Fachhochschule Köln
Cologne University of Applied Sciences

UNIVERSIDAD AUTÓNOMA DE SAN LUIS POTOSÍ

**FACULTADES DE CIENCIAS QUÍMICAS,
INGENIERÍA Y MEDICINA**

PROGRAMA MULTIDISCIPLINARIO DE POSGRADO
EN CIENCIAS AMBIENTALES

AND

COLOGNE UNIVERSITY OF APPLIED SCIENCES

INSTITUTE FOR TECHNOLOGY AND RESOURCES
MANAGEMENT IN THE TROPICS AND SUBTROPICS

POTENTIAL ASSESSMENT OF LAND USE, LAND USE CHANGE AND FORESTRY (LULUCF) PROJECTS UNDER THE CLEAN DEVELOPMENT MECHANISM (CDM) IN THE MATA ATLÂNTICA, MUNICIPALITY OF CACHOEIRAS DE MACACU, RJ - BRAZIL.

THESIS TO OBTAIN THE DEGREE OF

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Y
MASTER OF SCIENCE
ñTECHNOLOGY AND RESOURCES MANAGEMENT IN THE TROPICS AND SUBTROPICS
FOCUS AREA ñENVIRONMENTAL AND RESOURCES MANAGEMENTò
DEGREE AWARDED BY COLOGNE UNIVERSITY OF APPLIED SCIENCES

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SAN LUIS POTOSI, MEXICO **JULY 15TH, 2010**

Fachhochschule Köln
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PROYECTO FINANCIADO POR:

JOINT RESEARCH AND DEVELOPMENT PROJECT (JRDP) BR/MP2-GER/BMBF
CLIMATE CHANGE, LANDSCAPE DYNAMICS, LAND USE AND NATURAL RESOURCES IN THE ATLANTIC FOREST OF RIO DE JANEIRO

PROYECTO REALIZADO EN:

ITT IN COOPERATION WITH EMBRAPA-SOLOS, RJ
UNDER THE COORDINATION OF DR. JOYCE G. MONTEIRO

CON EL APOYO DE:
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CONSEJO NACIONAL DE CIENCIA Y TECNOLOGÍA (CONACYT)

LA MAESTRÍA EN CIENCIAS AMBIENTALES RECIBE APOYO A TRAVÉS DEL PROGRAMA NACIONAL DE POSGRADOS (PNP - CONACYT)

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ACRONYMS AND ABBREVIATIONS

A/R	Afforestation/Reforestation
AM	Approved Large Scale Methodologies
AMS	Approved Small Scale Methodologies
APP	Permanent Preservation Area (Area de Preservação Permanente)
AR-AM	Approved Large Scale A/R Methodologies
AR-AMS	Approved Small Scale A/R Methodologies
AR-NM	Afforestation and Reforestation New Methodology (under revision)
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CH_4	Methane
CO_2	Carbon dioxide
COMPERJ	Petrochemical Complex of Rio de Janeiro
COP	Conference of the Parties
COP/MOP	Conference of the Parties serving as the Meeting of the Parties of the Kyoto Protocol
DINARIO	Abbreviation for the research project: Climate change, landscape dynamics, land use and natural resources in the Atlantic Forests of Rio de Janeiro
DNA	Designated National Authority
DOE	Designated Operational Entities
EB	Executive Board
EMATER- RJ	Organization for Technical Assistance and Rural Expansion of the Rio de Janeiro State (Empresa de Assistência Técnica e Extensão Rural do Estado do Rio de Janeiro)
EMBRAPA	Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária)
FAO	Food and Agriculture Organization of the United Nations
F-gases	Fluorinated gases
GHG	Green House Gases
GIS	Geographic Information Systems
GIS	Geographic Information Systems
Gt	Gigatonne
HDI	Human Development Index
ICMS	Goods and Services Circulation Tax (Imposto sobre Circulação de Mercadorias e Serviços)
INEA	State Secretariat of Environment (Secretaria do Estado do Ambiente
INPE	National Institute for Space Research

IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
LULUCF	Land Use Land Use Change and Forestry
Mg	Mega gram carbon
N_2O	Nitrous oxide
NGOs	Non-Governamental Organizations
PDD	Project Design Document
PES	Payment for Ecosystem Services
PoA	Programme of Activities
PP	Project Participants
PRONAF	Programa Nacional de Fortalecimento da Agricultura Familiar
REDD	Reduced Emissions from Deforestation and Degradation
REGUA	Guapiaçu Ecological Reserve (Reserva Ecológica Guapiaçu)
RFL	Legal Reserve Forest Areas (Areas de Reserva Florestal Legal)
SOC	Soil Organic Carbon
t	Tones
UNFCCC	United Nations Framework on Climate Change

ABSTRACT

The LULUCF projects under the CDM mechanism of the Kyoto Protocol represent a valuable opportunity to link climate change mitigation and protection of severe endangered ecosystems like the Atlantic forest. The present study analyses the potential areas, stakeholders and barriers to develop carbon sequestration projects in the municipality of Cachoeiras de Macacu, RJ, Brazil. Using remote sensing and GIS suitable areas were computed. Interviews were realized to map the institutional framework for LULUCF projects and a SWOT analysis was done to identify main obstacles and possible strategies to be implemented.

Difficulties for the election of suitable lands for carbon sequestration projects, complexities to measure carbon pools and temporality of credits have been the major obstacles in developing LULUCF projects. Additionally, the specificity of the existing methodologies (that limits their replication) and demonstration of additionality represent important barriers. In Cachoeiras de Macacu, 27% (264 km^2) of the municipality are potential lands for LULUCF projects. Lands are highly parceled and mainly represent pastures (194 km^2) or agricultural lands (36,47 km^2). Historically deforested areas (like Cachoeiras de Macacu) have relatively high suitable areas for LULUCF initiatives, but also significant demand for lands for settlements and food production (situation that will intensify with the establishment of the COMPERJ, Petrochemical Complex of Rio de Janeiro). This fact sets a contraction that leads to the conclusion that, buffer areas of megacities in developing countries constitute ideal scenarios for Payment of Ecosystem Services frameworks and not for CDM projects. There are other existing schemes like the ecologic ICMS, voluntary carbon markets and PES that have demonstrate to be more effective than the CDM in protecting forests. Definitely, other mechanisms like REDD should be implemented and enforced to avoid deforestation and GHG emissions.

KEY WORDS

Atlantic forest, LULUCF, CDM, Cachoeiras de Macacu, Brazil, Suitable areas, Institutional Framework, SWOT.

RESUMEN

Los proyectos de LULUCF del MDL del Protocolo de Kioto representan una valiosa oportunidad para vincular la mitigación del cambio climático y la protección de ecosistemas altamente degradados como el bosque Atlántico. El presente trabajo constituye un análisis de áreas potenciales, grupos de interés y barreras para desarrollar proyectos de secuestro de carbono en el municipio de Cachoeiras de Macacu, RJ. Brasil. Usando Sensoriamiento Remoto y SIG las zonas más adecuadas fueron calculadas. Se realizaron entrevistas para crear el marco institucional de proyectos de LULUCF, así como un análisis FODA para identificar los principales obstáculos y posibles estrategias.

Dificultades para elegir las tierras aptas para proyectos de secuestro de carbono del MDL, complejidades para medir los sumideros de carbono y la temporalidad de los créditos han sido los principales obstáculos en el desarrollo de proyectos LULUCF. Además, de la especificidad de las metodologías (que limita su replicación en otros proyectos) y demostrar la adicionalidad representan importantes barreras. En Cachoerias de Macacu 27% (264 km^2) de la municipalidad la constituyen áreas potenciales para proyectos LULUCF. Las tierras aptas son altamente parceladas y son dedicadas a ganadería (194 km^2) o agricultura (36,47 km^2). De la misma manera, áreas históricamente deforestadas (como las estudiadas) poseen un porcentaje relativamente alto de tierras adecuadas para iniciativas de LULUCF, pero también, una importante demanda de tierras para asentamientos humanos y para producción de alimentos (situación que se intensificará con la creación del COMPERJ). Esta contracción, lleva a la conclusión que áreas de amortiguamiento de mega ciudades en países en vías de desarrollo, constituyen escenarios ideales para la implementación de Pagos por Servicios Ambientales y no para MDL. Otros sistemas como el ICMS ecológicos, los mercados voluntarios de carbono y REDD han demostrado ser más eficaces que el MDL en la protección de bosques.

PALABRAS CLAVES

Bosque Atlántico, LULUCF, MDL, Cachoeiras de Macacu, Brasil, áreas adecuadas, marco institucional, FODA.

RESUMO

Os projetos de LULUCF no âmbito do MDL do Protocolo de Quioto representam uma valiosa oportunidade de vincular a mitigação da mudança do clima e a proteção dos ecossistemas em perigo como a Mata Atlântica. O presente estudo analisa as áreas potenciais, os atores e as barreiras ao desenvolvimento de projetos de seqüestro de carbono no município de Cachoeiras de Macacu, RJ, Brasil. Utilizando sensoriamento remoto e GIS, as áreas adequadas foram computados. As entrevistas foram realizadas para mapear o quadro institucional para projetos de LULUCF e uma análise DAFO foi feito para identificar os principais obstáculos e possíveis estratégias.

Dificuldades para eleger terras adequadas para projetos de seqüestro de carbono no âmbito do MDL, as complexidades de mensurar os reservatórios de carbono e a temporalidade dos créditos foram os principais obstáculos ao desenvolvimento de projetos LULUCF. Além disso, a especificidade das metodologias existentes (limita a sua replicação) e a demonstração da adicionalidade são importantes barreiras. Em Cachoeiras de Macacu, 27% (264 km^2) representam terras potenciais. As terras são altamente parceladas e ocupadas por pastagens (194 km^2) ou para uso agrícola (36,47 km^2). Além disso, historicamente, as áreas desmatadas (como Cachoeiras de Macacu) têm relativamente alta porcentagem de áreas adequadas para iniciativas de LULUCF, mas também são procuradas como terras para assentamentos e produção de alimentos (situação que irá intensificar-se com a criação do COMPERJ- Complexo Petroquímico da Petrobras). Este fato estabelece uma contração que leva à conclusão de que, áreas de amortecimento de megacidades nos países em desenvolvimento constituem cenários ideais para Pagamento por Serviços Ambientais (PES). Existem outros sistemas existentes, como o ICMS Ecológico, os mercados voluntários de carbono e REDD que demonstraram ser mais eficaz pra proteção das florestas que no MDL.

PALABRAS CHAVES

Mata Atlântica, LULUCF, MDL, Cachoeiras de Macacu, Brasil, áreas potenciais, dimensão institucional, DAFO.

ZUSAMMENFASSUNG

Die LULUCF Projekte im Rahmen des CDM-Mechanismus des Kyoto-Protokolls stellen eine wertvolle Gelegenheit zur Minderung des Klimawandels und zum Schutz der gefährdeten Ökosystemen wie dem Atlantische Regenwald. Die vorliegende Studie analysiert die potenziellen Gebiete, Interessengruppen und Barrieren zu entwickeln Kohlenstoffbindung Projekte in der Gemeinde Cachoeiras de Macacu, RJ, Brasilien. Mit Hilfe der Fernerkundung und GIS, geeignete Gebiete wurden berechnet. Interviews um des institutionellen Rahmens für LULUCF-Projekte festzustellen und eine SWOT-Analyse wurden realisiert, um wesentliche Hindernisse und mögliche Strategien zu identifizieren.

Schwierigkeiten für die Wahl von geeigneten Ländereien für Kohlenstoffbindung Projekte, Komplexitäten Messung der Kohlenstoff-Pools und Zeitlichkeit von Krediten haben die größten Hindernisse bei der Entwicklung von LULUCF-Projekten. Darüber hinaus stellen die Besonderheiten der bestehenden Methoden (die Grenzen ihrer Replikation) und Demonstration der Zusätzlichkeit wichtige Barrieren. In Cachoeiras de Macacu, 27% (264 km^2) sind potentielle Flächen für LULUCF-Projekten. Grundstücke sind hoch parzelliert und stellen vor allem Weiden (194 km^2) oder Ackerland (36,47 km^2). Historisch abgeholzten Flächen (wie Cachoeiras de Macacu) haben einen relativ hohen geeignete Flächen für LULUCF Initiativen, sondern auch eine bedeutende Nachfrage nach Flächen für Siedlungen und Nahrungsmittelproduktion (Situation, dass mit der Errichtung des COMPERJ intensivieren wird). Diese Tatsache setzt eine Kontraktion, dass Puffer Bereichen der Megastädte in den Entwicklungsländern führt ideale Szenarien für die Zahlung von Ecosystem Services bildet und nicht für CDM-Projekte. Es gibt andere vorhandene Systeme wie die ökologische ICMS, Voluntary Carbon Märkte und REDD, die zeigen, wirksamer zu sein als CDM.

SCHLÜSSELWÖRTER

Atlantische Regenwald, LULUCF (Landnutzung, Landnutzungsänderungen und Forstwirtschaft), CDM (Mechanismus für umweltverträgliche Entwicklung), Cachoeiras de Macacu, Brasil, institutionellen Rahmen.

INTRODUCTION

Global climate change poses important challenges to the world in the near future, especially to poor developing countries where its effects might be stronger. The Certified Emission Reductions (CERs) under the Kyoto Protocol is the first international approach that combines reduction of Green House Gases (GHG), mitigation of climate change and sustainable development. This framework gives exceptional opportunities to enhance conservation of severe endangered ecosystems like the Atlantic Forests. It also provides the chance to improve the living conditions of the local rural population and the provision of important ecosystemic services to adjacent communities.

On the other hand and despite this great potential, the implementation of LULUCF projects worldwide is still squat. This is mainly because of the big difficulties to measure the available areas, the related costs, low local communitiesô engagement and finally the lack of interest of many developing country enterprises to invest in Afforestation and Reforestation (A/R) Certified Emission Reductions (CERs), due to the long recovery periods. Therefore, in the last years other mechanisms like voluntary carbon payments or social carbon schemes have been developed as an alternative to the LULUCF methodologies.

The present study represents a contribution of the project: ñClimate change, landscape dynamics, land use and natural resources in the Atlantic Forests of Rio de Janeiroò (DINARIO) developed under the cooperation of the Institute for Technology in the Tropics and Subtropics from the Cologne University of Applied Sciences, the University of Leipzig and the University of Jena with the Brazilian Agricultural Research Corporation EMBRAPA principally. The main objective of this work is to measure the potential areas for the implementation of carbon credit projects under the Clean Development Mechanism (CDM) in the Land Use, Land Use Chance and Forestry (LULUCF) applicable methodologies in the Brazilian municipality of Cachoeiras de Macacu (Rio de Janeiro State, Brazil).

The information presented along the present study represents a basic approach of the possible areas where LULUCF projects could be done. In any case, there is a need to corroborate the data here presented with highly resolution satellite images and information. Nevertheless, it suggests a Rapid Assessment method, a good start to optimize resources (time and labor, but also costs) by prioritizing LULUCF projects spots. The objectives of the present study are the following:

OBJETIVES

1. Determine the potential areas for the implementation of LULUCF projects according to the approved methodologies under the Clean Development Mechanism of the Kyoto Protocol.
2. Realize a stakeholder analysis and map the institutional framework of carbon forestry projects and potential actors.
3. Analyze the barriers and opportunities of forestry carbon sequestration projects in the study region.

PROBLEM FORMULATION AND STUDY HYPOTHESIS

The study region (Rio de Janeiro State, Brazil) is located in a highly biodiverse but intense degraded ecosystem: the Atlantic Forest, in the Macacu river basin. The overexploitation has been continuous over the last 400 years (Instituto Bioatlantica, 2009) and increased in the last decades (Wilson *et al.*, 2009) due to the high exploitation of natural resources to supply the wealth of the habitants of the surrounding areas, especially highly-populated cities like Rio de Janeiro. Agriculture, forestry, tourism and industries are part of the landscape in the Macacu river basin. However, it is extremely important to protect and ensure the future supply of several of the ecosystems services that are being provided: water for irrigation and human consumption, wood supply, biodiversity, recreation and food to mention only a few of them.

The increasing population, climate change and deforestation will worsen this scenario in the following years. The degradation of the environment endangers the quality of life of the inhabitants and the provision of environmental services to the region. From these problems the next hypothesis can be drawn:

1. There is a considerable potential for LULUCF projects under the Clean Development Mechanism (CDM) in the municipality of Cachoeiras de Macacu, RJ.

2. Due to the pressure on natural resources the remaining Atlantic Forest will be degraded and the biodiversity diminished, therefore, CDM projects and LULUCF projects represent a valuable opportunity to conserve and set a framework for the future implementation of Payment of Ecosystem Services.

METHODOLOGICAL APPROACH

The methodological approach presented in the following section, is detailed according to main goals of the overall thesis project.

Goal 1. Determine the potential areas for the implementation of LULUCF project according to the approved and applicable methodologies under the Clean Development Mechanism of the Kyoto Protocol.

Using Geographic Information Systems (GIS) and Remote Sensing tools, different maps were created in a top-down regional baseline approach (Sudha *et al.*, 2007; Hargrave *et al.*, 1998) and the WBCSD/WRI GHG Protocol[1], following the next procedure:

1. Image acquisition

   1.1 Remote Sensing Images and land cover/ land use maps (the more coherent to the DNA of Brazil (UNFCCC, 2009) were obtained:

   a. LANDSAT images from the National Institute for Space Research (INPE), of year 1985 were chosen. The main reason was the reduced cloud coverage. the

      - LANDSAT 5 TM 217/75 (1985-07-04)
      - LANDSAT 5 TM 217/76 (1985-04-15)

   b. Actual Land cover / Land use maps of Cachoeiras de Macacu (DINARIO project database; Land Use and Land Coverage data for Cachoeiras de Macacu from INEA, 2007; GIS database from the Prefeitura of Cachoeiras de Macacu)

   1.2 The images were georeferenced and reprojected. The geometric rectification was done in Envi 4.3 using ground control points (GCPs). The land cover classification was processed in Definiens Developer EII Earth (Nearest

[1] GHG Protocol Initiative launched in 1998 by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI) for quantifying and reporting GHG emissions.

Neighbour algorithm) (bands 1-5 and 7). The images were processed in the Laboratorio de Geografia Fisica (LAGEF), Universidade Federal Fluminense (UFF). The following land use classes where defined: clouds, water bodies, forest, urban areas, shadow, second-growth forest and other. Areas containing shadow (50,49 km^2) and clouds (0,4 km^2) were classified as No Data, and water bodies were added to the areas without forest. The dataset was set at a scale of 1:50.000.

1.3 Criteria to select the potential areas:

a. Any area inside the municipality of Cachoeiras de Macacu that does not contain forest in the images of 1985.

b. Areas that do not contain forest in 2007, after the comparative analysis.

c. Exclusion of water bodies

2. Land cover analysis to evaluate suitable lands for LULUCF projects by using ArcGis 9.0 software. Following the ñProcedures to demonstrate the eligibility of lands for Afforestation and Reforestation of the Clean Development Mechanism Activitiesò (IPCC Special Report on Land Use, Land-Use Change and Forestry, 2001) and according to the definition of Forest by the Designated National Authority of Brazil (CIMGC, 2008; available at: http://cdm.unfccc.int/DNA/ARDNA.html?CID=30) it was determined which are the possible A/R project areas in the region (Schlamadiger, 2004).

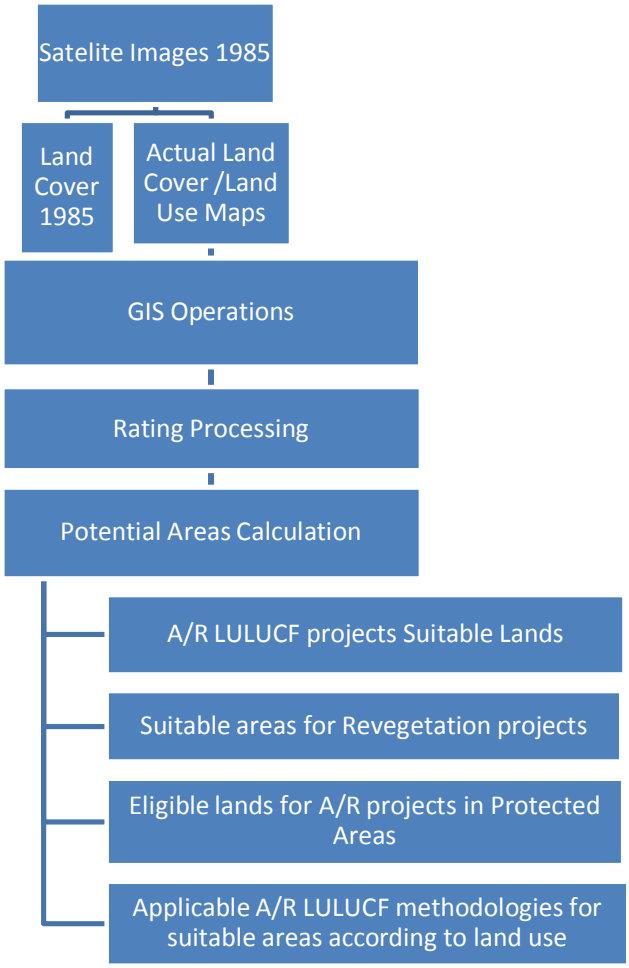
a. Suitable lands for Afforestation and Reforestation LULUCF projects

b. Suitable lands for Revegetation LULUCF projects

c. Eligible lands for A/R in Protected areas

d. Eligible lands for LULUCF approved methodologies under agricultural and/or pastoral activities.

Figure 1: Synthesized methodological procedure to determine suitable lands for LULUCF projects in Cachoeiras de Macacu.



Goal 2: To analyze the barriers for implementing these kind of projects from the social and economic point of view.

Goal 3: To study the institutional structure of the organizations linked to these projects or the ones that may help to support them, as well as the local perception the carbon trading projects.

In order to identify the main stakeholders two commonly applied methods were used: semi-structured interviews and the snowball sampling methodology (Reed *et al.*, 2009; Corbera and Brown, 2008). The first approach of possible stakeholders was through the selection of individuals or organizations involved with the development of carbon forestry activities in Brazil previously known by the partner researchers in Brazil,

especially EMBRAPA Solos. And to facilitate the analysis, the stakeholders were classified in four groups: 1. government (local, regional and national); 2. NGOs; 3. industry and 4. potential project participants.

The collection of data and informative interviews were carried out with representatives from regional and local governmental and administrative offices, research institutions and civil organizations. Consult experts interrelated with the project, dialogue with other research groups will be as well a key point. Verbal and written communicative methodologies were used (for more information, please refer to Annex 1).

Primary sources as interviews, polls and visits to key institutions and farmers were realized. Other secondary sources as bibliographical research were also utilized, especially data collected to set the local and regional institutions framework**.** All mentioned surveys and interviews were realized during the months of March, April and May of the year 2010.

To map the barriers for the implementation of LULUCF projects, a SWOT analysis was done using the basic methodology from Weihrich (1982) and an approach in Cameroon from Minang *et al.* (2008).

STUDY AREA

THE MATA ATLÂNTICA FOREST

The Brazilian coastal rainforest or Mata Atlântica originally covered more than 1 million km^2 (15% of the Brazilian territory) from the north region of Ceará (6°17ô South Latitude) to Rio Grande do Sul (south Brazil, 33°41ô South Latitude) (Torrico, *et al.*, 2009), which makes it the third largest biome of Brazil (Figure 2).The Atlantic forests are extremely biodiverse and conserve important endemic species (Bergallo, *et al.*, 2009) at all levels of flora and fauna organization (Torrico *et al.*, 2009). This biome may contain 60% of the total Brazilian terrestrial species (Galindo Leal and Gusmao Camara, 2005) and probably 40% of the plant species present in the Atlantic biome are endemic (*circa* 20.000 species) (Torrico *et al.*, 2009).The deforestation process started along with the colonization (Bergallo *et al.*, 2009; Torrico *et al.*, 2009), 84% of the original cover is lost (Bergallo *et al.*, 2009). Other estimations suppose that only 5-12%

of the forest remains (depends on the definition of forest borders) (Torrico *et al.*, 2009) (Figure 2).

