivity gains due to food security issues (according to Tilman et al., 2011, food production by 2050 has to increase in 100% to meet global population growth and diet changes), combined with pressure to reduce deforestation, it is possible that research on agriculture technology will be intensified. Increasing investments in technology may incur in even higher productivity gains in the next years. Besides, as discussed in this report, technology research can be coupled with policy instruments so as to increase technology adoption, enhancing overall observed productivity.

Considering Fiber and Rubber Products

[19] Produção Agrícola Municipal (PAM). See www.sidra.gov.br.

Land use change models treat a wide range of products related do agriculture and beef products, biofuels and forests. Nonetheless, it may be important also to taking into consideration rubber and fiber (cotton, jute and linen) products. According to the 2006 agriculture census, the total harvested area of temporary crops was 49.1 million hectares; rubber and fiber products accounted for almost 1 million hectares, accounting for almost 2% of the total harvested area. Cotton is by far the most important fiber product, accounting for 0.8 million hectares.

Tax Breaks Policies

In order to foster the adoption of new technologies for agriculture productivity gains, for sustainable agricultural methods (including low carbon techniques), and for cattle intensification, the government can resort to tax breaks instruments. To evaluate the effectiveness of these instruments, simulation models such as GLOBIOM can be a valuable tool. It is important then to have an accurate figure of the current true weight of total taxes for the total profitability for the rural establishments. If current taxes already account for a very low proportion of total expenses, tax break policies may not have the desired effects.

In Brazil, total taxes correspond to 34% of total gross domestic product. Compared to India, China and Russian (BRICS) for example, Brazil has the highest total tax charge; India, 12% of its GDP, 19%, and China, 23%. On the other hand, taxes for the Brazilian rural producers are much lower. According to the input-output matrix for Brazil (year base 2005), calculated by the IBGE, some of the agriculture sectors have negative total tax incidence (considering all subsidies). This is the case for rice, corn and cotton. For wheat, sugarcane, soy in grains, total taxes correspond to 3% or less of the basic production prices (final price to consumer, excluding transportation and retail costs). For coffee and beef products, total taxes vary between 5% and 9% of the basic production prices. These percentages are overall aggregated figures, and may not reflect the reality for specific groups of establishments, depending on property size and country region.

A more thorough investigation has to be performed so as to obtain better tax incidence estimates, to be used in land use change models. The most important tax instrument for rural establishments is the Rural Property Tax[20] (ITR), created to the Land Statute of 1964. Since its creation, this tax instrument has suffered from a high level of evasion, as studied by Moreira and Assunção (2001), in spite of the reforms carried out in 1979 and 1996. Therefore, a good estimate for the true effectiveness for the ITR is important when implementing scenarios for tax breaks policies.

Soy Moratorium

The soy moratorium is an environmental pact established among representative entities of Brazilian soy producers, NGO's, and later on was supported by the Brazilian government. The idea was to adopt measures against deforestation in the Amazon area. It was initially anticipated to be valid for two years, beginning in July 2006. The participant producers (initially accounting for 94%

[20] Imposto Territorial Rural – ITR.

of the total soy production in Brazil) agreed not to commercialize soy produced in areas deforested for expanding soy plantation in the Amazon biome.

Nowadays, the moratorium is monitored by satellite image analyses (Landsat/TM and Terra/MODIS). INPE has been playing a major role in this process, being responsible for the satellite monitoring (see Rudorff et al, 2011). Since 2008, the moratorium has been prorogated yearly, and it is in vigor. Several analysis have shown the effectiveness of the pact, although there has been observed some small conversion from forest to soy plantation.

Implementing the soy moratorium into GLOBIOM or other land use change models may be accomplished by specifying restrictions on land use conversion from forest to soy production. This restriction can be a hard one, with 0% transition allowed, or can be relaxed so as to allow a certain percentage (for example, 5%) of non-compliance. The non-compliance parameter may be obtained from observed land use transitions based on recent satellite analysis.

Beef Moratorium

The beef moratorium was idealized by the NGO Greenpeace, and was signed by the four major beef Brazilian exporters and by various beef retailers, compromising not to buy beef from animal production in areas illegally deforested. The idea was to guarantee an environmental complying origin for the beef exported to international markets. Rural establishments that deforested illegally after October 5, 2009, will have difficulties selling to main beef retailers and exporters.

For the sake of implementation of the beef moratorium in land use change models, it may not incur in any additional specification, provided that the model is already accounting for compliance with the new forest code, for example. The moratorium is another institutional arrangement to guarantee that the law will be obeyed, preventing illegal land use transition from forest to animal production.

7. Implementation Notes and Final Conclusions

Based on the discussion in the previous sections, we draw suggestions for implementation of land use change models in Brazil. The topics discussed above may be the basis for building the simulations considering model restrictions, which will affect all scenarios, including the baseline (business-as-usual) one, as well as policies to be evaluated. Figure 4 has a scheme of the challenge the team faces in terms of translating environmental regulation and policy instruments into model coefficients and restrictions. For scenarios built upon policy evaluation, we can consider not only the current government programs (under practical implementation of under planning) but also consider some additional proposed instruments (tax breaks, for example). Table 1 below has a summary of the main conclusions from our discussion on environmental regulations and on government environmental policies in Brazil.

Figure 4 – Policy Guidelines and Model Specification