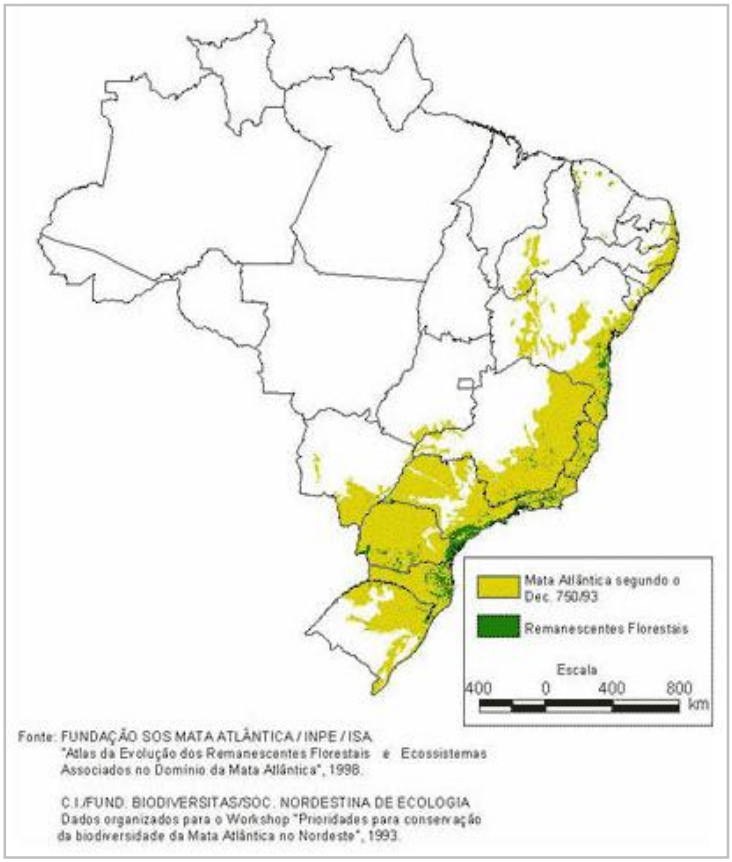


Figure 2: Brazil and the Extent of the Mata Atlântica (Fundação SOS Mata Atlântica *et al.*, 1998).

The loss of habitat and biodiversity is also reflected in the higher rates of endangered species (187 for Rio de Janeiro State) when compared to other states in Brazil (Bergallo, *et al.*, 2009). Deforestation, biodiversity loss, soil degradation, water quality and quantity diminish and high levels of GHG emission (Torrico *et al.*, 2009a) are some of the consequences of land use change, being the conversion of forests into agricultural land the principal reason (Torrico *et al.*, 2009b).

The remaining fragments are extreme vulnerable and need to be connected in order to restore its functionality (Pinto & Wey de Brito, 2005). Likewise, many other processes (chemical and physical) can be affected by destruction and unsustainable land use habits (Torrico *et al.*, 2009b). Further on, the inhabitants of the Mata Atlântica region seem to ignore the value and the presence of this important forest (Torrico *et al.*, 2009b).

Rio de Janeiro State encloses between 20 and 30% of the remaining Atlantic forest in Brazil (primary and secondary success stages), being the state with the highest

percentage (Bergallo *et al.*, 2009; Barreiro, 2009). *Circa* 60% of the remaining proportion corresponds to ñpastures and cattle activitiesò(Barreiro, 2009). Greenhouse gasses emissions from Agriculture, Forests and other Land Use Change (AFLO) represent only 14.6% as reported for Rio de Janeiro State; nevertheless, the majority of them correspond to land use change (61,4%) and the rest to livestock production (36,1%) (Centro Clima, 2007).

PROJECT REGION

The study area of the project is located within the federal state of Rio de Janeiro in Brazil, and conducted in the municipality of Cachoeiras de Macacu (Figure 3).

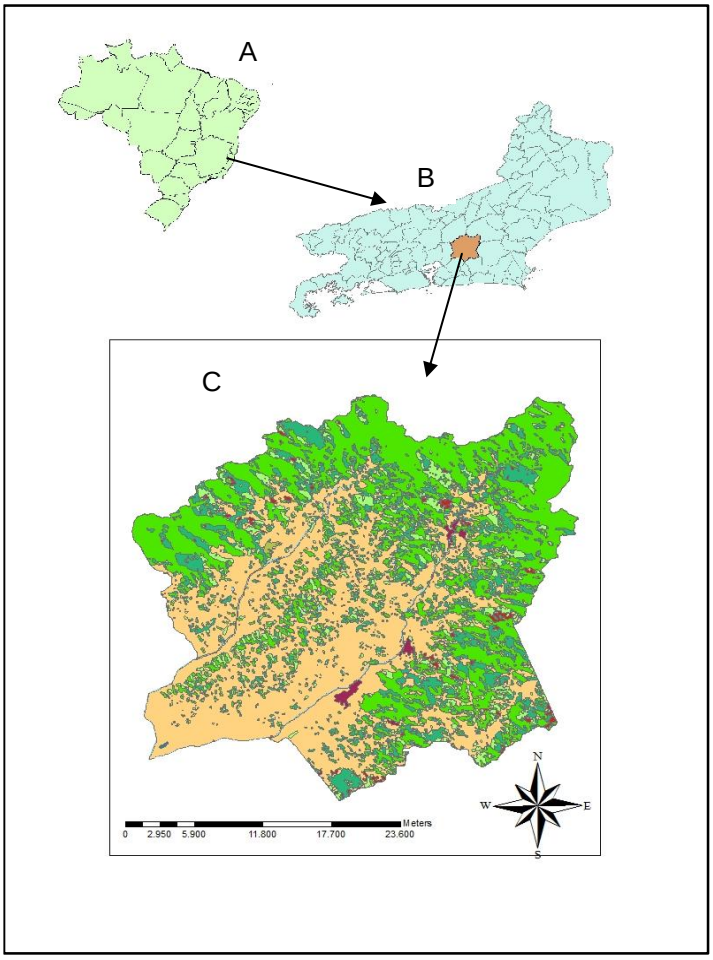


Figure 3: Study Area location. A: Brazil, B: Rio de Janeiro State; C, Municipality of Cachoeiras de Macacu (GIS-Database of the Prefeitura de Cachoeiras de Macacu

Located at 57 m above sea level, the municipality of Cachoeiras de Macacu has a population of 53.037 inhabitants (data from 2007) (IBGE, 2009) being 84.7% urban

population (data from 2000) (Moreira, 2009) in a surface of 956.8 km^2 (IBGE, 2009). Poverty affects around 41.50% of the population (Map of Poverty and Inequality-Brazilian Municipalities 2003) (IBGE, 2009).

LAND USE AND VEGETATION COVERAGE

The study area has been severely deforested for more than 200 years (Instituto Bioatlantica, 2009). Originally the Atlantic forest covered the entire municipality (*ca.* 956 km²); today only remains 43% (414 km²) of its original extend (SOS Mata Atlantica/INPE, 2009). In Table 1, a comparison of the vegetation coverage in the municipality of Cachoeiras de Macacu is shown.

Table 1: A comparison of the vegetation coverage in Cachoeiras de Macacu between the years 1956-1975, 1994 and 2001 (SOS Mata Atlantica/INPE, 2009; CIDE, 2001; INEA, 2007).

Land Use Type	**1956-1975**	**1994**	**2001**	**2007**
Forest remnants	49%[2]	51%	38%	65,13%
Secondary vegetation initial stage	-	15%	26%[3]	5,86%
Agricultural lands	-	15%	13%	4,32%
Pasture lands	-	14%	21%[4]	22,95%
Urbanization rate	-	0,9%	1,6%	1,36%

The principal loses of Atlantic forest occur between the periods of 1985 to 1990 (305 km^2) and 1990-1995 more than 1.403 km^2 for Rio de Janeiro Sate (Wilson *et al*., 2009).

[2] From this 49%: 46.06% corresponds to Atlantic Forest and 3.04% to Cerrado forest (Macega) (CIDE, 2001).

[3] From this 26%: 6.81% corresponds to advance secondary vegetation and 19.30% is intermediate secondary vegetation.

[4] Some of these pasture areas, may be abandoned pasturelands (pasto sujo) (T. Matos da Mata personal communication 9.06.2010)

SOCIO-ECONOMIC PROFILE AND ACTUAL LAND USE SYSTEMS IN CACHOEIRAS DE MACACU

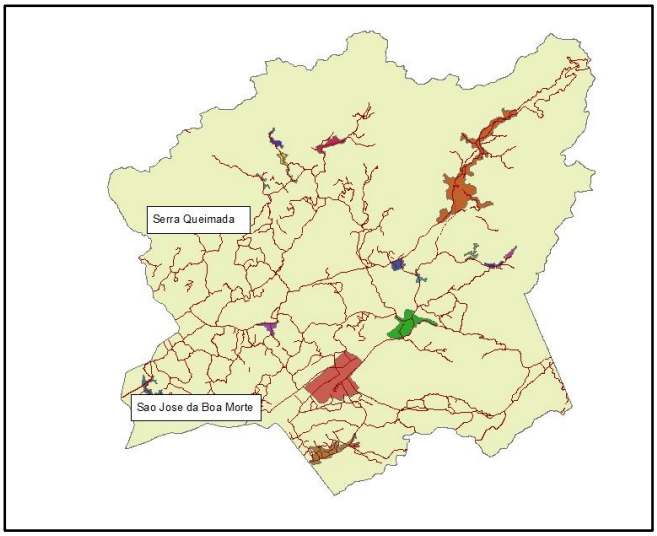
The main activities of the Cachoeiras de Macacu municipality are industrial with moderated agriculture and livestock activities and a predominately urban population (Bergallo *et al.*, 2009). The average income per capita is around R$ 219 per month (ca. EUR 100) and the medium nominal income of the municipality is R$433,93 (Instituto Bioatlantica, 2009). The Minimum Income in Brazil is R$510,00 (Salário Mínimo 2010; Diário Oficial da União, Medida Provisória nº 474, 23 de dezembro de 2009), equivalent to ca. EUR 230,00.

In the year 2007, 52% of the GDP of the municipality of Cachoeiras de Macacu corresponded to industry, 42% to services and only *circa* 5% to agricultural sector (Moreira, 2009). Farming activities involve the intensive use of chemicals and deforestation of riparian vegetation especially in the mountainous region of Rio de Janeiro State (dos Santos de Oliveira, 2009).

The remaining 40% of vegetation and the relatively low importance of agropecuary activities lead to the conclusion that reforestation activities can be successfully implemented in the municipality. Nevertheless, according to IBGE (2006) in 2006, 45.45% (674) of the farms had less than 10 ha; 50.37% (747) had between 10 and 100 ha; 4.04% (60) 100-1000 ha and finally 0.14% (2) more than 1000 ha. Therefore, the reduce size of the farms could increment the pre-implementation costs of LULUCF projects.

The famers produce *Musa* sp. (banana), *Colocasia* sp. (inhame), *Manihot* sp. (aipim), *Cocos nucifera* (coco), *Citrus* sp. (limão), *Solanum gilo* (jiló), *Cucumis anguria* (maxixe), *Passiflora edulis* (maracujá), *Cucurbita pepo* (abobrinha), *Zea mays* (milho verde), *Psidium guajava* (goiaba) (Moreira, 2009; Cardoso *et al.*, 2008). The more productive areas are São José da Boa Morte and Serra Queimada (Instituto Bioatlantica, 2009) (Figure 4: Cachoeiras de Macacu Map showing the settlements of São Jose da Boa Morte and Serra Quemaida (GIS-Database of the Prefeitura de Cachoeiras de Macacu (provided 2009).

Figure 4: Cachoeiras de Macacu Map showing the settlements of São Jose da Boa Morte and Serra Quemaida (GIS-Database of the Prefeitura de Cachoeiras de Macacu (provided 2009).



The share of seasonal crops (principally maize and manioc) reduced in the last years; however, permanent crops do not present major changes during the last decade (Bergallo *et al.*, 2009).

Pasturelands (predominated by the introduced gramineae *Brachiaria decumbens* are used in cattle ranching. ôCapoeiraõ lands (areas dominated by bush vegetation are parcels in secondary grow stage that were use as pastures) (Schlüter and Pedroso, 2009) can be also found in Cachoeiras de Macacu.

Pasture lands are important in the region and the principal livestock consists of: dairy and meat calves, horses, goats, aquaculture and lately ostriches (Instituto Bioatlantica, 2009).

The municipality of Cachoeiras de Macacu has a high vulnerability Index of Human Pressure over areas for conservation and protection (Bergallo *et al.*, 2009) making it important and extremely necessary to implement urgent actions to preserve surrounding forests. Existing cultivars and pasture lands in deforested areas before 1990, could be managed (according to LULUCF existing methodologies) to receive CERs.

The municipally also contains several protected areas inside its borders. The most important are:

- **Três Picos State Park** (Parque Estadual Três Picos, PETP) under the supervision of the State Forestall Institute of Rio de Janeiro (Instituto Estadual de Florestas do Estado do Rio de Janeiro, IEF-RJ). It has a total area of 46.317 ha; two thirds of it is located in Cachoeiras de Macacu and the rest is shared with the municipalities of Teresópolis, Silva Jardim, Nova Friburgo, and Guapimirim. It has a highly satisfactory index of implementation of Conservation Units (Instituto Bioatlantica, 2010).

- The **Paraiso State Ecological Station** (Estação Ecológica Estadual do Paraíso, EEEP) managed by State Secretariat of Environment (Secretaria Estadual de Ambiente, INEA). In the past was administrated by the former Instituto Estadual de Florestas do Estado do Rio de Janeiro (IEF-RJ) and the Fundação Estadual de Engenheira do Meio Ambiente (Feema). It has and extension of approximately 5.000 ha.

- **São João Watershed and Golden Tamarin Environmental Protection Area** (Área de Proteção Ambiental (APA) da Bacia São João- Mico Leão ï Dourado), managed by Instituto Chico Mendes de Conservação da Biodiversidade (ICMBIO). It has an extension of 150.686 ha.

- **APA da Bacia do Rio Macacu**, comprehends 194.498 ha. And itôs administered by INEA. It is still under proposal phase.

Besides the protected areas according to the Áreas Prioritarias da Mata Atlantica of the Ministry of Environment, there are three priority conservation areas for the Atlantic Biome in Cachoeiras de Macacu, (IBIO, 2009). The Macacu Watershed (Bacia do Macacu). It is highly important and has an extremely high priority for restoration, and has 34.958 ha. The Macacu watershed is usually integrated to the Guapi-Macacu Watershed (Bacia Guapi-Macacu), also a highly important area, which comprehends 33.922 ha and has an extremely high restoration priority. The Macacu watershed and the Guapi-Macacu watershed will form the APA da Bacia do Rio Macacu. And finally, the Sambê- Santa Fé Ecological Corridor (Corredor Ecológico Sambê-Santa Fé) has a total extension of 27.453 ha. It is extremely important and has a high priority for restoration.

LULUCF PROJECTS UNDER THE CLEAN DEVELOPMENT MECHANISM OF THE KYOTO PROTOCOL

3.1 FORESTRY CARBON SEQUESTRATION PROJECTS UNDER THE KYOTO PROTOCOL

ATLANTIC FOREST AS CARBON SINKS

Forests located in tropical regions are very important carbon reservoirs, they stock 212 Gt C in vegetation and nearly the same amount in soil (216 Gt C) (up to a depth of 1 m) (Pires de Campos, 2007 in Wilson *et al.*, 2008). Other often cited example, are Amazonian forests. They sink between 60-80 billion tC, equivalent to 175 tC/ha (Carvalho, 2004). Nevertheless, several research studies (Fearnside, 1997 and Houghton *et al.*, 2000 in Carvalho, 2004) assure that each year only the Amazon region emits 200-300 million tC because of deforestation processes, 25% percent of the total global emissions and 10% of the N_2O emissions (Palm *et al.* 2004) without taking into account emissions due to fires. In a general way, land use change represents 76% of the CO_2 emissions from Brazil (MCT, 2009).

On the other hand, other tropical forests like the Mata Atlântica can also constitute important carbon reservoirs. The Atlantic forests can storage up to 3.0 tC/ha per year (Guimarães, 2007). Correspondingly, according to Torrico *et al.* (2009), a mature forest of the National Park ñSerra dos Órgaosòstores ca. 300 tC/ha compared to a secondary forest that only traps around 90 tC per ha.

Estimations for Rio de Janeiro State, address 200 tC/ha for remnants in the Atlantic forest, 100 tC/ha for secondary forest (late successional stage) and 5 tC/ha secondary forest in initial succession stage and 4tC/ha in pasture lands (CIDE, 2001). These data match the estimations of Tiepolo *et al.* (2002; in Instituto Bioatlantica, 2009) for Atlantic forests: 106 tC/ha for late successional forests, 101 tC/ha for intermediate stage

forests and 42.89 tC/ha for *capoeira* lands[5]. And correspond to further estimations in secondary tropical forests that can also trap reasonable quantities of carbon (5 Mg C/ha yr) (Torrico *et al.*, 2009).

Forests constitute one of the principal carbon sinks of GHG, especially tropical forests located in developing countries. Therefore, one of the most important strategies to decrease GHG in the global atmosphere should be through the increment of forestall areas in developing countries.

THE UNFCCC AND THE KYOTO PROTOCOL

The Intergovernmental Panel on Climate Change (IPCC) is a group of experts that researches and argues relevant information about climate change. Due to the constant increasing of the GHG (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and F-gases) (IPCC, 2006) in the atmosphere, the global temperature is increasing, creating a cascade of unknown effects.

In 1992 in Rio de Janeiro, more than 180 countries signed the United Nations Framework Convention on Climate Change (UNFCCC) to decrease the amount of Green House Gasses (GHGs) in the atmosphere (UNCTAD, 2003). They identify three main mechanisms: Joint Implementation (JI), Emissions Trading (ET) and the Clean Development Mechanism (CDM).

CDM AND LULUCF

The CDM is the only modality where non-Annex I countries (developing countries) can participate in the Kyoto Protocol (UNCTAD, 2003). Technicality, developed countries (Annex I) can meet their reduction goals by financing sequestration projects in developing countries that have ratified the Kyoto Protocol (UNCTAD, 2003) by earning credits (CERs, Certified Reduction Emissions[6]) (Bloomfield and Pearson, 2000). Public and private organizations or individuals can participate in CDM projects.

[5] Lands in secondary stage of growth (Nehren *et al.*, 2009)

[6] According to the Global Warming Potential (GWP), a unity of CER corresponds to one t of carbon dioxide equivalent (t CO_2 eq) (MCT, 2009).

Depending on the duration, the CERs can be issue as short-term credits (Temporary Certified Emission Reductions, tCERs) and long-term credits (Long-term Certified Emission Reductions, lCERs) and they have to be replaced before the expiration date (Neeff and Henders, 2007). For both of them, but especially for long term periods, uncertainties about replacement costs increase the difficulty of its issuing (lCERs) (Dutschke, 2010).

Through Land-Use, Land-Use Change and Forestry (LULUCF) activities, GHG emissions from anthropogenic sources can be trapped and stored. The projects should demonstrate that emissions would occur in absence of these projects (Bloomfield & Pearson, 2000). In the Bonn the meeting of the Conference of the Parties (COP6) in 2001, the Board decided to exclude the *avoided deforestation* at least for the period 2008-2012 of the Kyoto Protocol (Carvalho, 2004).

Based on several already approved projects, the COP7 decided to delineate ñdefinitions, modalities, rules and guidelines relating to land use, land-use change and forestry activitiesé for the first commitment periodòof the Kyoto Protocol (IPCC, 2001). Nowadays, LULUCF projects only account for the 0.08% of all methodologies implemented worldwide (UNFCCC, 2008).

The crediting periods according to IPCC (2006) are: a fix credit up to 30 years with no extension, and a 20 years renewable credit, extended up to two periods of maximum 60 years.

The basic requirements for LULUCF projects are: a minimum project area of 0.05-1.0 hectares, trees of 2 to 5 meters tall maturity and coverage of 10 to 30% (IPCC, 2006). The carbon stock changes can be measure in aboveground biomass, belowground biomass, deadwood, litter, and soil organic carbon. In the Table 2, a synthesis of the principal sources of carbon matter for each pool is presented.

Table 2: Carbon Pools (IPCC, 2006; Schlamadinger, 2004; Wilson *et al.*, 2009)

Living Biomass	Above-ground biomass	Living biomass above the soil
	Below-ground biomass	Life roots biomass, except roots with less than 2 mm
Dead Organic Matter	Dead wood	Non-living wood not present in litter, include fallen wood and dead roots with a diameter over 10 cm
	Litter	Non-living plant in various states of decomposition includes fine roots between 2 mm and smaller than 10 cm. Also live roots with less than 2mm.

Soil	Soil Organic Matter (SOM)	Organic Carbon in mineral and organic soils, includes live fine roots (<2mm) in up 30 cm of soil depth.

The variety and complexity of the different carbon pools is shown in Table 2. More information about the formulas and logarithms for the estimation of carbon pools can be found in the Guidelines for National Greenhouse Gas Inventories (IPCC, 2006).

Along with the definition of carbon pools, some methodologies have been approved for the creation of LULUCF projects. In the next section (Table 3), is presented a summary of the principal modalities in which LULUCF of the Kyoto Protocol could be potentially developed. In 2001, the Marrakesh Accords (COP 7) limited the possibilities of LULUCF to the modalities of Afforestation and Reforestation, and the use of CERs from these sinks should correspond to 1% of the emissions of a Party in 1990 (UNFCCC, 2010).

Table 3: A summary of Land-Use, Land-Use Change and Forestry (LULUCF) modalities approved under the CDM of the Kyoto Protocol during the first commitments (according to IPCC, 2000; 2001)

Afforestation (A): conversion of a 50 years non-forested land into a plantation ñthrough planting, seedling and/or human-induced promotion of natural seed sourcesò

Reforestation (R): conversion of a deforested land (before 31-dec-1989) into a forested land with the same method as the Afforestation.

Deforestation (D): conversion of forested land into non-forested land through human intervention.

Revegetation: human activities to increase carbon stocks in minimum 0.05 hectares ñthrough the establishment of vegetationò

Forest Management (FM): sustainable use of forest that meets ecological, economic and social functions.

Cropland management (CM): a ñsystem of practicesòin actual or past croplands.

Grazing Management (GM): are processes that manage vegetation and livestock on land use for livestock.

The only the existing LULUCF methodologies are under Afforestation and Reforestation areas. Project activities in these two fields can be applied to remove

GHG following the mechanisms subsequently presented (adapted with small changes from Mangiat *et al.*, 2005):

- Agroforestry is a mixture system that integrates forest to agro-landscapes, crops or livestock areas.
- Monocultural or mixed industrial plantations, attractive for the profitability, require technical expertise and high investments.
- Forest landscape restoration, a form that combines ñnatural generation, tree planting and agro-forestryò generating socio economical and environmental benefits.
- Community forestry involves actions that involve rural communities contributing to the sustainable development of farmers.
- Biomass energy projects ñserve the production of energy in the form of electricity, solid, liquid or gaseous fuels and heat, which is based on biomass.

Until now the majority of the proposed projects have been for industrial plantations (Seroa da Motta *et al.*, 2000). The lack of proposals in other areas can be attributed to the high costs and technical difficulties, as will demonstrated later on.

In a general way, there are three kinds of eligible lands: forests, croplands and grasslands. They could maintain their actual use, improve their actual condition or be transformed in a higher carbon pool (forest). In Table 4, a resume of the principal LULUCF methodologies and their final land use is presented.

Table 4: Synopsis of LULUCF methodologies for the first period of the Kyoto Protocol[7] (from Schlamadinger, 2007).

Initial Land Use	**Final Land Use**		
	Forest	***Cropland***	***Grazing Land***
Forest	Forest Management	Deforestation	Deforestation
Cropland	Afforestation/ Reforestation	Cropland Management	Grazing Management
Grazing land	Afforestation/	Cropland	Grazing Management

[7] Revegetation is not considered.

	Reforestation	Management	

In the next section a study of the carbon sequestration potential for each methodology is analyzed.

LULUCF PROJECTSôCARBON SEQUESTRATION POTENTIAL

The main objective of the Climate Change Convention is the sequestration of carbon in several forms; however some associated impacts to each of type of activity have to be taken into account (Table 5).

Table 5: Summary of potential rates of carbon gain and associated impacts (Adapted and modified from IPCC, 2000)

Activity	Tropical ecozone	Key practices	Average (tC/ha/ yr)	Associated Impacts
Cropland management	Dry	Reduced tillage, residue retention	0.2	Increased food production, improved soil quality, reduced erosion, possibly higher pesticide use
	Wet	Reduced tillage, improved fallow management, fertilization	0.5	Increased food production, improved soil quality, reduced erosion, fertilizers often unavailable, possibly higher pesticide use
	Wet (Rice)	Residue management, fertilization, drainage management	0,50	Increased food production
Agro forest management		Improved management	1.0	
Grassland management	Dry	Grazing management, species introduction, fire management	0.9	Reduced soil degradation, higher productivity, woody encroachment (reduced productivity)
	Wet	Species introduction, fertilization, grazing management	1,20	Increased productivity, reduced biodiversity, acidification
Forest management	Dry	Forest conservation, reduced degradation	1,75	Ecological improvement, high cost efficiency
	Wet	Reduced degradation	3,40	Environmental improvement

Conversion to agro forestry		Conversion from cropland or grassland at forest margins	3,00	Improved biodiversity, CH4 sinks, poverty alleviation, food security

As shown in Table 5, forest management through reduced degradation is the option with the highest carbon sequestration potential, followed by conversion of croplands and grasslands into forests. Cropland and pasture management have the lowest carbon sequestration potential and probably also a limited impact. Awareness at this stage is important to be taken. The carbon storage capacity of each activity has not to be the only point to evaluate. Also the secondary impacts related to each activity, especially social and economical issues play an important role.

APPROVED LARGE-SCALE AFFORESTATION AND REFORESTATION BASELINE METHODOLOGIES

The approved large-scale afforestation and reforestation baseline methodologies have been created for any project that sinks more than 8 kilo tons of CO_2 per year. Based on UNFCCC (2001), in the next section a summary of the approved large-scale methodologies is presented.

AR-AM0001: Reforestation of degraded land: severely degraded land that has to be reforested by direct planting and/or seedling. Grazing will not occur, but the plantation can be harvested through short or long rotation. Only count for above and below ground carbon pools.

AR-AM0002: Restoration of degraded lands through afforestation/reforestation: severely degraded land where ñenvironmental conditions of anthropogenic pressures do not permit significant encroachment of natural tree vegetationò No grazing is permitted. It considers the five carbon pools.

AR-AM0004: Reforestation or afforestation of land currently under agricultural use: low carbon sink lands that can be restored by natural regeneration, tree planting, no-grazing and avoided fuel-wood recollection activities. Considers possible shifting of other current activities and also limits the use of nitrogen-fixing species. Selected carbon pools are above-ground and below-ground biomass.

AR-AM0005: Afforestation and reforestation project activities implemented for industrial and/or commercial uses: commercial or industrial activities on grasslands with low carbon (soil degradation or climatic-edaphic conditions). No expected natural regeneration because of the lack of seed sources or land use practices. Flood irrigation is avoided, and an insignificant use of nitrogen-fixing species permitted. Carbon pools accounted are above and below ground.

AR-AM0006: Afforestation/Reforestation with trees supported by shrubs on degraded land: degraded land remains with low carbon stocks because human activities do not permit recovery. Shrubs and tree may be planted, including nitrogen-fixing species. Plantations can be harvested, but burning and grazing are not allowed. Above, below ground biomass and soil organic carbon are counted as carbon pools.

AR-AM0007: Afforestation and reforestation of land under current agricultural or pastoral use: actual or future land use for pasture/agricultural practices where humans do not permit natural regeneration. Nitrogen-fixing species are not allowed. The selected carbon pools are: above and below ground biomass, deadwood and litter.

AR-AM0008: Afforestation or Reforestation on degraded land for sustainable wood production: degraded lands where human interventions do not permit natural regeneration. Grazing and forestation over wetlands or organic soils are not allowed. Above and below ground carbon pools are considered. Slash-and-burn practices are restricted to non-vegetated sites.

AR-AM0009: Afforestation of reforestation on degraded land allowing for silvopastoral activities: A/R on degraded grasslands through ñassisted natural regeneration or tree planting. Grazing is allowed, but manure should stay deposited. Nitrogen-fixing species accounts for 10% of the total. The five carbon pools are selected.

AR-AM0010: Afforestation and reforestation project activities implemented on unmanaged grasslands in reserve/protected areas: ñunmanaged grasslands or ñslowly regenerating woody coverò lands in reserves or protected areas that without direct human intervention will not revert to forests. The project boundary cannot include 20-years severely degraded lands or 3-years agricultural lands. Nitrogen-fixing species are less than 10%. Also considers, the absence of human activities that can lead to carbon sequestration. Above, below ground biomass and soil organic carbon are the selected carbon pools.

APPROVED SMALL-SCALE AFFORESTATION AND REFORESTATION PROJECT ACTIVITIES

Small-scale A/R projects are those that sink less than 16.000 t of CO_2 per year. They only consider aboveground biomass and belowground biomass pools. Design to be developed by small communities and ethnic groups. According to the Brazilian Designated National Authority (DNA), low income project participants are families with a monthly income of half of minimum wage per capita (CIMGC No. 3, 24.03.2006) (MCT, 2009). The small-scale methodologies are similar to the large scale-methodologies. There are five simplified baseline and monitoring methodologies according to the IPCC (2006) and UNFCCC (2010), presented as follows:

AR-AMS0001: applied on afforestation or reforestation of grasslands and cropland. The considered carbon pools are above-and below-ground tree and woody perennials biomass and below-ground biomass of grasslands.

AR-AMS0002: applied on settlements (transportation or rural and urban areas) and former agricultural areas. Above-and below-ground tree biomass are considered as carbon pools.

AR-AMS0003: Afforestation or Reforestation ñthrough assisted natural regeneration or seeding or tree planting on degraded wetlandsò. Consider methodologies are above and below- ground biomass of trees.

AR-AMS004: afforestation or reforestation. Not permitted on grasslands. Carbon pools are above-ground and below-ground tree biomass and soil organic carbon.

AR- AMS005: Afforestation or Reforestation in areas with a little ñpotential to support living biomass without human interventionò, like: sand dunes, bare lands, contaminated o alkaline or saline soils. Carbon pools are above-ground and below-ground tree biomass and soil organic carbon (SOC).

DEFORESTATION AVOIDANCE (D) OR AVOID DEFORESTATION / REDUCED EMISSION FROM DEFORESTATION AND DEGRADATION (REDD)

Forests are one of the principal carbon reservoirs worldwide and they are responsible for the maintenance of the carbon cycle (Costenbader, 2009). Brazil emits 2,5% of GHG in the world because of deforestation (Olsen and Bishop, 2009). Avoiding the actual deforestation rates especially in tropical forests through the CDM mechanism can be more effective than other mitigation options as reforestation and afforestation (Fearnside, 2001; Santilli, 2005; Canadell and Raupach, 2008; Schlamadinger *et al.*, 2007).

Reducing emissions from deforestation avoidance and forest degradation has been in the international climate policy one of the leading discussion topics (Olsen and Bishop, 2009; Blom *et al.*, 2010). The principal objective of this methodology is to avoid the conversion of existing primary forests into non- forested lands (Reyer, 2009) by providing economical incentives to conserve forests (Ghazoul *et al.*, 2010).

A still not approved methodology, but could probably be approved in the post-2012 meetings. The Bali Action Plan (COP-13) of the UNFCCC has being supporting the finance and framework of REDD projects (Blom *et al.*, 2010). And further on, COP-15 and COP-16 discussions continued with light improvements (Baker *et al.*, 2010).

The UN-REDD Programme (United Nations collaborative programme on reducing emissions from deforestation and forest degradation in developing countries) has already four pilot projects in Latin-America to support the design and implementation of REDD projects. Also facilitates the creation of procedures for the measurement, reporting and verification of deforestation avoidance methodologies (UN-REDD, 2009).

Recently, the REDD-Plus (REDD+) approach, has taking force in the negotiation arena because combines forest carbon sequestration with sustainable forest management practices (Blom *et al.*, 2010).

REDD has ñtechnical, social, economic, ethical and governance challengesò, that need to be resolved (Ghazoul, *et al.*, 2010). The principal complexity concerns ñleakage, additionality and environmental impacts (Baker *et al.*, 2010). The measurement of

benefits and carbon potentially sequestered could be calculated according to the existing methodologies (Karky and Banskota, 2009).

PROGRAMMATIC CDM

The modality Programmes of Activities (PoA) was approved during the first Meeting of the Parties (MOP1), as a ñvoluntary coordinated action by a private or public entity which coordinates and implements any policy/measure or state goal which leads to GHG emission reductions or increases net GHG removals by sinks that are additional to any that would occur in the absence of the PoA, via an unlimited number of CDM program activities (CPAs)ò(UNEP, 2009b).

The Managing Entity (project participant) is a public/private entity that sets the framework and manages the CERs. The entity has to be authorized as coordinator by the national DNA, being able to develop several asynchronous activities with duration of 28-60 years (for A/R projects) (UNEP, 2009b). Programmatic CDM can help to governmental (or any coordinator) entities to create laws, policies and/or programmes as incentives to promote the reduction of GHG (UNEP, 2009a) and obtain CERs from these activities.

The projects can use large or small scale CDM (SSC A/R-PoA) approved methodologies with a single measurement method in several locations or many measurement methods in different locations (UNEP, 2009b). Additional CDM Programme Activities could be added during the operation (UNEP, 2009a).

Afforestation and Reforestation Programme of Activities (A/R-PoA) has still ñscarce experience on the opportunities and limitations of this approachò(Robledo and Blaser, 2008). However, in October 2009, the project ñMethane capture and combustion from Animal Waste Management System (AWMS) of the 3S Program farms of the Sadia Instituteòwas registered in Brazil under the Programme of Activities CDM methodology (UNFCCC, 2009).

BUNDLING OF ACTIVITIES

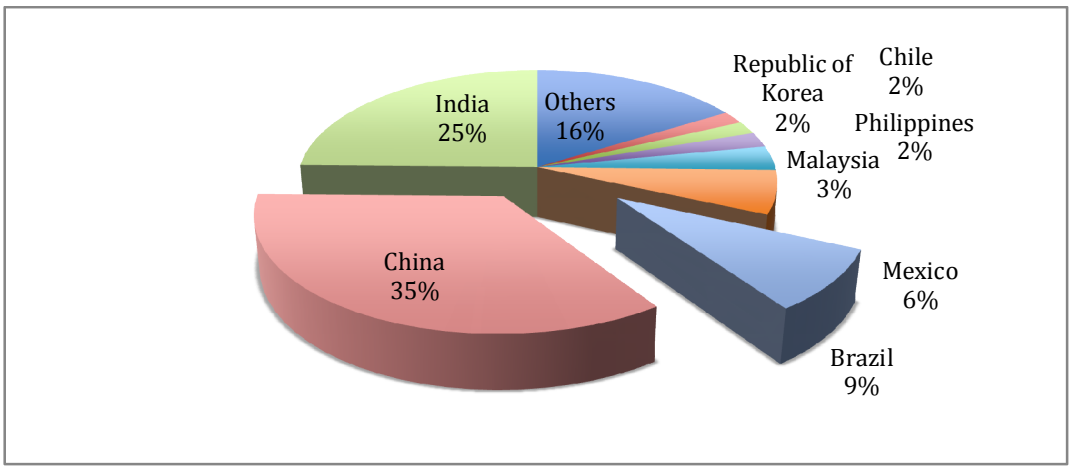
A project activity can be formed by a group of subprojects of the same baseline methodology and submitted at the same time in a form document (F-CDM-BUNDLE) (UNFCCC, 2010).

There is also the possibility to create Small-scale bundled project activities, therefore the Guidelines for completing the form for submission of bundled small-scale CDM project activities (F-CDM-SSC-BUNDLE) was created (for reference see: http://cdm.unfccc.int/Reference/Guidclarif/pdd/PDD_guid05_v01.pdf).

3.2 LULUCF PROJECT FRAMEWORK

Worldwide, Afforestation and Reforestation projects account for 0.35% of the registered projects and agriculture projects 5.32% (UNFCCC, 2009). In Figure 5, a chart illustrates the total registered project activities by host party, of a total of 1890 initiatives in 2009.

Figure 5: Registered project activities by host party (UNFCCC, 2009).



As demonstrated the leading countries in CDM activities are emerging countries: China, India and Brazil.

AFFORESTATION AND REFORESTATION CDM PROJECT CYCLE

To present and register a project activity the UNFCCC has delineated a guideline for the submission of proposals. Any A/R project under the CDM has to follow the subsequent procedures:

1. **A/R project activity design.** The project participants should submit their proposed CDM project using the *Project Design Document for Afforestation and Reforestation Project Activities* (CDM-A/R-PDD). When need it, a Proposal of a New A/R Baseline and/or Monitoring A/R Methodology should be submitted to the Executive Board and approved prior to CDM-A/R-PDD.

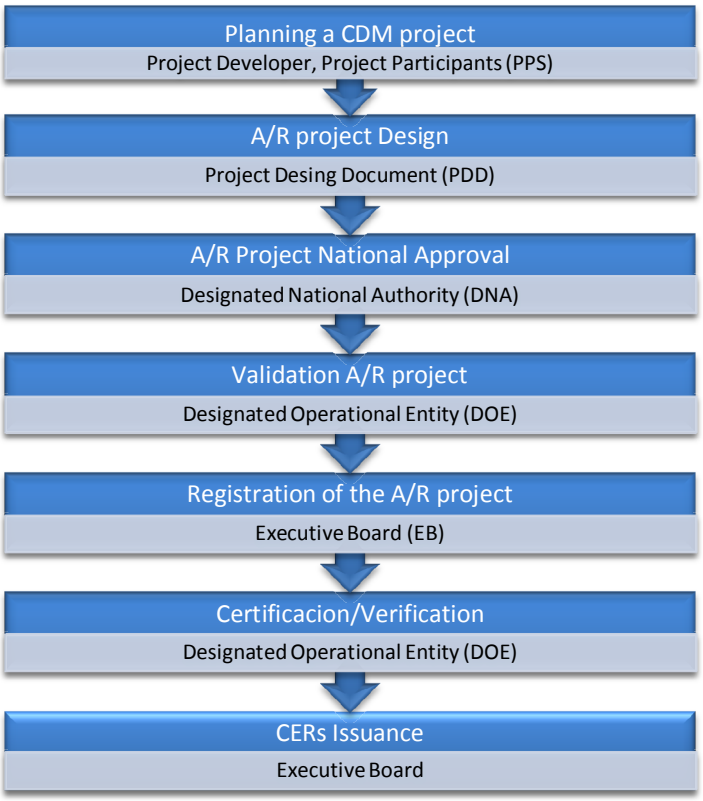
2. **Validation of the CDM A/R project activity.** The Designated Operational Entity (DOE) after revising the Project Design Document emits a validation document that certifies the sustainable component of the project among other important issues.

3. **Registration of the A/R CDM project activity.** The Executive Board formally accepts the validated project as an A/R CDM project activity.

4. **Certification/ Verification of the A/R CDM project activity.** The Designated Operational Entity periodically verifies the reduction of GHG emissions that have occurred under the registered A/R project activity.

In Figure 6, a CDM project cycle for Afforestation and Reforestation projects is illustrated, indicating the activity and the entity in charge of each step.

Figure 6: Afforestation / Reforestation Projects Cycle



The time for the approval of every step is dependent on the type of project, the country where the proposal is being done and the DOE.

COSTS AND FEES OF CDM PROJECTS

The costs can have big fluctuations and variations according to the size, location and type of project. In the same way, for large scale and small scale projects, the costs are higher during the pre-implementation phases (planning and design).

For all projects presented to the EB there are intrinsic fees besides the implementation and operational costs. As reported in Neeff and Henders (2007), a standard large scale A/R project could have the following fees: Project preparation (Consultancy Company: US$ 60.000-180.0000) + Validation (DOE: US$ 15.000- 25.000) + Registration fee (EB, for the first 15.000 CERs costs US$ 0,10/CER and above costs US$ 0,20/CER) + monitoring costs + verification (US$ 15- 25.000) + issuance fees + taxes (in some countries, in Brazil this has not been regulated).

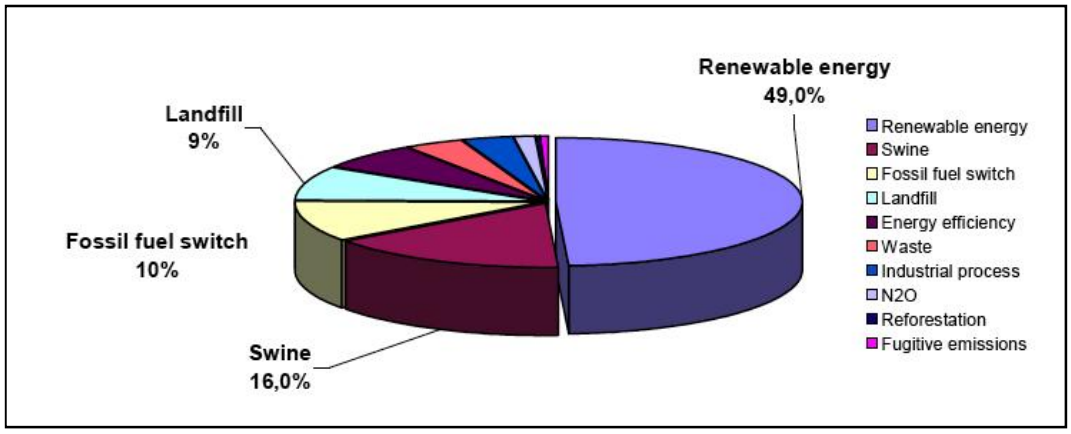
For A/R projects the transactional cost reported is US$ 30.000 - 70.000, for a US$5/t$CO_2$eq (Fox *et al.*, 2007). Other scientists in Brazil like May *et al.* (2010) reported an average of US$ 150.000 for each project.

For small-scale projects or any project with less than 15.000 tCO_2eq there is no fee for the first crediting period, later on, a fee will be calculated to cover administrative costs (MCT, 2009). Implementation and execution costs are additional.

CDM AND LULUCF PROJECTS IN BRAZIL

The majority of the CDM projects developed in Brazil correspond to the energy sector (Figure 7). Contradictory to the fact that the principal source of GHG emissions in Brazil are the agricultural sector (25%) and land use activities (56%) the majority of CDM projects are being developed in the energy sector (Teixeira *et al.*, 2006). Both together represent the 81% of the country profile emissions, while energy sector CDM projects account for almost 90% of the projects being undertaken in Brazil (UNFCCC, 2009). A/R projects are especially important for the rural development of Brazil and can be key for the sustainable development for local communities in a long-term base (Teixeira *et al.*, 2006).

Figure 7: Projects by Sectoral Scope in Brazil (UNFCCC, 2009)



Nowadays, only in Rio de Janeiro State there are 12 CDM projects in pipeline: energy efficiency own generation (2), fossil fuel switch (1), fugitive (1), hydro (3), landfill gas (3), methane avoidance (1) and wind energy (1) (Fenhann, 2009). However, as already stated none of them is in the CDM forestry sector.

According to the UNFCCC (reviewed on May 8th, 2010) the proposed projects are shown in Table 6.

Table 6: Proposed A/R projects in Brazil

Project Title	Methodology	Reduction (t CO_2eq /year)	Status
AES Tiete Afforestation/ Reforestation Project in the State of Sao Paulo, Brazil.	AR-AM0010 ver.3	172.086	Corrective action or clarification has been requested.
Electricity generation from renewable sources ï Sykué I Thermoelectric Power Plant.	AM0042 ver. 2	64.878	Corrective action or clarification has been requested.
Reforestation as Renewable Source of Wood Supplies for Industrial Use in Brazil.	ARAM005 ver. 1	101.714	Letter of Approval from Party (ies) awaited and Project activity has later been republished for global stakeholder consultation.
Thermoelectric Power Plant of 20MW driven by biomass originating from recently-planted energy forest dedicated to the project ï UTE RONDON II	AM0042 ver. 2	102465	Validation activities are still ongoing.

Half of the presented projects combine mitigation from GHG from the energy sector with reforestation activities. And all of them represent projects from the industry sector with commercial finalities.

OTHER MITIGATION PROJECTS IN BRAZIL

Carbon mitigation projects in Brazil have a long trajectory. The first approaches started in 1998, after the signature of the Kyoto Protocol. In Table 1, a resume of the main A/R projects developed in Brazil are shown. The table also contains information about the principal social and economical impacts. Lately, for Rio de Janeiro State, 8 mitigation projects have been reported under voluntary actions (May *et al.*, 2010).

Table 7: Carbon Mitigation projects developed in Brazil and the main reported impacts

Project Name	Project Developer	Place	Focus	Investment Funds	Duration	Area	Carbon Sequestration	Environmental and Social Impacts
Peugeot Carbon Sink Project / Poço de Carbono	Peugeot support by Office National de Forêt (ONF) and Pró-Natura International (PNI)	Juruena, Mato Grosso State	Commercial	Peugeot	1999-2004	2.000 ha	500.000 t C	• The original 5.000 ha that were planed had to be reduced to 2000, since the attempt to apply 5000 L Roundup (Pesticide) in 1500 ha to kill *Bachiaria decumbens* didn't worked well. That also cause low native species seedlings resistance and finally the rest was controlled using manual methods • Important scientific knowledge about native flora and fauna. • Support to local reforestation projects • Use of local man power and other indirect economic benefits. • Some environmental education (schools visits) • Support to local farmers in agro forestry projects using Teca (*Tectona grandis*), wood species and native fruit species
Ação Contra Aquecimento Global (ACAG)	Sociedade de Pesquisa em Vida Selvagem e Educação Ambiental (SPVS) and The Nature Conservancy (TNC)	Área de Proteção Ambiental (APA) de Guaraqueçaba, Paraná State. Mata Atlantica.	Conservation	American Electric Power (ACP), General Motors (GM), Chevron Texaco	1998- No Data	6300 ha protected forest 712 ha pastureland reforested	1 m t C	• Knowledge generation (flora and fauna) • Reforestation and carbon sequestration • Environmental awareness • Support to organic banana projects • Local man power • NGO´s discussion about carbon sequestration projects • Local schools libraries implementation
PLANTAR	PLANTAR S.A	Felixlandia e Curvelo, Minas Gerais State.	Commercial	Prototype Carbon Fund (PCF), World Bank	No data	23100 ha reforested with eucalyptus and 478 ha native forests	3,5 m tC	• Carbon sequestration and GHG emissions avoidance • Difficulties to demonstrate eligibility of lands • Possible reduction of pressure of native forests • Use of pesticides (Glifosato) and fertilizers • Low inclusion of adjacent communities • Land tenure concentration • Local man power • Indirect economic benefits
Bananal Island Carbon Sequestration Project (BICSP)	Ecológica Assessoria	Tocantis State.	Development	AES Barry Foundation	1999- No Data	200.000 ha conservation of primary forest 50.000 ha forest regeneration 3.000 ha agroforestry projects	35 m t C	• Scientific knowledge generation about native flora and fauna • Training and small business creation: handicrafts, tourism, cosmetics. • Environmental education • Local man power • No inclusion of small and medium farmers. • Partnerships with local and regional institutions never were achieved, reducing the impact of the project.

Emas-Taquari Bio Corridor Carbon Project	Oréades Geoprocessing Center with support of Conservation International and Créades	Goiás and Mato Grosso do Sul States.	Conservation and Development		Undergoing	681 ha	236,845.74 tCO2	• Participatory diagnosis and native species recognition and breeding. • Local population involvement and use of local man power. • Carbon sequestration and the implementation of a bio corridor, besides the improvement of the buffer zones of the Emas National Park. • Training and experience gained with the use of native species for reforestation processes.
Monte Pascoal ï Pau Brasil Ecological Corridor	Instituto Bioatlantica and The Nature Conservancy	Itabela, Bahia State.	Conservation		2009-undergoing	17.4 ha	5044.61 tons CO2	• Restore the connectivity between national parks and conservation of biodiversity. • Local man power • Support community associations • Education and capacity building
Genesis Forest Project	Instituto Ecológica	Tocantis State.	Conservation and development	Hyundai through Carbonfund.org	2009 -	130 ha	61.377 tCO2	• Reforestation with native Cerrado species • Local man power • Aims to support the local fire brigade and promote capacity building and environmental education.
The Juma Sustainable Development Reserve Project	Amazonas Sustainable Foundation	Amazonas State.	Conservation and Development	Marriott International, Inc.	2006 -	329.483 ha	189.767.029 tons CO2	• The plans are to install create schools, provide medical support, install solar energy, water supply. • Local man power • Forests and biodiversity conservation

3.3 ENVIRONMENTAL OPPORTUNITIES AND THREATS FROM LULUCF PROJECTS IN BRAZIL

Despite the emphasis of the agreements of the Kyoto Protocol for the need to build projects that lead the host countries to the sustainable development, efforts are not enough. There are several considerations that need to be discussed and defined. One of them is the definition of sustainable development that still remains undefined as well as the methodology its appliance in LULUCF projects.

To demonstrate the ambiguous of procedures related to sustainable development, the Decision 11/COP.7 can be use as an example: (e) é (LULUCF) ñContributes to the conservation of biodiversity and sustainable use of natural resourcesò or (f) ñforest management is é fulfilling é ecological, economic and social functions of the forest in a sustainable mannerò. Unfortunately all these approaches could be considered invalid, unless they are well defined and can be measure.

One of the main issues in the last decade meetings (especially Marrakesh Accords) brought to discussion the necessity to solve these uncertainties and to measure its effects (Madlener *et al.*, 2006). As Paulsson (2009) points out ñthe current structure of the CDM leads to focus on cheap emissions reductions at the expense of sustainable development benefits for the host countriesò.

ECOLOGICAL CONSEQUENCES

Mitigation of GHG can lead to significant environmental benefits related to the global climate change. This international approach can combine the sequestration of carbon and the conservation of important high diversity areas that provide many ecological goods and services worldwide. However, as Jackson *et al.* (2005) and Persson and Azar (2007) argument the LULUCF could be not taking into account the environmental (and social) connotations.

Plantations (monocultures), one of the most promoted forms of carbon sequestration under the CDM, can have negative implications in soil fertility, nutrient availability and increasing acidity (Jackson *et al.*, 2005). In addition, Jackson *et al.* (2005) exposed that the high probability of important ecological shifts in absence of carefully policies. Uncontrolled afforestation and reforestation projects can cause changes in stream flow, renewable water especially because plantations have a high water demand. In the same way, other researchers as Farley (2004) demonstrated how exotic plantations as

pines and eucalyptus lead to soil degradation, water retention and soil organic carbon losses.

There are several initiatives like Pronaf Florestal, (promoted by the Institute for Technical Assistance and Rural Expansion of the Rio de Janeiro State, EMATER) to plant *Eucalyptus* on hillsides and demoted soils (Xiromeriti, 2009). In Brazil most of the current studies for CDM projects centered efforts in exotic plantations of species like: rubber tree, oil palm, teak, eucalyptus (Vliet *et al.*, 2003) for commercial benefits. Principally because of the rapid rotation rates under humid tropical conditions (Seroa da Motta *et al.*, 2000). The nature of the proposals depends on the business possibilities to cover the costs, rather than on the ecological and social benefits that trade can bring. Possibly for that reason, exotic wood monocultures are promoted indirectly.

On the other hand, there are approaches like the Costa Rican (Redondo-Brenes, 2007) that shows how tropical native tree plantations can ñserve diverse economic, social, and ecological functionsòand act as a good sinks of carbon emissions. Supplementary, Jackson *et al.* (2005) showed how contrary to monoculture, reforestation projects with native species, could have positive benefits over water quality and supply. Native forests can help to the maintenance of ñbiodiversity, hydrological cycle, soil conservationò (Carvalho *et al.*, 2004), biogeochemical cycles and other important ecological processes. Authors like Tschakert *et al.* (2007) have gone further demonstrating the necessity to incorporate a ñholisticò approach in carbon management that combines: GHG, economic aspects, ecological and environmental criteria, and social issues. Agro forestry and sustainable agricultural practices under the Kyoto Protocol can be also seen as positive approaches to enhance soil quality and conservation (Montagni and Nair, 2004; Roshetko *et al.* 2007; Canadell, 2002).

RESULTS AND DISCUSSION

In the following section, the results of the present study are presented. They were developed according to the methodologies previously offered.

4.1 POTENTIAL AREAS AND LULUCF PROJECTS METHODOLOGIES

One of the key issues regarding Afforestation and Reforestation (A/R) projects has been to determine potential land available for mitigation projects, making this one of biggest challenges (Sudha *et al.*, 2007; Wilson *et al.*, 2009). Despite the fact that free available low resolution LANDSAT images can be good enough for determine areas for A/R projects, processing the images can be very difficult. Indeed, georeferecing and geoprocessing and land use classification phases require trained experts, costly software and some basic actual land coverage data of the area.

In the subsequently segment, analysis of the eligible lands for LULUCF projects is presented. The spatial research was done according to the already documented methodological proceedings.

ELEGIBLE LANDS

The eligible lands were selected according to the "Procedure for Demonstrating the Eligibility of Lands for Afforestation and Reforestation CDM Project Activities"[8]; however, not all requirements were accomplished. And also choose in base to the obtained data from the interpretation of the satellite images; and later on with the comparison to the actual land use maps in Cachoeiras de Macacu.

In Table 8, the results of the land cover classification for Cachoeiras de Macacu in year 1985 are presented.

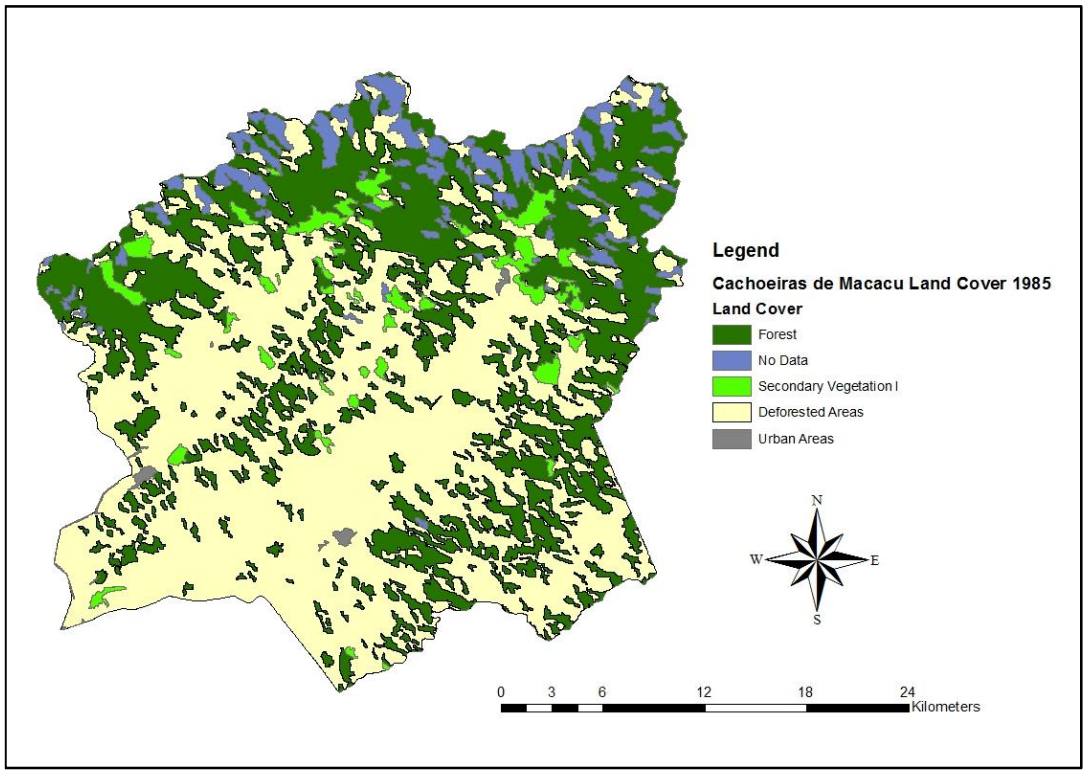
[8] "Procedures to Demonstrate the Eligibility of Lands for Afforestation and Reforestation CDM Project Activities" (Available at: http://cdm.unfccc.int/methodologies/ARmethodologies/Tools/methAR_proc02_v01.pdf)

Table 8: Land Cover Class for Cachoeiras de Macacu in year 1985.

Land Cover Class	Area (km^2)	Percentage (%)
Forest	330,30	34,62
Secondary Vegetation	33,78	3,54
Deforested	536,02	56,19
Urban Areas	2,90	0,30
No Data	50,89	5,34

According to the spatial analysis, 536 km^2 could be suitable for LULUCF projects. In Figure 8, the suitable land for LULUCF projects in Cachoeiras de Macacu according to the land cover classification of 1985 is presented. These potential areas mainly represent lands under actual agricultural and pasture.

Figure 8: Suitable Lands for LULUCF projects in Cachoeiras de Macacu according to the Land Cover Classification of 1985 (LANDSAT 5TM, 1985; INPE)



SUITABLE LANDS FOR AFFORESTATION AND REFORESTATION PROJECTS

Following the CDM Procedure, suitable lands for A/R are those that did not contain forest for at least 30 years and remain deforested. For afforestation projects, there are difficulties in demonstrating that these areas where deforested for more than 50 years. The analysis should include the processing of images (aerial) and land cover maps of the 60s-70s. Because of this complexity and the low probability to find sufficient suitable lands, afforestation projects have been excluded of the present analysis.

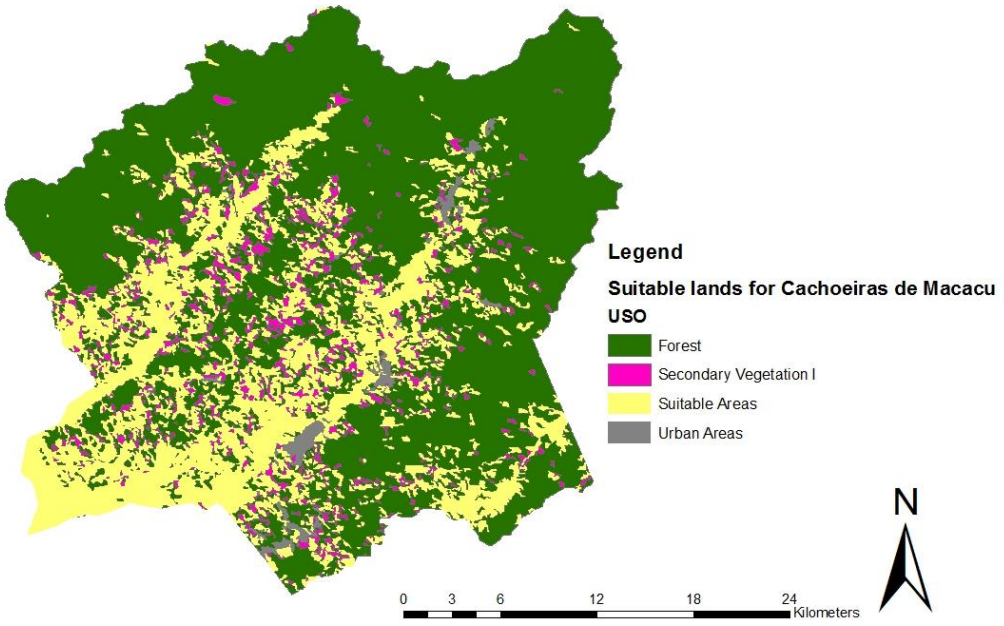
In the case of reforestation projects, the Procedure recommends areas that have been deforested before December 31 of 1989. In the last years, important areas in Cachoeiras de Macacu have been reforested, especially lands that correspond to the National Park Três Picos and REGUA. The actual forest area corresponds to 622 km^2 as shown in Table 9 and presented in Figure 9.

The Suitable areas include agricultural and pasture lands, exposed soil lands and could also include some water bodies.

Table 9: Land cover for Cachoeiras de Macacu in year 2007, and suitable areas for LULUCF projects.

Land Cover 2007	**Area (km^2)**	**Percentage (%)**
Forest	622	65,13
Secondary Vegetation I	56	5,86
Suitable Areas for LULUCF	264	27,64
Urban Areas	13	1,36

Figure 9: Land cover map of Cachoeiras de Macacu in year 2007, showing suitable lands for LULUCF projects (INEA, 2007).



The majority of the Suitable Areas are located in the basin of the Macacu and the Guapiaçu rivers. Afforestation and Reforestation modalities under the CDM are the only ratified methodologies. Therefore, just A/R project activities could be developed in the mentioned suitable areas.

POTENTIAL LANDS FOR REVEGETATION LULUCF PROJECTS

The methodologies for Revegetation LULUCF CDM projects haven't been approved yet. However, in the hope of a future scenario of the inclusion of a wider variety of other modalities under the CDM, the suitable lands for Revegetation were also computed. The assessment of the suitable areas for Revegetation projects was done by comparing the deforested lands (according to the land cover classification of 1985) to areas covered with secondary vegetation (according to land cover classes of 2007).

Demonstration of eligible lands can become even more complicated for areas that today represent secondary forests. According to the procedure eligible lands for

Revegetation projects have to be below the limit of the forest definition by the Brazilian Designated National Authority. For the Brazilian DNA the minimum selected values for A/R projects activities (Resolução No.2, 10-08-2005, Art. 3; CIMGC, 2009), are:

- A single minimum tree crown cover value between 10 and 30 %;
- A single minimum land area between 0,05 and 1 ha;
- A single minimum tree height value between 2 and 5 m;
- A/R project activities do not include Palm trees and Bamboos.

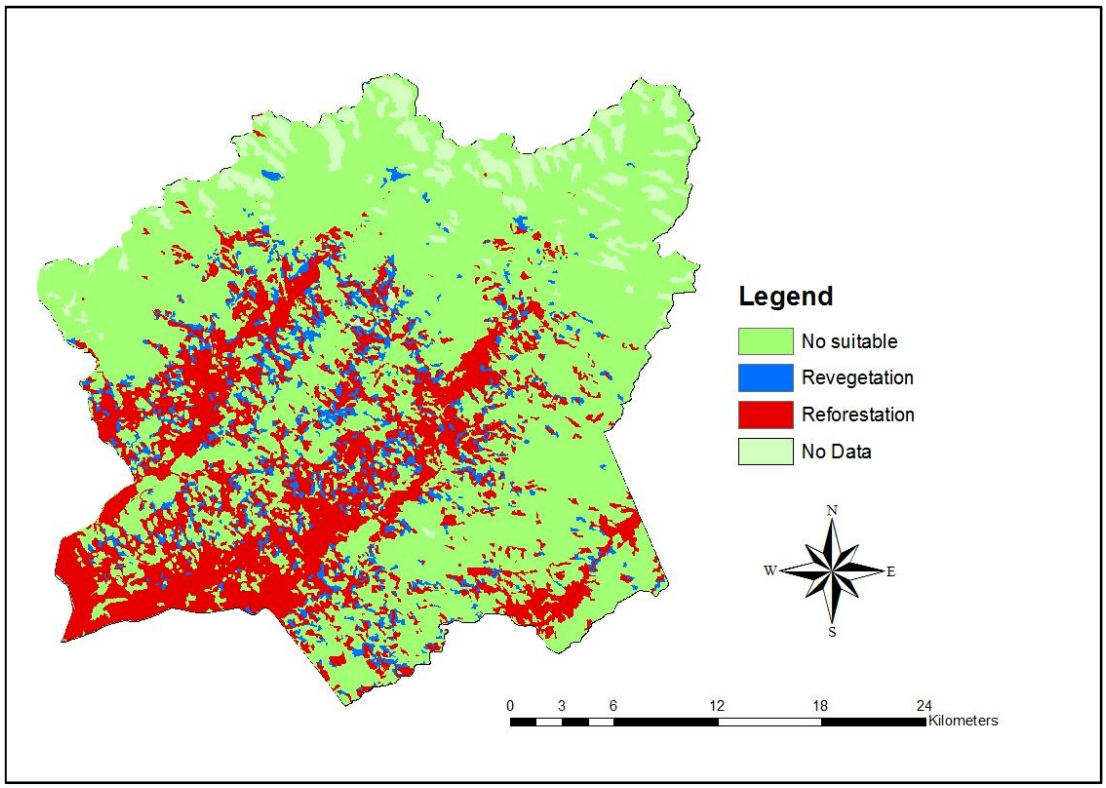
In the present study these definitions have not been taken into account because of the difficulties to measure this information for the total area. The results here presented show areas that contain secondary forest where possibly Revegetation CDM could be realized (if the methodologies are approved). Data has to be corroborated.

In Table 10, the suitable areas for Revegetation projects are presented and also available lands for reforestation projects.

Table 10: Suitable lands for Revegetation and Reforestation CDM projects in Cachoeiras de Macacu

Potential LULUCF	**Area (km^2)**
No suitable	611
Revegetation	59
Reforestation	234

Figure 10: Map showing the location of the Potential Areas for revegetation and reforestation projects (INPE, 1985; INEA, 2007).



The 59 km^2, where Revegetation CDM projects could be done is so small and disperse, that a project under these not yet approved methodology, probably would not justify the investment.

ELIGEBLE LANDS FOR A/R PROJECTS IN PROTECTED AREAS

Any kind of A/R project that will be implemented in protected areas, national parks or reserves, that by law are protected or should be reforested, will face important problems to demonstrate its additionality. This is especially true in Brazil for the APPs or Permanent Preservation Areas and Legal Reserve Forest Areas.

APPs are lands inside private rural properties that by law have to be kept free of any extractive activity for the conservation of native vegetation. The aim is to protect soil and water resources and serve as biodiversity corridors (EMATER, 2007). According to the Atlantic forest law for Rio de Janeiro (Mata Atlantica Law: Lei da Mata Atlântica, No. 11.428 (22/12/06) and the state law for economic-ecologic zoning: Lei Estadual de

Zoneamento Econômico- Ecológico, No. 5.067 (09/07/07)) (Presidência da República, Casa Civil, Subchefia para Assuntos Jurídicos, available at: http://www.planalto.gov.br/ccivil_03/) the following percentages of each rural property will be dispose for creation of Permanent Protected Areas (APP, Areas de Preservação Permanente) with native species of Atlantic forest (EMATER, 2007):

- A protection area along rivers: for small water courses of less than 10 meters a marginal buffer zone of 30 meters and up to 500m of any water course with a length of more than 600m.
- A minimal area of 50 m around lakes, lagoons and natural or artificial water reservoirs.
- A minimum radio 50 m for any water spring.
- One third of the top of mountains, mountain ranges and hills with a higher altitude of 50 m.
- Slopes with an inclination of more than 45 degrees.
- Any property above 1.800 m above sea level.

Legal Reserve Forest Areas or RFL (Areas de Reserva Florestal Legal) are areas of minimum 20% of any rural property (excepting the APP areas) for conservation where activities as sustainable forestry management and selective wood extraction can be done (EMATER, 2007).

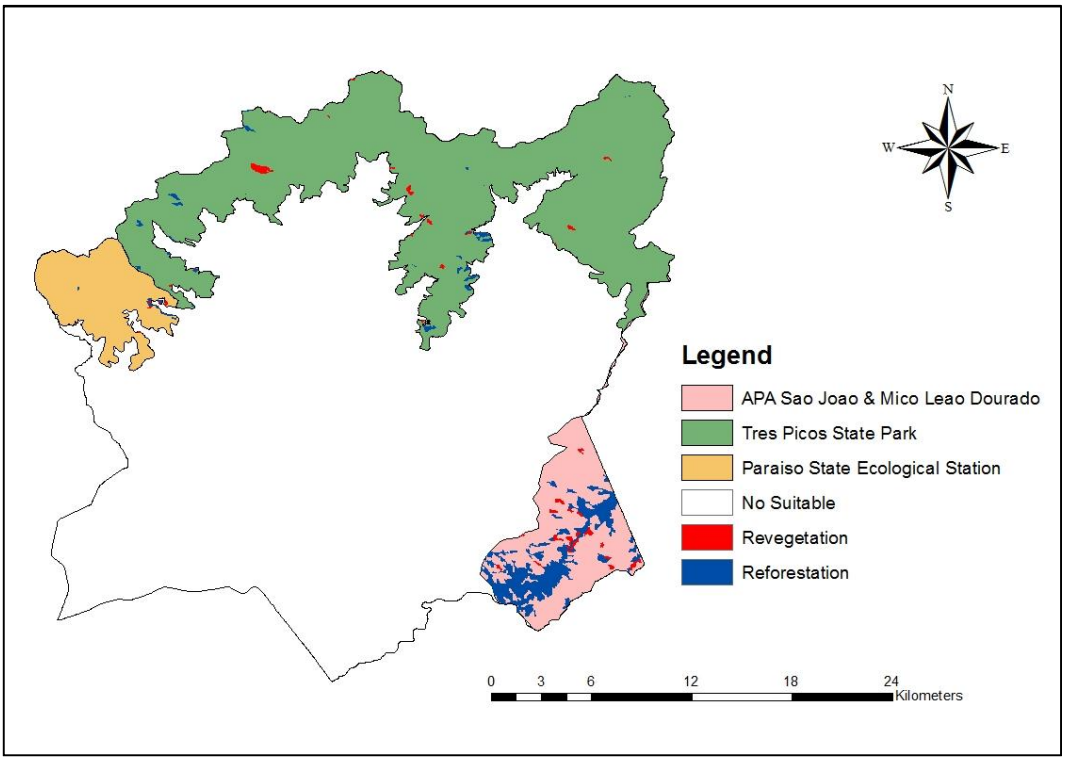
APPs and Legal Reserve Forest Areas have not been taking into account in the present analysis. Difficulties to obtain the spatial information, uncertainties about the locations of RFL and the future creation of the APA of the Macacu River will change the scenarios. Nevertheless, the suitable areas for Reforestation projects in Protected Areas were calculated (refer to Figure 11 and to Table 11 for the corresponding areas).

To facilitate the analysis, the APA of the Macacu River was excluded. Consequently, the protected areas considered in the current analysis are: the Três Picos State Park (222 km^2 located in Cachoeiras de Macacu), the Paraiso State Ecological Station (36 km^2 in the municipality) and the São João Watershed and Golden Tamarin Environmental Protection Area (61 km^2 of extension in Cachoeiras de Macacu).

Table 11: Reforestation and Revegetation suitable Areas for LULUCF projects in Protected Areas.

CDM LULUCF Modality	**Area (km^2)**
Revegetation	2,76
Reforestation	16,29

Figure 11: Map showing the suitable areas in Cachoeiras de Macacu for Reforestation LULUCF CDM projects in Protected Areas (INPE, 1985; INEA, 2007)



The São João Watershed and Golden Tamarin Environmental Protection Area contain the majority of the suitable areas for Reforestation projects. However, as already pointed out, demonstration of additionality can be difficult. For the other two areas, Três Picos State Park and Paraiso State Ecological Station the implementation of a Reforestation project under the CDM could not justify the investments. A CDM reforestation project could be very expensive and have low return.

POTENTIAL AREAS IN THE MUNICIPALITY OF CACHOEIRAS DE MACACU FOR LULUCF PROJECTS, RESULTS AND DISCUSSION

According to the results from the spatial analysis, deforested areas correspond to 536 km^2 in 1985 and the final computation for suitable areas for LULUCF projects are 264 km^2. The difference could be a result of the increment of the forest areas in the municipality. The forested area increased from 330 km^2 in year 1985 to 622 km^2 in 2007. In the same way, secondary vegetation also increased from 33 km^2 (1985) to 56 km^2 (2007).

In the next section an analysis of the methodologies that could be applied in the areas is presented.

LULUCF METHODOLOGIES APPLICABLE IN THE MUNICIPALITY OF CACHOEIRAS DE MACACU

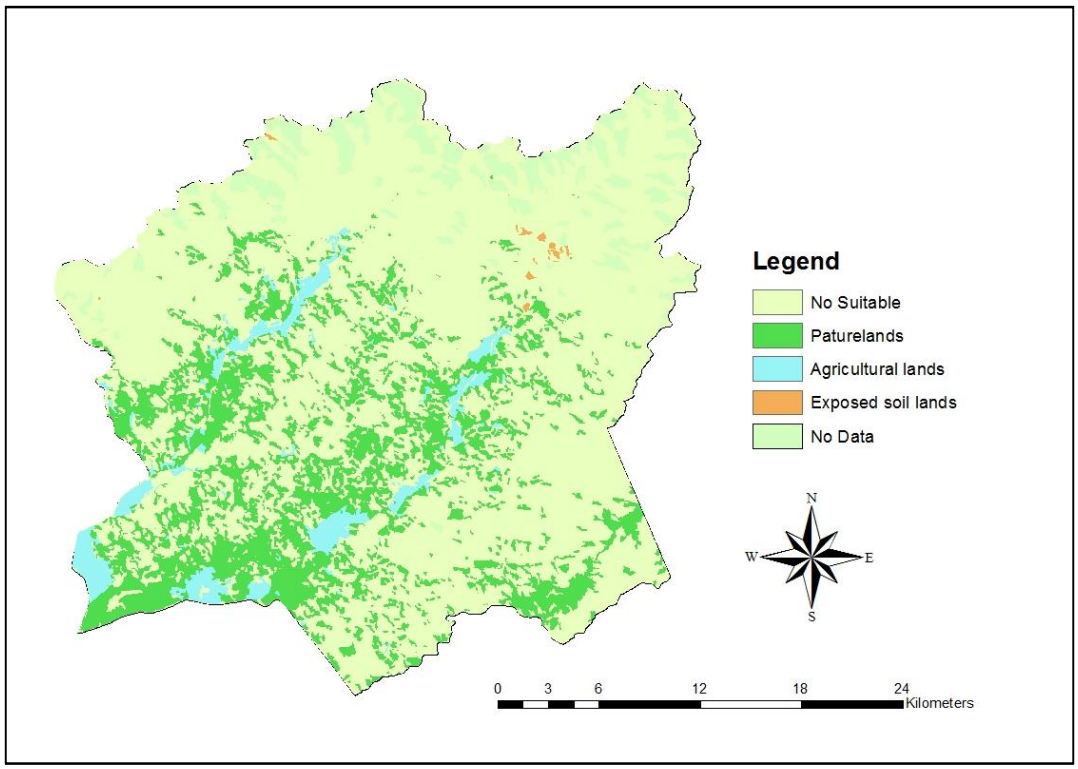
The high fragmentation of the landscape in Cachoeiras de Macacu remains the necessity to integrated sustainable actions that integrate the environment with the social-economical and institutional dimensions.

According to the previous classification of suitable areas, the majority of the potential areas for CDM LULUCF projects are today under use as pasturelands, as shown in Table 12 and presented in Figure 12.

Table 12: Suitable LULUCF lands and actual land use (2007)

Land Use 2007	**Area (km^2)**
Pasturelands	194,32
Agrolands	36,47
Exposed Soil	1,49
No Suitable	670,72

Figure 12: Actual land use of Suitable lands for Reforestation projects under the CDM (Based on data from INEA, 2007).



In the next section an analysis of the approved large-scale and small-scale afforestation and reforestation methodologies is presented. The Tables 13 to 29 contain data about the requirements for their applicability and the principal points of awareness. For all LULUCF projects the use of native species should be encouraged.

All the methodologies now presented consider that all potential areas are degraded. The definition of degraded land has all to be carefully managed according to the LULUCF Procedures (CIMGC, 2008). Also, special attention needs the projects that will use nitrogen fixing species and/or fertilizers.

LARGE-SCALE METHODOLOGIES

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented in reforestation of degraded lands is presented in Table 13.

Table 13: AR-AM0001, Reforestation of degraded lands

CODE	AR-AM0001		
NAME	Reforestation of degraded land		
Ver	3		
Scale	Large		
Base	Facilitating Reforestation for Guangxi Watershed Management in Pearl River Basin, China		
Selected Carbon Pools	Above ground and below ground		
Applicability /Awarness	No shifting of pre-project activities (same amount of goods and services);	X	Subject to the price tC/ha
	Sever degraded land;	Ok	
	Environmental conditions and human-caused degradation do not permit the encroachment of natural forest vegetation;	Ok	
	Direct planting/seedling;	Ok	
	Site preparation no significant long term emissions from soil carbon;	Ok	Slash/burn practices should be avoid
	Plantation will be harvest (short & long rotation) & regenerated by planting or natural sprouting;		Should be encouraged the use of native species. Dependent on the Silviculture zoning map for Rio de Janeiro State.
	Decrease erosion and human intervention or increase less in the absence of the project;	Ok	Specially if Atlantic Forest species are used
	Grazing will not occur within the project boundary in the project case.		Could cause some inconveniences for projects developed in big farms. Is dependent on the project.

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented in reforestation of degraded lands through A/R activities is presented in Table 14.

Table 14: AR-AM002, Restoration of degraded lands through Afforestation and Reforestation

CODE	AR-AM0002		
NAME	Restoration of degraded lands through A/R		
Version	2		
Scale	Large		
Base	Moldova Soil Conservation Project		
Selected Carbon Pools	Above and below ground, dead wood, litter, soil organic carbon		
Applicability	Does not lead to a shift of pre-project activities outside the project;		Agricultural and pasture activities could be shifted.
	Lands to be reforested are severely degraded and still degrading;	Ok	
	Environmental conditions or anthropogenic pressures do not permit significant encroachment of natural tree vegetation;	Ok	
	Grazing will not occur within the project boundary in the project.		Could cause some inconveniences for projects developed in big farms. Depends on the project.

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented in lands under current agricultural use is presented in Table 15.

Table 15: AR-AM004, Reforestation or Afforestation of lands under agricultural use

CODE	AR-AM0004		
NAME	A/R of land currently under agricultural use		
Version	3		
Scale	Large		
Base	Reforestation around Pico Bonito National Park, Honduras		
Selected Carbon Pools	Above and Below ground		
Applicability	Soil drainage and disturbance are insignificant, so that non CO_2-GHG emissions from these types of activities can be neglected;	Ok	
	A/R of degraded land, degrading or in a low carbon steady state, through assisted natural regeneration, tree planting, or control of pre-project grazing and fuel-wood collection activities;	Ok	
	The amount of nitrogen-fixing species (NFS) used in the A/R CDM project activity is not significant;		Especially problematic in areas with high soil degradation
	The A/R CDM project activity is implemented on land where there are no other on-going or planned A/R activities;		Limits the possibility to include areas considered as priority for reforestation or any protected area
	The project activity can lead to a shift of pre-project activities outside the project;		Some farmers could have some interest in A/R projects. Problematic in areas under current agro-pastoral use. And will depend on the price tC.
	Site preparation does not cause significant longer-term net decreases of soil carbon stocks or increases of non-CO_2 emissions from soil;		Slash/burn cannot be applied.
	Carbon stocks in soil organic carbon, litter and dead wood can be expected to further decrease due to soil erosion and human intervention or increase less in the absence of the project activity;	Ok	
	Flooding irrigation is not permitted	Ok	Could be managed

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented for industrial and/or commercial use is presented in Table 16.

Table 16: AR-AM005, A/R project activities for industrial and/or commercial uses.

CODE	AR-AM0005
NAME	A/R project activities implemented for industrial and/or commercial uses
Version	3
Scale	Large
Base	Reforestation as Renewable Source of Wood Supplies for Industrial Use in Brazil

Selected Carbon Pools	Above and below ground		
Applicability	A/R activities undertaken to meet commercial or industrial needs on grasslands, with low soil carbon content;	Ok	Dependent on the Silviculture zoning map from Rio de Janeiro State.
	Land cover within the project boundary is in steady state as grassland;	Ok	
	Natural regeneration is not expected to occur because of the absence of seed sources or land use practices do not permit;	Ok	
	Lower soil carbon under grassland compared to plantations or secondary forests can be expected under tropical conditions;	Ok	Should be encouraged the use of native species. Dependent on the project.
	Flooding irrigation is not permitted;	Ok	Could be managed.
	Soil drainage and disturbance are insignificant;	Ok	
	The amount of nitrogen-fixing species (NFS) used in the A/R CDM project activity is not significant.		Could be difficult to prepare the soils that are highly degraded.

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented on degraded lands with trees supported by shrubs is presented in Table 17.

Table 17: AR-AM006, A/R with trees supported by shrubs on degraded land

CODE	AR-AM0006		
NAME	A/R with Trees Supported by Shrubs on Degraded Land		
Version	2		
Scale	Large		
Base	Afforestation for Combating Desertification in Aohan County, Northern China		
Selected Carbon Pools	Above, below ground and soil organic carbon		
Applicability	Lands to be afforested/reforested are severely degraded and the lands are still degrading or remain in a low carbon steady state;	Ok	
	The project activity does not lead to displacement of production of goods or delivery of utilities;		Dependent on tC/ha prices. Can lead to conflicts in croplands or pasturelands.
	Environmental conditions and human-caused degradation do not permit the encroachment of natural forest vegetation;	Ok	
	Lands will be afforested/reforested by direct planting or seeding, with trees/shrubs complying with the minimum thresholds for the forest definition by the DNA;	Ok	Could be applicable
	Inter-cropping between rows of trees/shrubs is allowed in the project activity and will then be included in the monitoring;		Requires technical knowlege
	Nitrogen-fixing species are allowed to be used;	Ok	
	Plantation may be harvested with either short or long rotation and will be regenerated either by direct planting or natural sprouting;	Ok	Native species plantations should be encourage
	Carbon stocks in litter and deadwood can be expected to decrease more or increase less in the absence of the project activity, relative to the project scenario;	Ok	

	Grazing will not occur within the project boundary in both the project case and baseline scenario;		Problematic in big farms with long tradition of pecuary activities.
	Site preparation and intercropping may cause a significant long-term net emission from soil carbon;		Depends on the project.
	If the proposed A/R CDM project activity produces forage to feed livestock, all forage shall have a similar nutritional value and digestibility, and will support only a single livestock group with a single manure management system;		Depends on the project activities.
	Biomass burning for site preparation is not practiced.		Could be problematic because of the tradition to use slash and burn practices.

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented in lands under current agricultural or pastoral use is presented Table 18.

Table 18: AR-AM007, A/R of land currently under agricultural or pastoral use[9]

CODE	AR-AM0007		
NAME	A/R of Land Currently Under Agricultural or Pastoral Use		
Version	5		
Scale	Large		
Base	Chocó-Manabí Corridor Reforestation and Conservation Carbon Project		
Selected Carbon Pools	Above and below ground (depending on the project litter, dead wood, and SOC).		
Applicability	Afforestation or reforestation activities undertaken on agricultural or pastoral lands.	Ok	
	The establishment of the project occurs after a period of decreasing intensity of agricultural and pastoral activities and it may be expected that the trend would be continued in the absence of the project activity.		As previously stated, Cachoeiras de Macacu has a tendency to increase agricultural and pastoral activities. Data for 2001 show a decrease in agricultural activities but an increase on pastoral activities. This fact has to be analyzed for a specific case.
	Soil organic carbon pool may be conservatively neglected in the proposed A/R CDM project	Ok	
	Flooding irrigation is not applied	Ok	

[9] **INDICATORS:** AGRICULTURE * Total production of crops collected from the planned project area has decreased by at least 30% during five years preceding the validation year; *Area cultivated within the planned project boundary has decreased by at least 30% during five years preceding the validation year. PASTORAL *The annual average number of animals present in the planned project area when expressed using the common livestock unit used in the host country has decreased by at least 30% during five years preceding the validation year.

	The pre-project crown cover of trees within the project boundary is less than 20% of the threshold for crown cover reported to the EB by the host Party.		Depends on the project.

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented on degraded lands for suitable wood production is presented in Table 19.

Table 19: AR-AM008, A/R on degraded land for suitable wood production

CODE	AR-AM008		
NAME	A/R on degraded land for sustainable wood production		
Version	3		
Scale	Large		
Base	Reforestation on degraded land for sustainable wood production of woodchips in the eastern coast of the Democratic Republic of Madagascar		
Selected Carbon Pools	Above and Below ground		
Applicability	Lands to be afforested or reforested are degraded;	Ok	
	The application of the procedure for determining the baseline scenario in Section II.4 leads to the conclusion that baseline approach 22(a) [existing or historical changes in carbon stocks in the carbon pools with the project boundary] is the most appropriate choice for determination of the baseline scenario, and that the land would be expected to remain degraded in the absence of the project activity;		Depends on the project
	The project activity does not lead to a shift of pre-project activities outside the project boundary;		Dependent on pre-project activities. Can result in conflict with crop and pasturelands.
	Environmental conditions and human-induced degradation prevent the encroachment of natural forest vegetation;	Ok	
	Biomass of non-tree vegetation is either at steady-state or is decreasing under the baseline land use;	Ok	
	Litter and dead woodð including harvest residuesð are left at the plantation site, and wildfire is not common;	Ok	
	Site preparation involving slash-and-burn practices shall be restricted to non-tree vegetation, and burning shall be carried out in such a manner as to avoid damage to trees existing within the project area at the start of the project;	Ok	
	Grazing shall not occur within the project boundary;		Could be problematic in some areas.
	Site preparation does not cause significant longer-term net emissions from soil organic carbon pool;		Dependent on the project
	Lands to be afforested or reforested are not drained wetlands or organic soils (e.g., peat-lands).	Ok	

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented on degraded lands allowing for silvopastoril activities is presented in Table 20.

Table 20: AR-AM009, Afforestation or Reforestation on degraded land allowing for silvopastoril activities

CODE	AR-AM0009		
NAME	Afforestation or reforestation on degraded land allowing for silvopastoral activities		
Version	4		
Scale	Large		
Base	San Nicolás CDM Reforestation Project		
Selected Carbon Pools	Above and below ground; (alternatively no dead wood, litter, SOM)		
Applicability	The A/R CDM project activity is implemented on degraded grasslands, which are expected to remain degraded without human intervention;	Ok	
	Encroachment of natural tree vegetation that leads to the establishment of forests according to the host country definition of forest for CDM purposes is not expected to occur;	Ok	
	Flooding irrigation is not applied in the project activity;	Ok	
	The project activity does not lead to a shift of pre-project activities outside the project boundary, i.e., the land under the proposed A/R CDM project activity can continue to provide at least the same amount of goods and services as in the absence of the project activity;		Dependent on the prices of tC/ha. Possible conflicts with croplands and pasturelands.
	Site preparation and project management practices shall not involve biomass burning.		Manual practices can be very expensive

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented on unmanaged grasslands in reserve/ protected area is presented in Table 21.

Table 21: AR-AM0010, Afforestation and/or reforestation activities implemented on unmanaged grassland in reserve/ protected areas

CODE	AR-AM0010		
NAME	A/R project activities implemented on unmanaged grassland in **reserve/protected** area		
Version	3		
Scale	Large		
Base	AES-Tiete Afforestation/Reforestation Project Activity Around the Borders of Hydroelectric Plant Reservoirs		
Selected Carbon Pools	Above and below ground		
Applicability	The methodology is applicable only if project proponents can clearly show that baseline approach 22(c) of the CDM Modalities and Procedures ð Changes in carbon stocks in the pools within the project boundary from the most likely land use at the time the project startsð is the most plausible baseline scenario;		Dependent on the project.

	The most likely land use at the time the project starts shall be unmanaged grassland with A/R implemented at a non-CDM baseline forestry rate. This rate may be zero, in which case the most likely land use at the time the project starts is continuation as unmanaged grassland;		Extremely specific and depends on the project.
	The biomass of herbaceous vegetation within the project boundary at the start of the project is at steady-state, or is declining due to competition from woody species, and so baseline removals by herbaceous vegetation can be conservatively neglected;		Depends on the project.
	The soil carbon pool within the project boundary is at steady state at project commencement: that is, the project boundary shall not include areas that within the last 20 years were either severely degraded, or have been used for agricultural cropping for more than 3 years;		Dependent on the project
	Site preparation to afforest or reforest is carried out in such a way as to avoid levels of soil disturbance or soil erosion sufficient to significantly to reduce the soil carbon pool over the project lifetime;	Ok	Could be managed
	The land within the project boundary will be afforested or reforested by direct planting and/or seeding of trees to establish a forest that complies with the minimum forest thresholds advised to the CDM Executive Board by the host country's DNA;	Ok	
	Nitrogen-fixing (N-fixing) trees planted as part of the A/R CDM project activity account for less than 10% of the total planted forest crown area, so nitrous oxide (N_2O) emissions from decomposition of litter from the N-fixing trees can therefore be considered insignificant;	Ok	
	No direct human-induced activities leading to loss of carbon stocks (such as harvesting, selective logging, fuel gathering, removal of litter, or removal of dead wood) shall occur on lands within the project boundary;	Ok	
	Carbon stocks in the dead organic matter pools (litter and dead wood) are expected to be smaller in the absence of the proposed A/R CDM project activity, relative to the project scenario, and therefore accounting of these pools can be conservatively neglected;	Ok	
	Flood irrigation or drainage of primarily saturated soils are not permitted as part of A/R CDM project activities,	Ok	
	If the non-CDM baseline forestry rate is other than zero, the only approach to address non permanence is to claim emissions reductions as tCERs,		Depends on the project
	Land to be afforested or reforested shall comprise unmanaged grassland which is designated as a reserve/protected area, and is not likely to be converted to any other land use except forestry. The grassland may include areas with either a steady-state or slowly regenerating woody cover of shrubs and/or scattered trees. However, the land shall have no potential to revert to forest without direct human intervention (through planting, seeding, or promotion of natural seed sources);	Ok	Could be applied in other protected areas in Brazil.
	The project activity does not lead to a shift of pre-project activities to outside of the project boundary; i.e., the land under the proposed A/R CDM project activity can continue to provide at least the same amount of goods and services as in the absence of the project activity;		Depends on the project.

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented on degraded land is presented in Table 22.

Table 22: AR-ACM001, Afforestation and Reforestation of degraded land

CODE	AR-ACM0001		
NAME	Afforestation and reforestation of degraded land		
Version	3		
Scale	Large		
Base	AR-AM0003 and AR-NM0032-rev		
Selected Carbon Pools	Above and below ground, and alternatively no litter, dead wood and SOC		
Applicability	The A/R CDM project activity is implemented on degraded lands, which are expected to remain degraded or to continue to degrade in the absence of the project, and hence the land cannot be expected to revert to a non-degraded state without human intervention;	Ok	
	Encroachment of natural tree vegetation that leads to the establishment of forests according to the host country definition of forest for CDM purposes is not expected to occur;	Ok	
	Flooding irrigation is not applied in the project activity;	Ok	
	If at least a part of the project activity is implemented on organic soils, drainage of these soils is not allowed and not more than 10% of their area may be disturbed as result of soil preparation for planting;	Ok	
	The establishment of project shall not decrease availability of fuel wood.	Ok	

The CDM Afforestation and Reforestation approved methodology for large scale projects to be implemented on degraded land without the displacement of pre-project activities is presented in Table 23.

Table 23: AR-ACM0002, Afforestation and/or Reforestation of degraded land without displacement of pre-project activities

CODE	AR-ACM0002		
NAME	A/R of degraded land without displacement of pre-project activities		
Version	1		
Scale	Large		
Base	AR-AM0001 and AR-AM0008		
Selected Carbon Pools	Above and below ground		
Applicability	The project activity does not lead to a shift of pre-project activities outside the project boundary, i.e., the land under the proposed A/R CDM project activity can continue to provide at least the same amount of goods and services as in the absence of the project activity;		Dependent on tC prices. Conflicts with agricultural lands and pasturelands can occur.

	Lands to be afforested or reforested are degraded, or degrading and it may be expected that the land would remain degraded in the absence of the project activity;	Ok	
	Environmental conditions and human-caused degradation do not permit the encroachment of natural forest vegetation;	Ok	
	Soil organic carbon pool may be conservatively neglected in the proposed A/R CDM project activity;	Ok	
	Carbon stocks in litter and deadwood can be expected to decrease more due to human intervention or increase less in the absence of the project activity, relative to the project scenario;	Ok	
	Flooding irrigation is not applied in the project activity.	Ok	

SMALL-SCALE METHODOLOGIES

The CDM Afforestation and Reforestation approved methodology for small scale projects to be implemented on unmanaged grasslands or croplands is presented in Table 24.

Table 24: AR-AMS0001, Projects under the CDM implemented on grasslands or croplands

CODE	AR-AMS0001		
NAME	Projects under the CDM implemented on **grasslands or croplands**		
Version	5		
Scale	Small		
Selected Carbon Pools	Above- and below-ground tree and woody perennials biomass and below-ground biomass of grasslands (i.e. living biomass).		
Applicability	Project activities are implemented on grasslands or croplands;	Ok	
	Project activities are implemented on lands where the area of the cropland within the project boundary displaced due to the project activity is less than 50 per cent of the total project area;		Dependent on the project
	Project activities are implemented on lands where the number of displaced grazing animals is less than 50 per cent of the average grazing capacity of the project area;		Dependent on the project
	Project activities are implemented on lands where Ò 10% of the total surface project area is disturbed as result of soil preparation for planting.		Dependent on the project

The CDM Afforestation and Reforestation approved methodology for small scale projects to be implemented on settlements is presented in Table 25.

Table 25: AR-AMS0002, Simplified baseline and monitoring methodologies for Small-scale A/R project activities under the CDM implemented on Settlements[10].

CODE	AR-AMS0002		
NAME	Simplified baseline and monitoring methodologies for small-scale A/R project activities under the CDM implemented on **settlements**.		
Version	2		
Scale	Small		
Selected Carbon Pools	Above and below tree biomass		
Applicability	Implemented on settlements;	Ok	Nevertheless, the possibilities to find available land are extremely low. The COMPERJ will possibly bring many families and man power to the adjacent municipalities like Cachoeiras de Macacu.
	Implemented on lands where areas used for agricultural activities within the project boundary, and displaced due to the project activity, are less than 50% of the total project area;		Dependent on the project
	Implemented on lands where Ò10% of the total surface project area is disturbed as result of soil preparation for planting.		Dependent on the project

The CDM Afforestation and Reforestation approved methodology for small scale projects to be implemented on wetlands is presented in

Table 26.

Table 26: AR-AMS0003, Simplified baseline and monitoring methodology for Small-scale CDM A/R project activities implemented on wetlands

CODE	AR-AMS0003
NAME	Simplified baseline and monitoring methodology for small scale CDM A/R project activities implemented on **wetlands**
Version	1
Scale	Small
Selected Carbon Pools	Above and below biomass of trees

[10] **Indicator**: Transportation infrastructure: Land strips along streets, country roads, highways, railways, waterways, overhead power cables, gas pipelines, provided such land is functionally or administratively associated with the transportation infrastructure and is not accounted for in another land-use category; Human settlements: Residential and commercial lawns (rural and urban), gardens, golf courses, athletic fields, parks, provided such land is functionally or administratively associated with particular cities, villages or other settlement types and is not accounted for in another land-use category.

Applicability	Project activities are implemented on wetlands. The DNA of the host country shall provide a statement that project activities conform to national policies and legislation applicable to wetlands. If the host country is a Party to Ramsar or other conventions applicable to wetlands, the DNA shall additionally provide a statement that project activities conform to the provisions of the convention/s.	X	The Municipality of Cachoeiras de Macacu doesnd have significant presence of natural or artificial wetlands that could justify a LULUCF project. The flooding areas of Sao Jose da Boa Morte, adjacent to the rivers Guapiacu and Macacu, are under agricultural use and they also have important rural settlements. For that reason, the implementation of reforestation activities in these areas is extremely difficult.
	Direct measures/activities undertaken by the project proponents for the establishment of forest on degraded or degrading wetlands shall not lead to any changes in hydrology of land subjected to afforestation or reforestation project activity under the control of the project participants. Some examples of direct activities that are not permitted include drainage, flooding, digging or ditch blocking. Therefore, the A/R project activities are specifically restricted to the following wetland categories: (i) Degraded intertidal wetlands (e.g. mangroves); (ii) Undrained peat swamps that are degraded with respect to vegetation cover; (iii) Degraded flood plain areas on inorganic soils and (iv) Seasonally flooded areas on the margin of water bodies/reservoirs.	X	
	Project activities are implemented on lands where <10% of the total surface project area is disturbed as result of soil preparation for planting. However, in project areas with organic soils, site preparation activities such as sloughing and drainage before or after the trees are planted are not allowed.		
	Not applicable if is implemented on wetlands where the predominant vegetation comprises of herbaceous species in its natural state.		
	Implemented on lands where in the pre-project situation, areas used for agricultural activities (other than grazing) within the project boundary are not greater than 10% of the total project area.	X	Hardly possible to find in the suitable areas.
	Implemented on lands where displacement of grazing animals does not result in leakage.		
	Through assisted natural regeneration or seeding or tree planting on degraded wetlands, which may be subject to further degradation and have tree and / or non tree component that is declining or in a low carbon steady-state.		

The CDM Afforestation and Reforestation approved methodology for small scale agroforestry projects is presented in Table 27.

Table 27: AR-AMS004, Approved simplified baseline and monitoring methodology for Small-scale agro forestry A/R project activities under the CDM

CODE	AR-AMS0004		
NAME	Approved simplified baseline and monitoring methodology for small-scale **agro forestry** -A/R project activities under the CDM		
Version	2		
Scale	Small		
Selected Carbon Pools	Above and below ground tree biomass and SOC		
Applicability	Project activities are not implemented on grasslands;	Ok	Only Agricultural lands are eligible

	Project activities lead to establishment of forest (according to area, height and crown cover thresholds reported to the EB by the host Party) and allow for continuation or introduction of a cropping regime;		Measurement and technological problems.
	The pre-project crown cover of trees within the project boundary is less than 20% of the threshold for crown cover reported to the EB by the host Party;	Ok	
	If there is a decrease in the area cultivated with crops attributable to implementation of the project activity then the decrease is not more than 20% of the total area cultivated with crops at the start of the project.	Ok	Dependent on the project.

The CDM Afforestation and Reforestation approved methodology for small scale projects to be implemented on lands having low inherent potential to support living biomass is presented in Table 28.

Table 28: AR-AMS005 Approved simplified baseline and monitoring methodology for Small-scale A/R project activities under the CDM implemented on lands having low inherent potential to support living biomass.

CODE	AR-AMS0005		
NAME	Approved simplified baseline and monitoring methodology for small-scale A/R project activities under the CDM implemented on **lands having low inherent potential to support living biomass**		
Version	2		
Scale	Small		
Selected Carbon Pools	Above - below ground tree biomass and SOC		
Applicability	Project activities are implemented on areas having low inherent potential to support living biomass without human intervention. The project activities shall be implemented on areas listed in (i) to (iv) below. The project participants (PPs) shall provide evidence/data to support that the selected project sites meet the local/national criteria for these categories using information from verifiable sources and/or expert opinion as appropriate: (i) Sand dunes; (ii) Bare lands; (iii) Contaminated or mine spoils lands; (iv) Highly alkaline or saline soils.		The municipality of Cachoeiras de Macacu doesnô have significant coverage of the required type of lands.

The CDM Afforestation and Reforestation approved methodology for small scale silvopastoral projects is presented in Table 29.

Table 29: AR-AMS006 Approved simplified baseline and monitoring methodology for Small-scale silvopastoril A/R project activities under the CDM.

CODE	AR-AMS0006
NAME	Approved simplified baseline and monitoring methodology for small-scale **silvopastoral** - A/R project activities under the CDM
Version	1

Scale	Small		
Selected Carbon Pools	Above and below tree biomass and SOC		
Applicability	Project activities are implemented on degraded croplands or grasslands subjected to grazing activities;	Ok	
	Project activities lead to establishment of forest (according to area, height and crown cover thresholds reported to the EB by the host Party) in a silvopastoral system;		Could have some measurements difficulties, and applications troubles.
	The pre-project crown cover of trees within the project boundary is less than 20% of the threshold for crown cover reported to the EB by the host Party.	Ok	Could be managed.

One of the main ideas behind the implementation of LULUCF projects in the area should be to maintain the connectivity between forest patches. An integrated group of LULUCF projects, acting as bio-corridors to interconnect protected areas and to provide sustainable income to its inhabitants, can increase the social, economical and environmental situation of the region, but also, be as a promoter of sustainability.

Either for large scale methodologies and small scale methodologies, the price of the tC or tCO_2, strongly influences the feasibility of carbon sequestration projects. Now days, the prices are extremely low, and they cannot cover the implementation costs, unless a funding organization covers with most of the expenses. In the same way, for any case, technical knowledge is needed and the use of native species has to be encouraged at all levels.

For some methodologies (especially AR-AM0002, AR-AM0004, AR-AM0008 and AR-AM0009), agricultural activities and pastoral activities could be shifted. And the impact of this reallocation of activities has to be analyzed for each specific case.

For silvicutural activities is extremely necessary to the zoning map of Rio de Janeiro indicating the areas where plantations can be done. Nevertheless, plantations can be proposed to the INEA until the definition of the mention areas.

Manual weeding can be highly costly, and difficult. Therefore, the costs might rise up in pasturelands or severe degraded lands.

Difficulties related the replication of methodologies, determination of carbon pools (also reported in Wilson *et al.*, 2009) and the eligibility of lands have also to be considered. Another issue that limits the replication of the methodologies is that they are created for a specific area in a specific biome. Therefore, the implementation can be hardly accurate and in most of the cases a new methodology will have to be developed for

each project. Nevertheless, a first attempt of a resume of the methodologies that could be applied in the municipality is presented in Table 30 and in Table 31. The implementation categories here presented, have to be modified according to the project type and location. Many of them probably will have to be modified and presented as a new methodology.

Table 30: Large Scale methodologies

CODE	NAME	Implementation
AR-AM0001	Reforestation of degraded land	Possible with dificulties
AR-AM0002	Restoration of degraded lands through A/R	Possible with dificulties
AR-AM0004	Reforestation or afforestation of land currently under agricultural use	Possible with dificulties
AR-AM0005	A/R project activities implemented for industrial and/or commercial uses	Possible with dificulties
AR-AM0006	A/R with Trees Supported by Shrubs on Degraded Land	Possible with dificulties
AR-AM0007	A/R of Land Currently Under Agricultural or Pastoral Use	Not possible
AR-AM0008	A/R on degraded land for sustainable wood production	Possible with dificulties
AR-AM0009	Afforestation or reforestation on degraded land allowing for silvopastoral activities	Possible under certain conditions
AR-AM0010	A/R project activities implemented on unmanaged grassland in reserve/protected area	Possible under certain conditions
AR-ACM0001	Afforestation and reforestation of degraded land	Possible under certain conditions
AR-ACM0002	A/R of degraded land without displacement of pre-project activities	Possible under certain conditions

The AR-AM0007 is the only methodology that cannot be applied in Cachoeiras de Macacu. Because the project has to be established in lands where the intensity of agricultural and pastoral activities decreased; and it may be expected that the trend would be continued in the absence of the project activity. All other methodologies could be applied after changes; some of them require high technical knowledge and site preparation.

Table 31: Small Scale methodologies

CODE	NAME	Implementation
AR-AMS0001	Projects under the CDM implemented on grasslands or croplands	Possible with dificulties

AR-AMS0002	Simplified baseline and monitoring methodologies for small-scale A/R project activities under the CDM implemented on settlements.	Possible with dificulties
AR-AMS0003	Simplified baseline and monitoring methodology for small scale CDM A/R project activities implemented on wetlands	Not possible
AR-AMS0004	Approved simplified baseline and monitoring methodology for small-scale agro forestry -A/R project activities under the CDM	Possible with dificulties
AR-AMS0005	Approved simplified baseline and monitoring methodology for small-scale A/R project activities under the CDM implemented on lands having low inherent potential to support living biomass	Not possible
AR-AMS0006	Approved simplified baseline and monitoring methodology for small-scale silvopastoral - A/R project activities under the CDM	Possible under certain conditions

Small-scale methodologies could be more easily implemented in the municipality because of the simplicity of the conditions of the pre-implementation and implementation phases. There are two that cannot be applied: Methodology AR-AMS003 and Methodology AR-AMS005. AR-AMS003 should be implemented in wetlands, nevertheless, Cachoeiras de Macacu doesn´t have significant areas. Some important flooding zones are located in Sao Jose da Boa Morte and are use for intense agricultural activities. And Methodology AR-AMS005 is not possible because the municipality does not have any significant natural bare soil lands.

In the same way, small-scale projects will possibly have high transaction cost, labor and technical knowledge; hardly achieve by small-farmers without external assistance.

DEFORESTATION AVOIDANCE

Brazil and the Rio de Janeiro state have a great potential to reduce emissions from deforestation avoidance. There are little remnants of primary forests but important extensions of secondary forests that could sequester high quantities of carbon, if they are well managed.

Despite the fact, that REDD under the CDM has not been approved so far, could be possible to support the creation of private Legal Reserve Forest Areas or RFL (Areas

de Reserva Florestal Legal) trough carbon sequestration projects under voluntary markets. There are an important number of voluntary carbon sequestration projects in Brazil, probably because of the allowance of Brazilian government to develop carbon sequestration credits from REDD projects under the voluntary schemes (Tackas, 2009).

Brazilian scientists and national institutions have to develop more precise data about deforestation rates (Persson and Azar, 2007) before REDD can be applied. Nevertheless, REDD still remains as the bigger Brazilian opportunity to participate in CDM projects (Fearnside, 2001). In fact, carbon credit buyers would prefer to acquire CERs from avoided deforestation projects (Ecosecurities, 2009).

MITIGATION FROM AGRICULTURE AND AGRO FORESTRY

Developing countries account for more than 70% of the mitigation potential from agriculture, and Brazil is one of the countries with high possibilities (FAO, 2010). The discussion about the necessity to include the Agricultural sector to reduce GHG emissions has been in debate for many years. And in reality, the possibility to incorporate this modality under the CDM still remains vague.

Since agriculture and land for cattle ranching represent the principal competitor with Atlantic forests and they are responsible of biodiversity losses (Torrico *et al.*, 2009) could be a real and effective option to integrate conservation and agro-production. Agro forestry comprehends a certain agro and silvicultural management practices that combines crop species selection and sustainable performance that enhance food security and ecological and economical conditions.

In the same way, due to fact that the region is historically an agro landscape and the economical profitability of agro products (has to be proven) it could very difficult to switch from actual agricultural activities to preserved areas. Agroforestry can become a sustainable possibility of carbon storage, nevertheless, this methodology could be overestimated, because of the success of cattle ranchers in Brazil; meaning that the participation of small farmers in this productive system would not be significant (Fearnside, 2001).

The major issue in Agroforestry projects under the CDM (modality that has not brought into play) is the requirement to accomplish the forest definition. In other words,

Agroforestry projects under the CDM have to combine agricultural lands with forest patches that meet the definitions of forest of the Brazilian DNA. This can limit the implementation of projects, because of the difficulties to measure and maintain patches under the requirements.

SILVICULTURAL PLANTATIONS

The majority of the proposed projects regarding A/R activities have been for silvicultural plantations (Fearnside, 2001). Studies in the region have showed that farmers (especially small-family-owned-farms) consider wood plantations a ñsafe long-term investmentò, including eucalyptus plantations (Xiromeriti, 2009). Nevertheless, there are few experiences with native species that could be use for tree plantations in Brazil (Oreades Geoprocessing Center, 2009; N. Locke, personal communication, 30.03.2010.) Then again, some important steps have been done in the potential native species list for Silviculture systems. Species like *Acnistus arborescens* (marianera) could be very appropriate for Agro ecosystems, especially because of it fast-growing potential, biomass production and reproduction (Torrico *et al.*, 2009).

The implementation of A/R CDM projects in Cachoeiras de Macacu will depend on the Silviculture Zoning map for Rio Janeiro State. However, in any case, the use of native Atlantic forest species should be encouraged.

OTHER CONSIDERATIONS

The quality of the interpretation and differences in the sources of GIS data could lead to losses and duplication of information. Also the fact that the images are from 1985 reduce five years of interpretation.

The deforestation rates obtained from the interpretation of the satellite images can also be corroborated with other studies. According to Wilson *et al.* (2009) there principal loses of Atlantic forest occur between the periods of 1985 to 1990 (305 km^2) and 1990-1995 more than 1.403 km^2. However, the recently, reforestation of important areas in Cachoeiras de Macacu, could show that other incentives like the ICMS ecológico and voluntary markets can have a more deep impact than international mechanisms more difficult to implement.

For all reforestation projects, areas should be designed according to the location (near to protected areas, ecological corridors) (CIDE, 2001). Until now, the majority of the reforestation projects that have been developed in Cachoeiras de Macacu are related to water conservation. Certainly, the creation of the COMPERJ brought to discussion the necessity to protect the Macacu and Guapiaçu watersheds in order to guarantee the provision of water to the Petrochemical Complex. Therefore, reforestation activities as compensation will be realize in adjacent areas to the COMPERJ. The creation of the APA Macacu and the State laws that protect riparian forests could have a deeper impact than CDM LULUCF projects. The recommended area for reforestation projects according to Green Index II is approximately 1.952 ha (2,05% of the municipality area) or 19,52 km^2 (CIDE, 2001).

The majority of the available areas are along the Macacu and Guapiaçu rivers, the more productive areas. Competition with agricultural production can risk food availability. In South America, more than 50% of the suitable lands for A/R areas are croplands (Zomer *et al.*, 2008). On the other hand, for Cachoeiras de Macacu the majority of the available areas correspond to pasturelands. The potential to undertake actions to convert cattle areas into forest can be more plausible than agricultural lands.

The suitable lands also correspond to the most productive areas of the Municipality and in them are located the two more important rural settlements (São José da Boa Morte and Serra Queimada). Probably also, these are the most parceled areas. This fact also shows that probably the majority of suitable lands were deforested along rivers and today shifting of activities could be almost unavoidable.

The suitable areas for LULUCF projects (26400 ha) in Cachoeiras de Macacu are disperse and the ecological functionally has to been taking into account. Even so, the minimum recommended area for carbon sequestration plantations should be one thousand ha (May *et al.*, 2010).

The benefits of top-down approaches for baselines are important, because they reduce administrative costs, enable the creation of energy policies and lead to the development of planning tools (Hargrave *et al.*, 1998). Never the less, for building the capacity needed a common regional and national strategy has to be developed, but also funding to cover the costs of implementing regional or/and national baselines.

CONCLUSIONS

Difficulties to choose the suitable lands for carbon sequestration projects, carbon pools, temporality of credits have been the major obstacles in developing LULUCF projects. Additional, both for large-scale and for small-scale, the specificity of the existing methodologies, does extremely difficult to use them in other initiatives. The creation of the COMPERJ will change the landscape of the area and probably increase the pressure over lands for settlements and food production. Even more, suitable areas are adjacent to the Petrochemical Complex, and represent important productive areas; the majority of the available lands are under current agricultural or pastoral use. Conflicts and shift of activities can result when LULUCF projects are planned. The actual land use, the human settlements and the size of the land could strongly limit the possibilities to implement A/R projects in the area. Conflicts between actual land uses in suitable areas could strongly limit the creation of LULUCF projects in Cachoeiras de Macacu.

2.2 INSTITUTIONAL NATIONAL, REGIONAL AND LOCAL FRAMEWORK FOR CDM PROJECTS

Brazil has a long trajectory in the climate change forum. The first steps began when the United Nations Framework Convention on Climate Change was signed in 1992. After two years the National Congress ratified it on February 1994 and entered into force on May 1994 (MCT, 2008). Four years later, on April of 1998, Brazil singed the Kyoto Protocol and ratified it in August 23rd of 2002 (UNFCCC, 2008).

In June 1994 by the Presidential decree No. 160, the Ministry of Science and Technology took the lead of the National Coordination for Implementation of the United Nations Framework Convention on Climate Change. In this decree, the Minister of Science and Technology (MCT) was elected as the President of the National Coordination and the Minister of Environment (MMA) will be in charge of the Vice-Presidency. The Ministry of Science and Technology is also the Executive Secretariat (Ministry of Science and Technology, 2008).

Later on, in July 1999 the Inter-ministerial Commission on Global Climate Change was created, to replace the National Coordination for Implementation of the United Nations Framework Convention on Climate Change and to serve as the institution in charge of coordination of the UNFCCC initiatives in Brazil.

On December 2000, the Brazilian Government created the National Policy for Climate Change (Lei No. 12.187, 29-12-2009) (Presidência da República, Casa Civil, Subchefia para Assuntos Jurídicos, available at: http://www.planalto.gov.br/ccivil_03/) to enhance the mitigation, adaptation, to reduce emissions and to support research and institutions linked to climate change.

STAKEHOLDERS IDENTIFICATION

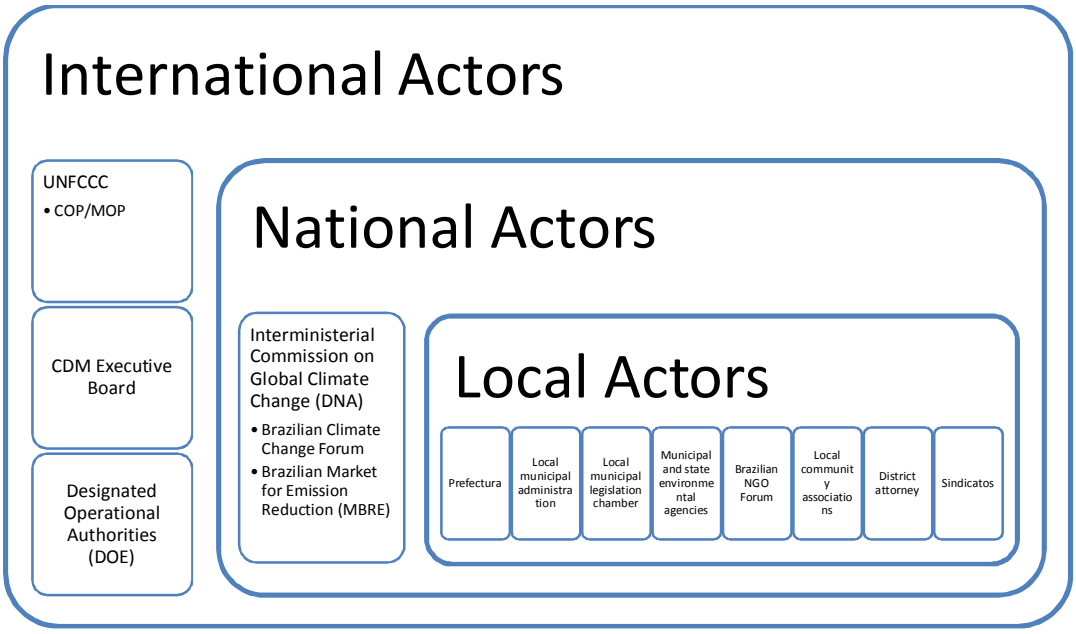
The MCT and the CIMGC are the principal governmental institutions related to LULUCF projects. Further on, according to the Brazilian law, the following instances to be consulted in every CDM project (CIMGC, 2008; Castro and Michaelowa, 2008):

- Local municipal administration (Prefeitura Municipal)
- Local municipal legislation chamber (Câmara dos Vereadores)

- Municipal and state environmental agencies (Órgão ambiental municipal e estadual)
- Brazilian NGO Forum (Fórum Brasileiro de ONG´s e Movimentos Sociais para o Meio Ambiente e Desenvolvimento FBOMS)
- Local community associations
- District attorney (Ministério Público Federal)

Some of these institutions like the municipal environmental agencies have been lately created as a requirement for the ICMS ecologico. The interaction between the different stakeholders is lead by the Project Developer and this institution will decide the degree of engagement of the actors. The organizational level of each stakeholder is shown in Figure 13**¡Error! No se encuentra el origen de la referencia.**.

Figure 13: Brazilian Designated stakeholders for a LULUCF ï CDM Project



The Stakeholders provided in Figure 13 and other important identified actors along this work are presented in the next section. They are divided according to the organizational level: international, national, regional and local level.

INTERNATIONAL ACTORS

United Nations Framework Convention on Climate Change (UNFCCC) entered in force on March 1994. The main duties are to collect information, initiate strategies, offer technical and financial support to global governmental efforts avoiding climate change (UNFCCC, 2010).

Intergovernmental Panel on Climate Change (IPCC), created by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) evaluates technical, scientific and socio economic information for assessing and reporting climate change (IPCC, 2010).

Conference of the Parties (COP), comprehends all meetings of the Parties to the Kyoto Protocol. In the COPs workshops recommendations by the Executive Board are analyzed, Designated Operational Entities (DOE) are defined, modalities and procedures for CDM A/R projects are discussed, etc (UNFCCC, 2010).

Conference of the Parties serving as the meeting of the Parties of the Protocol (COP/MOP), occur once a year to take decisions for the effective implementation of the Kyoto Protocol.

CDM Executive Board (EB) supervises the CDM, under the Conference of the Parties of the Kyoto Protocol. Reviews the rules of procedures and modalities of the project participants and/ or the Operational Entities, supervises modalities of the project cycle and makes recommendations in order to safeguard the "efficient, cost-effective and transparent" function (UNFCCC, 2009).

Concerning to the complexity of A/R activities the Afforestation and Reforestation Working Group was created to work on recommendations and proposals for baselines and methodologies for A/R CDM projects.

Designated Operational Entity (DOE) validates, verify, and certify any activity under the CDM. DOE are "either a domestic legal entity or an international organization accredited and designated, on a provisional basis until confirmed by the CMP, by the Executive Board" (UNFCCC, 2009).

NATIONAL ACTORS

Designated National Authorities (DNA) approves or rejects CDM projects proposed by a host Party. It also, validates the sustainable development component of the projects. Each Party (country) designates a DNA with equivalent authority form small-scale projects, A/R projects and small-scale A/R projects (UNFCCC, 2009). For Brazil is the **Interministerial Commission on Global Climate Change.** The representatives from eleven Ministries compose the Comissão Interministerial de Mudança Global do Clima (CIMGC). It is main duty is to advise the government representatives during UNFCCC meetings. Also under request, analyze and revise proposals for changes for sectoral policies, legal issues and norms related to global climate change. Besides that, one of the most important attributes is to analyze and approve or reject proposed projects for emission reduction under the Clean Development Mechanism. And finally, to represent a bounding institution between public institutions and the government to promote actions against climate change (Ministry of Science and Technology, 2009).

Brazilian Climate Change Forum created under Decree No. 3515 (2000) has the objective to increase the consciousness of the Brazilian population, promote discussion and decision capacity about climate change and CDM projects in the country. The Forum is an organism dependent from the Interministerial Commission on Global Climate Change (Ministry of Science and Technology, 2008).

Brazilian Market for Emission Reduction (MBRE, Mercado Brasileiro de Redução de Emissões) is an implementation center of negotiation of CDM projects in Brazil. It includes a group of institutions, rules and a registration project system. It was created after an agreement of the Ministry of Development, Industry and International Trade (Ministério do Desenvolvimento, Indústria e Comércio Exterior) and Bolsa de Valores, Mercadorias e Futuros (BM&FBOVESPA S.A). The main objectives are to incentive and facilitate CDM projects in an organized and clear way. Validated Brazilian CDM projects can be registered in this electronic data base, and become more accessible for possible investors or CER buyers (BMF&FBOVESPA, 2009).

Amazonia Fund (Fundo Amazonia) managed by the Brazilian Development Bank (Banco Nacional de Desenvolvimento Econômico e Social, BNDES) captures non-refundable investments for the preservation, monitoring and combative actions against deforestation, and promotes conservation and sustainable use of forests (Fundo Amazonia, 2010).

Brazilian Institute of Environment and Natural Resources (IBAMA, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis): executes environmental policies at national level, attributions to environmental licenses, environmental quality and control, controls the use of natural resources and many other supplementary actions to assure an effective accomplice of the environmental legislation (IBAMA, 2009).

Brazilôs National Environment Fund (FNMR, Fundo Nacional do Meio Ambiente): gives financial support to environmental projects that promote the rational use of natural resources, conservation and the restoration of environmental quality in the nation.

EMBRAPA Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Corporation) an organism under the Ministry of Agriculture, Livestock and Food Supply (Ministério da Agricultura, Pecuária e Abastecimiento) for research and technology transfer in agriculture, livestock production, agribusiness and sustainable development.

REGIONAL ACTORS

State Secretariat of Environment (INEA, Secretaria do Estado do Ambiente): protects, conserves and restores Rio de Janeiro Stateô environment to promote sustainable development (INEA, 2009). Under command of INEA, is the Fundação Estadual de Engenharia do Meio Ambiente (FEEMA) in charge of environmental control and permits, and environmental impact assessment. And the Fundação Instituto Estadual de Florestas (IEF- RJ), responsible for the execution of the forestall policy and the conservation of the natural removable resources of Rio de Janeiro State.

State Institute of Environment (SEA, Instituto Estadual do Ambiente): a department of the government of Rio de Janeiro State in charge of the planning, promotion, co-ordination and overseeing the implementation of environmental programs and services (INEA, 2009).

Superintendência de Clima e Mercado de Carbono. Evaluate the vulnerability of Rio de Janeiro State to the possible effects of climate change, focusing in health and social issues, water resources, ground elevation, etc.

Rio Climate Change Forum (Forum Rio de Mudanças Climáticas) created since 2008 by the State Government of Rio de Janeiro with coordination of the Secretaria do Ambiente (SEA) for the implementation of actions to mitigate GHG emissions from industries. Carbon Parks (Parque do Carbono) will offer to industries and other GHG emitters the opportunity to acquire land that has been reforested. The Pedra Branca pilot project plans to reforest Vila Valqueire and Campo Grande (RJ) with 3 million seedlings (SEA, 2010).

Organization for Technical Assistance and Rural Expansion of the Rio de Janeiro State (EMATER-RJ, Empresa de Assistência Técnica e Extensão Rural do Estado do Rio de Janeiro)**,** develops and executes several projects to increase the agricultural production and to enhance the living conditions of the rural inhabitants of the state.

PROJECT PARTICIPANTS (PPS)

Project Participants are any voluntary participants from a private and/ or public entity that create, develop and execute any CDM project. All the members of a CDM project should have a written approval from the Designated National Authority (DNA), and any changes should communicate to the Executive Board (EB).

STAKEHOLDER ANALYSIS

The stakeholder[11] analysis presented in Table 32 compiles information from interviews and bibliographic sources. Any analysis or interpretation error here presented is responsibility of the author.

[11] For this analysis, the definition of Stakeholder is ñAny individual, group, or institution who has a vested interest in the natural resources of the project area and/or who potentially will be affected by project activities and have something to gain or lose if conditions change or stay the sameò(WWF, 2005).

Table 32: Stakeholder Compiled Analysis in LULUCF projects[12]

Stakeholder	Organization	Roll in carbon forestry activities	Interests	Challenges
National Government	Interministerial Commission on Global Climate Change	Also under request, analyze and revise proposals for changes for sectoral policies, legal issues and norms related to global climate change. Analyzes and approves or rejects CDM proposed projects	Promote any activities that reduce GHG emissions and sustainable development.	Increase stakeholder responses; provide clear procedures for additionality demonstration.
Local Government	Environmental Restoring Project Macacu River Basin (Projeto de Recuperação Ambiental da bacia do Rio Macacu)	Some of the planned reforestation projects could be done under the Kyoto Protocol.	Reforestation of the Macacu and Guapiçu river margins and creation of a riparian park.	There is still difficult to demonstrate addicionality for A/R riparian forests.
	Secretaria de Meio Ambiente, Prefeitura de Cachoeiras de Macacu	The Environment Secretariat is in charge of fiscalization and environmental compensation. It also, gives advice of reforestation activities inside the municipality. Provides species and technical support.	Reforestation projects in private and public lands, law enforcement, maintain a high ecologic ICMS.	The Secretaria has a limited capacity to attend all the necessities of the municipality, maintains a minimal staff (8 people).
Non Governmental Organizations	Pacto pela Restauração da Mata Atlântica	Group of public and private institutions articulating common projects goals for the conservation and development of the Atlantic Forest.	Valorization of PES, reforestation activities.	Not all institutions related to the Atlantic forests are involved.
	Instituto Bioatlântica	Through important partnerships develop knowledge and collective actions like carbon sequestration projects.	Conservation of Atlantic forest and develop strategies for its protection.	
	Rede Brasileira Agroflorestal (REBRAF)	Potential executor and planner of A/R projects	Promote agroforestry systems and degraded land recovery.	Already collaborated developing a forestry carbon sequestration project (not implemented because of the low prices of CERs).
Industry	AES Corporation-Brazil	Energy generation, distribution and trade. Develop high profitability	Organize companies to engage them in	External instability and uncertainty

[12] Modification from Stakeholder interests in marketing forest carbon (Corbera & Brown, 2008)

		carbon trading projects	carbon sequestration projects	market rules for financing carbon projects. Presented the AES-Tiete A/R Project Activity around the Borders of Hydroelectric Plant Reservoirs (ARNM0034 under revision). Difficulties to demonstrate eligibility of lands.
	Federative systems of the Industry of Rio de Janeiro (Sistema Federação das Indústrias do Estado do Rio de Janeiro (FIRJAN), Escritório de Carbono)	Support industries, syndicates, and investors, local and state governments in carbon mitigation actions.	Project Cultivar plans to promote the planting of one million trees before 2014.	Uncertainty in financing schemes and technology transfer mechanisms
	CarboClima	Services provider and developer of GHG mitigation projects	80% of the potential clients are interested in A/R projects	Still difficult to implement, high costs, lack of trained experts
Potential Donors	Fundo Amazonia	Captures non-refundable investments for avoidance of deforestation and forest conservation.	Support projects for reforestation and forests protection.	Only 20% of the Amazonian Fund is available for projects in other biomas.

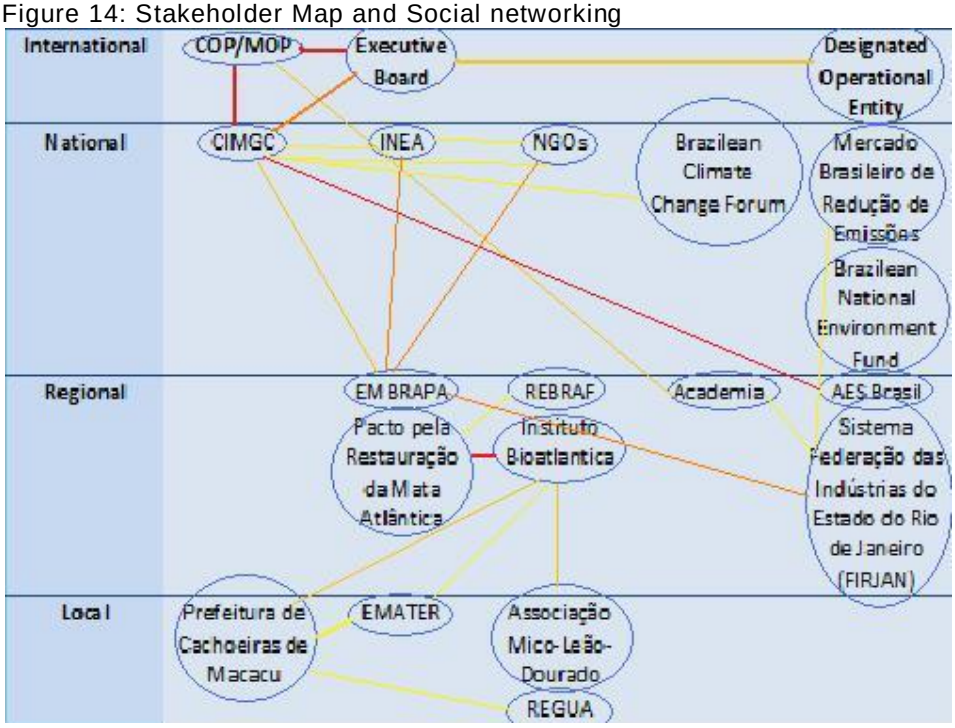
It would be recommendable, the participation of the majority of stakeholders during the pre-implementation and implementation phases of LULUCF projects in order to guarantee the success of it.

STAKEHOLDERS AND SOCIAL REDS

The international stakeholders have a direct and solid relationship with the CIMGC. However, at a national scale, the main networks are built up only when a project developer begins with a proposal for a forestry carbon sequestration project. In the

Figure 14, a stakeholder map and the conjecture social networking is presented.

Figure 14: Stakeholder Map and Social networking



Legend

	Frequent contact
	Occasional contact
	Seldom contact

Main contact between stakeholders is done due to the interactions in other projects, unless a specific project is created or any other form of incentive will be very difficult to promote in interaction between different actors.

BRAZILIAN DNA PROCEDURE FOR CDM PROJECTS APPROVAL

Brazil has a standardized and mandatory procedure for the approval process of CDM projects. In determinate cases, the Interministerial Commission has the capacity to revoke the approval, if the project commits any illegibility or any act contrary to the public interests (CIMGC, 2008).

For the Brazilian Designated National Authority the minimum selected values for A/R projects activities (Resolução No.2, 10-08-2005, Art. 3; CIMGC, 2009), are:

- A single minimum tree crown cover value between 10 and 30 per cent,
- A single minimum land area between 0,05 and 1 hectare,
- A single minimum tree height value between 2 and 5 meters,
- A/R project activities do not include Palm trees and Bamboos.

The project developers should send a written consultation letter to a group of stakeholders, inviting them to do comments about the project. Nevertheless, other methods have been use by project developers to guarantee locals participation: newspaper advertising, emails, personal communications and other more interactive methodologies like: consultation meetings, focus groups and surveys (Castro and Michaelowa, 2008). The standard written procedure doesnôt reach local farmers and stakeholders (Castro and Michaelowa, 2008; Friberg and Castro, 2008).

The instances to be consulted are the local municipal administration, local municipal legislation chamber, municipal and state environmental agencies, Brazilian NGO Forum, local community associations and the district attorney (Castro and Michaelowa, 2008; CIMGC, 2008)

Unfortunately, only 5% of the CDM projects in Brazil have receive any comments about the project (Castro and Michaelowa, 2008), and these comments dontô criticize the project design (Friberg and Castro, 2008). Possible reasons can be the lack of technical knowledge, time or urgency to solve other issues (Friberg and Castro, 2008). The lack of feedback leads to the conclusion that another consultation method has to be found in order to involve all possible stakeholders in the process.

As Friberg and Castro (2008) point out, there is ñno specific internationally recognizedé stakeholder consultation processes in CDM projectsò to guarantee the participatory enrollment of stakeholders, besides standards created for voluntary carbon markets.

According to Castro and Michaelowa (2008), the Interministerial Commission on Global Climate Change, CDM projects have to contribute to the ñlocal environmental sustainability, the development of working conditions and employment generation, income distribution, capacity building and technology development, and to regional integration and articulation with other sectorsò However, mechanisms to demonstrate

the contribution to sustainable development have to be developed in order to set clear rules for coming projects.

There is a need to define in a measurable way, which is the minimum contribution that a CDM proposed project has to achieve to fulfill the sustainable development requirements (Castro and Michaelowa, 2008). A set of clear and defined contributions for sustainable development can avoid the extreme difference between the expectations of the contributions to sustainable development (Castro and Michaelowa, 2008), but also be more efficient and effective. In the same way, the demands of locals can be better fulfilled if there is a good level of participation of principal stakeholders (Friberg and Castro, 2008).

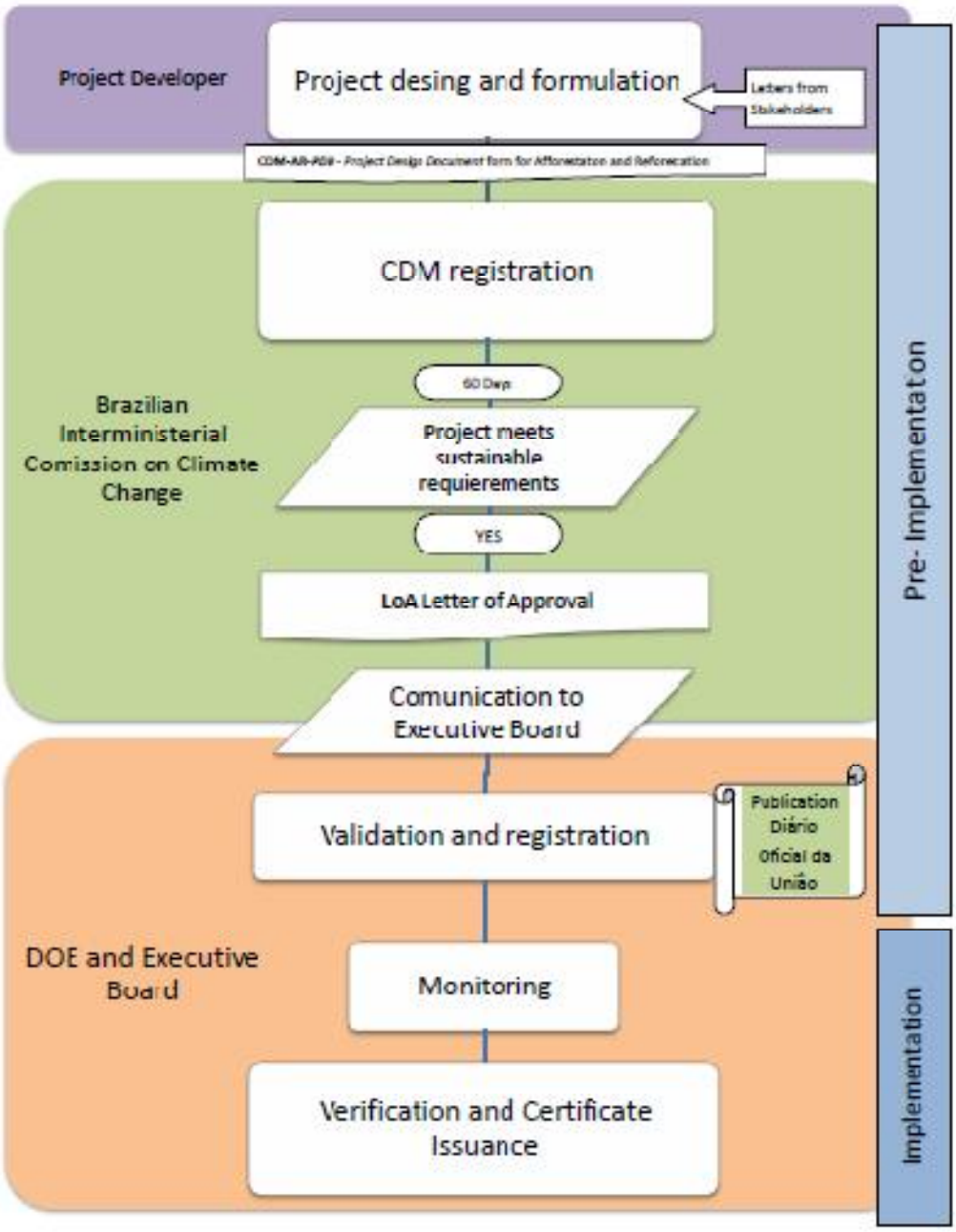
The percentage of Brazilian CDM rejected projects is high when compared to submitted and registered projects, especially for additionality demonstration (Castro and Michaelowa, 2008).

Within 4-6 weeks, the Brazilian DNA sent a letter of Approval. Time difficulties are seen when the project has to be validated by the DOE, because of the large number of projects in the pipeline (Castro and Michaelowa, 2008).

BRAZILIAN CDM PROJECT FLOW CHART

The proposed A/R projects for validation under the CDM of the Kyoto Protocol have to follow a similar process worldwide. In the next flowchart, a version adapted for the Brazilian procedure is presented (Figure 15).

Figure 15: Brazilian CDM Project Flow Chart



Under this procedure, some projects can go under revision and will have to start the process again until every step is approved.

INSTITUTIONAL FRAMEWORK FOR CDM CAPACITY BUILDING IN BRAZIL

Institutions should be created and adapt to serve as a link between the stakeholders and the environment: from international to national and local level, interact with other institutions (Corbera *et al.*, 2008) Therefore is necessary to identify clear roles, responsibilities and duties, but also to determine the mechanisms for the interaction between stakeholders.

In this study has been demonstrated that Brazil has important base information and solid institutions, but they don't reach the community at local levels. In the same way, there is a need to enforce the interaction between institutions and to encourage the transference of information from the national (international) level to local levels and vice versa. The fact has been also reported in other studies in the northeast of Brazil where "stakeholders are not properly involved" (Teixeira, 2006).

Other related institutions and potential actors should be trained to link projects to possible investors, but also to engage more potential project participants. The possibilities and benefits of LULUCF projects have to be spread to possible investors and local institutions. This will help to the capacity institutional building, but also to diminish transaction costs and to formulate and finance A/R CDM projects.

Other important issues are the creation of incentives to involve more institutions in mitigation projects. The existing mechanisms have to be strength and fully applied to have better results. In the same way, the creation of fast and accessible procedures will also increase the interest of possible project developers. That means that CDM offices and related organisms have to receive more technical and financial support.

In Cachoeiras de Macacu, existing institutions need financial and technical support. Some of the municipality departments related to carbon sequestration issues have been recently created. Therefore, a lack of structure, personnel and budget are still important limitations.

4.3 SWOT ANALYSIS FOR LULUCF PROJECTS

A Strengths, Weaknesses, Opportunities and Threats Analysis has been use for the identification of chances and barriers for the implementation of LULUCF CDM projects. In the following section, each component is described and finally and analysis is presented.

STRENGTHS

In general, the majority of carbon credits´ buyers prefer forest carbon projects located in South America (Ecosecurities, 2009). This fact linked to the overall Brazilian good climate for CDM investments (CDM Investment Climate Index) and the rapid response times from the Brazilian Designated National Authority (DNA) (Hirschle, 2006) creates exceptional conditions for carbon sequestration projects. Furthermore, despite there are still some legal unsolved issues (relating carbon sequestration credits and projects) seems that the Brazilian government has ñthe capacity to implement complicated forest laws and policiesò(Takacs, 2009). Also due to the high standards and coherence of the CIMGC, the Brazilian projects a high credibility and the carbon credits of Brazilian markets can be better sell (R. Schaeffer personal conversation, 14.05.2010).

There have been some important documents that present key data and guidelines for CDM projects, like for example: Mudança do Clima. Volume I ï Negociações internacionais, vulnerabilidade, impactos e adaptação à mudança do clima (NAE, 2006). Also the recently updated Guia de Orientacao-2009 for CDM projects in Brazil (CIMGC, 2009) that describes procedures and gives guidelines for project developers and general audience. And in the last years, there are some important publications like the ñUser´s Guidebook for the Adaptation Policy Frameworkò (UNEP, 2003) and Estimating mitigation potential of agricultural projects in Brazil (FAO, 2010) that set bases for other modalities of GHG sequestration.

Other important success is the occurrence of new approaches in climate mitigation sector in Brazil. For example, the recently approved project under the Programme of Activities in Brazil for mitigation emissions from pig farms (UNFCCC, 2009) will possibly encourage the creation of proposals under this unexploited methodology. Additionally, in Brazil exists enough capacity build for REDD projects under the voluntary market; this fact is highlighted because the government allows the issuing carbon sequestration credits (Tackas, 2009).

The technical and consultation body concerning GHG emissions avoidance in Brazil is relatively small and keeps a good relation between all the related people (R. Schaeffer personal conversation, 14.05.2010).

The Geoprocessing Center and the Department of Environment have interest and competent personal to support projects under mitigation of GHG.

WEAKNESSES (BARRIERS)

It seems that the principal barriers for CDM projects are valid for large-scale and small-scale projects (Castro and Michaelowa, 2008).

- The **National Institutional Framework** has still some difficulties and needs to consolidate a solid structure, also pointed out by the Brazilian government (NAE, 2006). The political and financial stability at a national level has significant impacts on investors, especially to define the duration of the carbon commitments (Cottle and Crostwaite-Eyre, 2005).

  On the other hand, the Brazilian law enforces the Mata Atlantic population to protect some percentage of existing forest but also to the regeneration of forest remnants (APPs or Permanent Preservation Areas and Legal Reserve Forest Areas). All these protected areas (most of the cases in only in paper) are not eligible for carbon sequestration projects because additionality can be hardly demonstrated (Tackas, 2009).

- There is a need to develop methodologies and parameters to measure and demonstrate the **additionallity** (R. Schaeffer Personal Conversation, 14.05.2010) technology transfer issues and the accomplishment of sustainability goals of forestry carbon sequestration projects.

- **Financial** issues. As Castro and Michaelowa (2008) state all CDM Brazilian projects (from their case study) had financial problems, being the Brazilian National Development Bank (BNDES) the only provider of long-term loans. Also the access to credits, ñthe high interest rates and high financial risksò discourage possible investors (Castro and Michaelowa, 2008).

- Human capital and knowledge, needs to be develop to supply the requirements, a concerning also shared by the Brazilian government (NAE, 2006). That

includes the necessity to support not only universities, federal and state governmental institutions, but also community organizations (especially important for indigenous groups and small farmers) financial and technological.

- **Technological** issues. The use of Remote Sensing and satellite images for estimating the A/R areas requires specialized technicians and instruments. Other technical problems that have been reported by Ferreti and Miranda (2006) in a reforestation project in the Mata Atlantica in southern Brazil, like the need to develop machines and techniques related to soil preparation, production of seedlings and planting; especially related to native species. Also ñlow survival rate of seedlings planted in é brachiaria grassò (Teixeira *et al.*, 2006).

- **Environmental** challenges. The control of existing vegetation, specially introduced grasses make difficult reforestation processes. In REGUA for example (N. Locke personal communication, 30.03.2010) and in the Plantar project (Yu, C. M., 2004) Round up had to be used to eradicate Bachraria grass. Similar problems have been also reported for the Emas-Taquari Biocorridor Cabon Project (Oreades Geoprocessing Center, 2009).

  Supplementary, reforestation projects have to be well structure and planed in order to secure the provision of seeds (especially difficult when the forest fragments (bank seeds) are too far away) (D. Barbosa da Silva, personal communication, 30.04.2010).

- There is a need to ingrate all planed projects and structure them to the according to environmental conditions (forest fragments connectivity is especially important).

OPPORTUNITIES

There is a high potential for CDM and especially LULUCF projects in Brazil (NAE, 2006; Teixeira, 2006), including an adequately structured General National Institutional Framework for Climate Change.

There are already some incentive mechanisms like the property land rights laws in Brazil that permit the creation of A/R and REDD carbon projects in private lands, indigenous lands and also local and state government (Takacs, 2009).

Other important approaches like the law to incentive forest carbon sequestration projects (especially REDD projects) created by the federal state of Amazonas (Takacs, 2009) could be also undertaken by other municipalities in Brazil. Likewise, some tax incentives have been already created and have a great potential to be used in carbon sequestration projects. One of them, is the Programa Nacional de Fortalecimento da Agricultura Familiar PRONAF, is a financial fund to help to develop agriculture and livestock activities that are direct realized by the farmers, includes: rural tourism, handicrafts, small agribusiness and other rural environmental services (Banco Nacional do Desenvolvimento, 2009).

As well, on October 2007, the Secretaria de Estado do Ambiente (SEA) modified of the law ñLei do ICMS Verdeò to promote conservation through the creation of the Goods and Services Circulation Tax or ICMS-Ecológico (Imposto sobre Circulação de Mercadorias e Serviços, ICMS). The ICMS is the first model of payment of ecosystem services (PES) in Brazil. It is a fiscal instrument to reward local governments that protect forests and biological resources (May *et al.*, 2005). It has preliminary good results but some changes have to be done before its implementation in other Brazilian states. In Rio de Janeiro will be distributed 2.5% to all municipalities in the state until 2011 (45% Conservation Unities, 30% water quality and 25% solid waste administration) (TNC, 2010). It is divided in the following manner: 45% for conservation areas, 30% water quality and 24% for solid waste management (SEA, 2009).

There are some important reforestation experiences in the Atlantic forest that could improve and facilitate A/R activities in the next years. Locally, REGUA has been working with reforestation for more than 25 years having a lot of knowledge acquired in species and seed bank collections (N. Locke personal communication, 30.03.2010). Regionally, EMBRAPA (2009b) developed a list of native tree species that will be use for reforestation activities in the area of the COMPERJ. These species lists have information about succesional stages, seeds breeding conditions and other important data. Other experiences with reforestation in the Atlantic forests, especially for rural private properties have been documented by Instituto Bioatlantica (Siqueira and Bernardo Mesquita. 2007) and the well documented book (Referencial dos Conceitos e Ações de Restauração Florestal) from the Pacto pela Restauração da Mata Atlântica (Instituto Bioatlantica, 2009) that compiles different experiences in Brasil.

In Rio de Janeiro State there are some well established nurseries like the Vivero do Jardim Botânico do Rio de Janeiro, INEA has also nurseries in several municipalities, some from the Prefeitura da Cidade do Rio de Janeiro and many other public and private located in the surrounding municipalities (Viveros no Rio de Janeiro, Listagem Preliminar, provided by the Secretaria do Meio Ambiente, Prefeitura de Cachoeiras de Macacu, 2010).

The municipality of Cachoeiras de Macacu has a well established nursery that contains tree wood species (Ipê *Tabebuia sp*.; acácia *Acacia sp.*; pau brasil and pau ferro *Caesalpinia sp.*), native tree species (Ingá *Inga sp.*; cambucá *Plinia edulis*; palmito *Eutherpe edulis*; leocena *Leucena sp.*) and fruit trees (Acerola *Malpighia emarginata*; cacao *Theobroma cacao*; goaiba *Psidium guajava*; manga *Mangifera indica*; pinha *Annona squamosa*, etc.). The prices are accessible (around R$1,00 and R$3,00) (List provided by the Secretaria de Meio Ambiente, Horto Municipal, Cachoeiras de Macacu, 2010). REGUA has also an exceptional variety with more than 130 spp., the majority of them native tree species (List provided by REGUA, 2010).

Voluntary Carbon credits are a good alternative for A/R projects. Some projects in Cachoeiras de Macacu, REGUA for example, have been successfully implemented. Voluntary Carbon Markets like CCX or New South Wales are recognized and valuable trading schemes.

Partnerships between investors, local NGOs and state and local governmental institutions can be more efficient and can even reduce implementation costs[13].

Other valuable chance is to link tourism with carbon sequestration projects. A variety of cascades and other attractions in the municipality of Cachoeiras de Macacu, could bring other sources of economic benefits to the potentially existing LULUCF projects. REGUA, for example, already applies this concept by matching bird watching, tourism and reforestation.

[13] According to CIDE (2001) the cost implementation of a corridor to connect forests fragments is much higher ($US 1500 /ha) for the government alone, when compare to the cost (around $RE 800 /ha) when is implemented with partnerships. These costs depend on the slope, soil type, species and labour costs.

THREATS

The uncertainty related to modalities and procedures of the Kyoto Protocol limits the participation of countries, investors and potential project participants. This is also connected to the lack of concrete resolutions after COP 15 (D. Barbosa da Silva personal communication, 30.04.2010). International decisions especially the referred to temporality of the credits and eligibility, addicionality demonstration (D. Barbosa da Silva personal communication, 30.04.2010; Wilson *et al.*, 2009) can retard negotiations.

These unsolved issues are especially problematic for A/R projects, because the investments have to be done for 15 years or more in order to enhance the profitability of the project. Reforestation related activities need long term commitments. To increase A/R projects, long-term national and international politics have to defined, especially those related to judicial and economical issues (Cottle and Crostwaite-Eyre, 2005). External instability and uncertainty market rules for financing carbon projects (D. Barbosa da Silva personal communication, 30.04.2010).

These factors can become a disincentive for investors to buy forest carbon credits (R. Schaeffer personal communication, 14.05.2010). The permanence of the credits is especially problematic when credits are temporary. This fact doesn't permit the creation of large scale projects (D. Barbosa da Silva personal communication, 30.04.2010), but also discourages private investors (R. Schaeffer personal communication, 14.05.2010).

- There are several market barriers like the volatility of the markets and the high transaction costs that have been largely analyzed by other authors. This concern also, includes the cost for the project (R. Schaeffer personal conversation 14.05.2010) mainly elevated (Ferreti and Miranda, 2006).

- The difficulties to obtain historical data (Wilson *et al.*, 2009) to and interpret data from satellite images (before 1990) and the inaccessibility to actual land use or land cover maps can become an important barrier in the creation process of the baseline of a project. Trained staff and experts in the field of Remote Sensing and Geographic Information Systems are needed in order to develop the information about the area, forest coverage and other baseline information.

- Some cultural problems have been also reported as threats. The land owners have shown little interest in bank loans for reforestation projects, mainly because of the mistrust in on-timber forests and fear to debt (Oréades Geoprocessing Center, 2009).

- There is a lack of providers of native species for reforestation projects. The existing information does not reach small farmers or any interested farmers. Another reason could be the lack of demand for native tree species. This issue is especially important because in some areas of the Atlantic Forest the existing fragments are to deteriorate or too far from reforestation areas, diminishing the capacity to provide seed banks (D. Barbosa da Silva personal communication, 30.04.2010).

- Land tenure systems and property rights could not be solved for all the potential areas for LULUCF projects. A/R projects in private lands of national parks or reserves can create several problems. Additionally, Brazil has not defined the property rights over carbon credits; this could lead to future legal inconveniences (Takacs, 2009).

  The Decree 750 (Article 1, Decreto da Mata Atlântica [750/1993]) prohibits the use of primary and secondary (intermediate and advanced stages) forests. Therefore, this decree indirectly promotes the burn of `*capoeiras*` (lands in secondary stage growth) for future agricultural use (Nehren *et al.*, 2009). The local farmers keep the land clean in order to avoid losing the land rights or get into judicial problems (Schlüter and Pedroso, 2009). Only a good financial propose can become an incentive to change the actual status of capoeiras.

  Additional to the just mentioned decree, the Atlantic Forest Law (Lei da Mata Atlantica, No. 11.428 (22/12/06) and Lei Estadual de Zoneamento Econômico-Ecológico, No. 5.067 (09/07/07)) (Presidência da República, Casa Civil, Subchefia para Assuntos Jurídicos, available at: http://www.planalto.gov.br/ccivil_03/) that dispose for creation of APP (Areas de Preservação Permanente) with native species of Atlantic forest in rural properties limits the potential of LULUCF projects (R. Schaeffer personal conversation, 1.05.2010; S. Wunder personal conversation, 07.05.2010).

  EMATER promotes the creation of silvicultural plantations including forestry projects with eucalyptus and pinus. There is a State Law (Lei Estadual No.

5067, Art. 8, 9 and 10; 06-2007) that establishes an ecological-economical zoning for silvicultural activities in the municipality of Rio de Janeiro, classifying the different hydrographical regions and the conditions in which silvicultural activities could be implemented. Nevertheless, this zoning map is not finished yet (M.L. Davies Freitas personal conversation, 11.05.2010) and therefore the possibility to determine the areas for LULUCF will change as soon as the zones are determined. A preliminary version already exists and will be available soon (T. Matos da Mata personal communication, 08.06.2010).

- The municipality is a highly populated area that provides man power and agro products to the metropolitan area of Rio de Janeiro. The next years the socio-economic tendencies will be affected and change due to the creation of the Petrochemical Complex of Rio de Janeiro[14] (COMPERJ, http://www2.petrobras.com.br/Petrobras/portugues/pdf/rima.pdf) in the adjacent municipality of Itaborai. COMPERJ could bring real estate speculation (Instituto Bioatlantica, 2009) and promote the urbanization and increase fragmentation of ecosystems (Lima, *et al.*, 2009).

- More precise data about reforestation rates need to be developed by Brazilian scientists and national institutions (Persson and Azar, 2007). Supplementary, there is still a lack of information about the amount of Carbon that can be trapped in Atlantic Forests (N. Locke, personal communication, 30.03.2010; Wilson *et al.*, 2009). Carbon monitoring programs and trained experts in that field has to developed studies in order to have certain data about the CO_2 storage potential (Persson and Azar, 2007). This also linked to the difficulty to measure the relatively high and diverse number of carbon pools and their changes in carbon storage, especially problematic for soil organic matter (J.

[14] Reforestation is one of the mitigation strategies that the Petrochemical Complex of Rio de Janeiro (COMPERJ) (Complexo Petroquimico do Rio de Janeiro) will implement on the buffer zones of the project. About one million square meters of riparian forest will be planted along Macacu River and 10 million square meters in non build areas (COMPERJ, http://www2.petrobras.com.br/Petrobras/portugues/pdf/rima.pdf). According to the soil type, soil hydrological conditions and the succesional stages reforestation activities are planned in degraded areas. In former „fazendas“ and wood plantations, agro-forestry systems are planning to be implemented, and finally in exiting fragments will be enriched with tree and epiphyte species. Finally the idea is to recover native vegetation in present agricultural and pasture areas to create biodiversity corridor (EMBRAPA, 2009a).

Monteiro personal communication 10.06.2010; also reported in Wilson *et al.*, 2009). Usually they include complicated models and algorithms. Both, the carbon storage potential and the carbon pools quantification include are high related costs.

According to the information presented, in Table 33 a summary of the SWOT analysis

Table 33: Summary of SWOT analysis and possible applicable strategies[15]

	Strengths (S)	**Weaknesses (W)**	
Opportunities (O)	(SO) Strategies - Support and provide technical and economical to enhance the positive existing work ambiance and the extension of promotion of good practices as the ICMS ecologico. - Explore possibilities of carbon sequestration projects under voluntary markets.	(WO) Strategies - Make more accessible the existent information that has been already published. - The existing geo-processing center of the Planning Secretariat in the Municipality of Cachoeiras de Macacu could provide support and information to project developers. - EMBRAPA, EMATER and the Municipality Agricultural Secretariat have experience and knowledge in A/R activities.	(OT) Strategies - Organize workshops involving stakeholders and principal institutions in the area to share acquired knowledge and to build networks and partnerships among them. - Link conservation and tourism activities. - Support existing nurseries and promote the use of native species in A/R projects.
Threats (T)	(ST) Strategies - Support existing networking and promote the inclusion of other important stakeholders. - The consolidated existing national framework could be sufficient to provide certainties to investors, especially if REDD methodologies enter officially in the negotiations.	(WT) Strategies - Document and monitor existing approaches and evolution of already approved projects. - Link financial institutions and carbon forestry activities. Promote the creation of especial bank loans for carbon forestry activities that include especial conditions for small farmers or agro-cooperatives. - INPE free accessible LANDSAT images and the current land coverage information	

[15] Base on Summary of SWOT analysis of forest information infrastructure in Cameroon, Minang *et al.* 2008.

		could set baselines for A/R projects together with an adequate training in remote sensing processing could permit existing governmental offices generate information in historical data for land use change.	
	(SW) Strategies - Develop national procedures for the demonstration of additionality coherent to the national existing legislation.		

The majority of the decisions have to be taken at an international and national level to incentive A/R CDM projects. Nevertheless, the Municipality could act as a project developer and finance some of the projected A/R projects with CERs from the CDM. Is also important, the creation of local incentives to A/R projects that facilitate and invite project developers to invest in the municipality.

4.4 FINAL CONSIDERATIONS REGARDING LULUCF PROJECTS

There are some still pending issues that concern the international and national level that directly affect LULUCF projects. Issues like technology transfer, voluntary carbon markets and other mechanisms to finance A/R are discussed in the next section.

TECHNOLOGY TRANSFER

Worldwide one of the main challenges of climate change for scientist and governors is to maintain sufficient food production to satisfy the increasing demand. Above all, should be considered that one of the best ways to enhance food security is through increasing biodiversity, reducing erosion and maximizing crop productivity. The correct transfer of technology from Annex-I countries to developing countries can assure the productivity in degraded lands (Trines *et al.*, 2006). Increasing the capability of adequate resources management and the use of technological advances can enhance productivity in agricultural lands to protect people from climate change (La Vina, 2002; FAO, 2008).

Such transfer of technology should include: forest management and conservation, sustainable silviculture in afforestation and reforestation projects, genetic manipulation, effective harvesting, low-tillage practices, and cattle supervision (UNEP, 2009) as well as instruction and guidance (Roshetko, *et al.*, 2007). The lack of these transfers can retard the mitigation process and advantages related with them (Sathaye *et al.*, 1999 in IPCC, 2009).

Despite the emphasis of the agreements in the Kyoto Protocol for the need to build projects that lead the host countries to sustainable development, the reduction of GHGs is perceive as the only objective of the UNFCCC. The link between green house gases, climate change and the risks to food production (Amin, 2005) has been unnoticed. Furthermore, the correlation between the opportunities of technology transfer through LULUCF projects in developing countries remains vague. As the FAO states (2008) it is extremely important to acknowledge the potential of LULUCF projects as providers of environmental services and as an approach to enhance the living conditions of poor people. Missing objectivity can lead to doubling efforts (Nkem *et al.*, 2007).

Therefore, is extremely important to ensure the ñeffective transfer of technologies and implementationòstrategies (Amin, 2005) in developing countries. As a matter of fact, is essential to increase the consciousness between international developers. The correct transfer of technology can help to increase ñfood security, health, biological diversity and conservation of natural resourcesò (UNFF, 2004) of the recipient country. As appropriate, is really necessary to ensure the cooperation between farmers, government, local, national and international stakeholders to guarantee the successful accomplishment of the project (Roshetko *et al.*, 2007). Indeed, governments should include adapting, global change and food security into their national agendas, policies and planning (Nkem *et al.*, 2007).

POTENTIAL FOR VOLUNTARY CARBON MARKETS

As we have seen, Brazil has considerable experience, but also potential for A/R and REDD projects, both, for CDM and voluntary markets. Therefore the municipality of Cachoeiras de Macacu could also get engaged in LULUCF projects. Existing knowledge has to be exploited and supported to connect more institutions. Nongovernmental organizations are key stakeholders and they will have a predominant roll in carbon sequestration projects in the next years.

The benefits of voluntary carbon projects are innumerable, principally because they are more flexible and permit the creation of more adequate projects according to the social and environmental conditions of the area. In other words, projects under voluntary markets could serve as biodiversity corridors, private protected areas and still maintain the providence of subsistence benefits to rural communities. Also they could be applied in a wider variety of suitable lands (political, land tenure or conservation reasons).

Despite, the value of carbon credits from voluntary carbon markets is still low to be successfully trade in international markets (D. Barbosa da Silva personal communication, 30.04.2010), international agreements of the last year showed that in the future more commitments will be signed. In fact, the increasing number of carbon sequestration projects under voluntary markets promotes competition, denotation that the prices could be higher on the next years (S. Wunder personal conversation, 22.04.2010).

POTENTIAL FOR PROGRAMMATIC CDM PROJECTS

The recently approved project under the methodology or Programme of Activities is a good step to incentive more project developers to explore this field. Certainly under this methodology the inclusion of small and medium farmers is more realistic than in other models.

The conditions in Brazil are good for Programmatic CDM projects. Nevertheless, for its implementation is necessary leadership and support to the socioeconomic framework, consultation processes, education and engagement (D. Barbosa da Silva personal communication, 30.04.2010). For Cachoeiras de Macacu, the municipality or a leading NGO could act as the project developer guiding and supporting the creation of A/R projects in this innovative modality.

A POTENTIAL FRAMEWORK FOR PAYMENT FOR ENVIRONMENTAL SERVICES (PES)

The increasing deforestation, biodiversity loss and the consequent diminishment of the ecosistemic services that the forests provide, force to humanity to create market economic mechanisms to conserve forests (Pagiola, *et al.*, 2005). In the last years, the international community has a tendency to demand the inclusion of the surrounding

rural communities and to enhance the living conditions of the people adjacent to these areas.

Ecosystem Services are ñbenefits that people derive from ecosystems, including both commodities and regulating, supporting and cultural servicesò (Jack *et al.*, 2009).The most common and usually easier to quantify ecosistemic services are: watersheds protection, biodiversity conservation and carbon sequestration (Pagiola, *et al.*, 2005).

In Brazil the Goods and Services Circulation Tax or ICMS-Ecológico has become a significant opportunity to link reforestation projects with this kind of incentives. Cachoeiras de Macacu has the qualification and several pre-conditions to explore the ICMS ecológico (M.L. Davies Freitas personal conversation, 11.05.2010). Indeed, Cachoeiras de Macacu has the highest percentage of protected areas in RJ (more than 60% of its extension, mainly because of the presence of the National Park Três Picos and the APA Macacu) (T. Matos da Mata personal communication, 08.06.2010).

There are other important initiatives like Proambiente, another PES framework implemented in the Brazilian Amazonia to avoid deforestation and apply sustainable agricultural practices (Wunder *et al.*, 2008). An additional scheme is the Forest Stewardship Program (Bolsa Floresta) in the Amazonas state that comprises forest conservation and the enhancement of the living standards of indigenous communities in the area. Bolsa Floresta is a governmental program running since 2007, a partnership between the Amazonas Sustainable Foundation, the Secretariat for the Environment and Sustainable Development and Bradesco. The basic idea is to reward families that avoid deforestation or to apply penalties when the commitments are not successfully implemented (Wertz-Kanounnikoff *et al.*, 2008).

Bolsa Floresta and Proambiente have several common aspects: both are focused in deforestation avoidance and also are implemented in the Brazilian Amazonia by governmental institutions. There is still little information about these PES approaches and the impacts of them in the areas where they have been implemented (Wunder *et al.*, 2008). Nevertheless, they constitute a good start to develop better frameworks for PES.

The concept of a framework for Payment of Ecosystem Services and the related institutions has to ñenhance or change natural resource managersôbehavior in relation to ecosystem managementò (Corbera, *et al.*, 2009). It´s effectiveness will depend on

the judicial system and a fund that covers the transaction costs of implementing a PES framework (Wunder *et al.*, 2008).

A general framework could be designed to include all forms of PES including: forest carbon trading through Certified Emission reductions (CERs) in the CDM of the Kyoto Protocol, Voluntary Forest Carbon Markets (including the Climate Chicago Exchange), and finally state initiatives that include carbon sequestration along with other ecosistemic services (Corbera, *et al.*, 2008).

Highly develop municipalities like Cachoeiras de Macacu demonstrate the inapplicability of A/R projects when they are not linked to other ecosystem services, especially water supply.

RECOMMENDATION FOR A POTENTIAL FRAMEWORK FOR PES IN CACHOEIRAS DE MACACU MUNICIPALITY

The creation of support and regulatory institutions can consume time and financial resources (Pagiola *et al.*, 2005). Nevertheless, some PES projects have showed that working on pre-existing institutions can be faster and have positive results (especially if the new conception process old institutional problems are also attacked) (Pagiola *et al.*, 2005). For Cachoeiras de Macacu, the Environment Secretariat could be the base institution for the establishment of a PES framework in Cachoeiras de Macacu. However, there is a need to invest in human and economic capital, to increase its capacity to work in such a demanding project.

In the same way, institutions for Ecosystem Services (or carbon sequestration projects) are new, therefore, Ătheyshould be flexible enough to adapt to the dynamics of socio-ecological systems é (and) to new conditions (Corbera, *et al.*, 2009). Cachoeiras de Macacu could offer these conditions, because of the technical and human capacity to cope in complex circumstances.

A PES framework should be carefully designed, taking into account: a clear definition of the services that are provided, targeting threatened areas and conditionality (S. Wunder personal communication, 24.04.2010). Therefore workshops that involve the majority of stakeholders will be essential. Community organizations can reduce operational costs (Pagiola *et al.*, 2005), for that reason partnerships that allow exchange of knowledge and that support the overall structure should be encouraged.

GENERAL CONCLUSIONS

The current situation of the landscape in the Cachoeiras de Macacu Municipality (i.e. Atlantic Forest Region) remains us the necessity to seek for options to integrate the complex human-social-environmental conditions in order to enhance the socio-economical well being of the inhabitants, but also to increase the biodiversity and the provision of ecosistemic services. A mosaic of agricultural lands, patches of remaining natural forests and urban and rural settlements make difficult to find conditions to satisfy all necessities.

The methodology here presented, represents a first approach to map the suitable lands for A/R projects under the CDM. It is a rapid assessment methodology that could be developed in municipalities like Cachoeiras de Macacu to prioritize areas and consequently resources. Correspondingly, there is a need to develop rapid and cheaper methodologies to measure potential sites. Likewise, the available information for land use cover is still squat. More research should be done to identify native tree species (fast-grow and economic representative) that can be applicable for LULUCF projects, but also for silviculture and agro forestry practices.

LULUCF methodologies should be multifaceted to be well integrated in conditions like the present in the municipality. For that reason, other CDM modalities like Programmatic CDM and Bundling of Activities have to be explored.

There is a well established overall national framework for CDM projects. Generally, the implementation of LULUCF worldwide is still limited, mainly because of the difficulties to determine available areas and baseline, accounting of carbon pools and carbon sequestration potential as well as the costs related to the design and implementation of projects. Other problems are the specificity of the existing methodologies, the size of the lands and difficulties to demonstrate additionality. External dilemmas include financial schemes and technology transfer.

The stakeholder network directly related to CDM activities is relatively small and has overall good relations, principally at international and national level. Nevertheless, relationships with local and regional stakeholders, as well, as potential project participants dond exist until a project is developed.

Historical deforested areas (like Cachoeiras de Macacu) have relatively high suitable areas for LULUCF, but also high demand for food production and lands for settlements (situation that will intensify with the COMPERJ). Lands are highly parceled and under pasture or agricultural use. This fact sets a contraction that can lead to the conclusion that buffer zones of megacities in developing countries constitute ideal scenarios for Payment of Ecosystem Services frameworks. And definitely other mechanisms like REDD should be implemented and enforced to avoid deforestation and GHG emissions.

The limitation above describe also lead to the conclusion that there are other existing frameworks like the ICMS ecologico, voluntary carbon markets and PES that have demonstrate to be more effective than the CDM. A deep change has to be enforced and other modalities like REDD should be ratified.

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ANNEXES

ANNEX 1

SEMI-STRUCTURED INTERVIEW MODEL

According to in person or institution that participates from the interview, the questions were changed or altered. As stated in the methodology, this questionnaire corresponds to a semi-structured interview model, therefore, in all cases more questions have been added o suppressed.

- How are you/ your institution related to carbon sequestration projects?
- What could roll your institution play in carbon forestry projects?
- Was the process to follow in case of a silviculture project with exotic species?
- According to your personal opinion which should be the parameters to approve LULUCF projects under the CDM?
- What are the opportunities for large-scale projects? What are the possibilities for small-scale projects?
- What you think are the principal reasons (barriers) for the lack of LULUCF projects in Brazil, in Cachoeiras de Macacu?
- Which are the circumstances in which LULUCF projects are possible in protected areas?
- What are the main barriers for your institution to get involved in carbon forestry activities?
- Which are possible incentives to promote LULUCF projects?
- Do you know any project /institution involved in carbon forestry projects?
- Do you have contact with any other institution/person related to carbon sequestration activities?

ANNEX 2

INTERVIEWS LIST

Barbosa da Silva, Demostenes. Environmental Management and Carbon Credits, AES Tieté Director. Coordinator of the CDM AES Tiete Afforestation/ Reforestation Project in the State of Sao Paulo, Brazil (under revision) and the methodology AR-AM0010 ver.3. Interviewed on 30.04.2010.

De Freitas Davies, Maria de Lourdes. Director of the Development and managerial Institute for the Environment- IMAH and Executive Secretary of the Brazilian Agroforestry Net ï REBRAF. A NGO dedicated to the promotion of agroforestry land-use alternatives in Brazil. Interviewed on 11.05.2010.

Franco de Oliveira, Andrea. Coordinator of the Geoporcessing Center of the State Secretariat of Environemnt - INEA. Interviewed on 20.04.2010.

Locke, Nicholas. Project Manager. Reserva Ecologica Guapiacu, REGUA. A Ecological reserve that restores Atlantic Forest through reforestation of degraded pasturelands in Cachoeiras de Macacu. Interviewed on 30.03.2010.

Matos da Mata, Tabita. Secretaria de Meio Ambiente. Prefeitura Cachoeiras de Macacu. Interviewed on 08.06.2010.

Schaeffer, Roberto. Researcher in the Energy Planning Program (PPE), Coordination for Postgraduate Programs in Engineering (COPPE), Federal University of Rio de Janeiro (UFRJ), Brazil, member of the Methodology Panel on Baseline Emissions and Monitoring of the Clean Development Mechanism of the United Nations Framework on Climate Change (UNFCCC CDM Meth. Panel), and associate editor of two international scientific journals: Energy: The International Journal and Climate Policy. Interview on 14.05.2010.

Vianna, Gabriela. 2010. Sustainable Landscapes Program Coordinator, Instituto Bioatlantica. IBio develop a restoration program for Permanent Preservation Areas (APP) in Cachoeiras de Macacu. Interviewed on 29.04.2010.

Wunder, Sven. Principal Scientist, Forest and Livelihoods at the Center for International Forestry Research (CIFOR) dedicated to Payments for Environmental Services, Deforestation (REDD) and poverty. Interviewed on 07.05.2010.