FINAL REPORT for APN PROJECT

Project Reference Number: **EBLU2010-01NSY(R)-Suneetha**

Evaluation of Trade-offs between conservation and development- Case of land use change in Malaysia and Indonesia

The following collaborators worked on this project:

Project Leader: Suneetha M.S, UNU-IAS , Japan, Subramanian(at)ias.unu.edu

(Collaborators: Heli Lu, UNU-IAS and Henan University , China, luheli(at)gmail.com

Claudia Ituarte-Lima, UNU-IAS , Sweden, claudia.ituarte(at)cantab.net)

Jamal Othman, UKM , Malaysia, jortman(at)ukm.my

(Collaborator: Mastura Mahmud, UKM, Malaysia, Mastura(at)ukm.my)

SR Joeni, LIPI , Indonesia , joenisr@indo.net.id

Evaluation of Trade-offs between conservation and development- Case of land use change in Malaysia and Indonesia

Project Reference Number: EBLU2010-01NSY(R)-Suneetha
Final Report submitted to APN

PAGE LEFT INTENTIONALLY BLANK

OVERVIEW OF PROJECT WORK AND OUTCOMES

Minimum 2pages (maximum 4 pages)

Non-technical summary

There is a need for optimum land use management in tropical forest ecosystems given increasing carbon emissions from deforestation. This means that compromises have to be reached between multiple stakeholder priorities- as, governments are interested in maximizing incomes, ensuring employment, augment environmental goals; local communities in ensuring their livelihoods, access to sacred areas, etc; businesses in exploiting natural habitats and resources suited for commercial purposes and so on. This project attempts to identify the trade offs in land use decisions and develop a decision support system that will incorporate various biophysical and social parameters determining land use options that may be useful for a planner. Biophysical parameters include indicators such as area and type of forest, species richness, water regulation capacity/ soil erosion among others. Data for this was obtained from records and remote sensing maps.

Social parameters include indicators such as income from different forest based commercial and livelihood activities, rights to forests and resources of traditional dwellers, cultural value, among others. Data obtained from participatory interviews and biophysical records are subjected to an integrated analysis to enable an understanding of drivers of ecosystem change and likely outcomes if different development scenarios are pursued.

Objectives

The main objectives of the project were:

1. Examine the impacts of the different kinds of plantations (Rubber and Oil Palm) on the biodiversity and species interaction in the regions using multi-temporal satellite image analysis, field surveys and relevant indices such as species richness index.
2. Estimate the carbon flux of the plantation systems combining geo-spatial techniques (GIS, Remote sensing) with ground based measurements and existing national accounting estimates
3. Conduct economic valuation for the land use options and identify the opportunity costs of conversion from forest to plantation for various stakeholders, particularly local communities, businesses and governments
4. Develop a decision tool incorporating both conservation and economic development choices
5. Identify implications for policies such as Reduction of Emissions Due to Deforestation and Degradation (REDD).

Amount received and number years supported

The Grant awarded to this project was:
US$ 35,5000 for Year 1

Activity undertaken

1. Field research
2. Mapping land use data for study sites
3. Understanding policy frameworks within which decisions are made
4. Data analysis
5. Organized an International Symposium on Costs and Benefits of REDD plus: What, Who, How and When from 19-20 Sep,. 2011 at Kuala Lumpur, Malaysia. This was co-organized with

Hiroshima University, Forest Research Institute Malaysia, the Ministry of Natural Resources and Environment, Malaysia,Forest and Forest Products Research Institute, Japan and the Research Institute for Humanity and Nature, Japan

Results

The project was carried out in 2 study areas in Malaysia (Sibu, Sarawak) and Indonesia (Pulang Pisau, Central Kalimantan)- both on the island of Borneo. The sites therefore share a contiguous area with similar geographical characteristics, although politically distinct. Field data indicate large scale land use changes of forested land to plantations. The conversion has been most rapid from the 1990-2000 period, with rate of conversions peaking in Indonesia around 2000 (Forest Resource Assessment of FAO, 2010). Several factors determine continued momentum of deforestation- almost all of which are related to human activity. While agriculture is a major economic activity in the region, other activities that led to large scale deforestation related to timber logging, and ad-hoc felling of forest lands to open them up for rubber and oil palm plantations. These plantations – some of which are now classified as planted forests- were established quickly to capitalize on a growing export demand for the products. In Indonesia, the region is also the site identified by the government to transmigrate populations from other islands supposedly without sufficient consultation with the communities living there or a complete appreciation of the ecological pressures to the landscape.

The biophysical indicators chosen for the study relating to the forest area, biodiversity loss, water erosivity show negative trends. In this context, the introduction of principles related to REDD-plus (to reduce deforestation and forest degradation, ensure sustainable management of forests and maintain or enhance carbon stocks) has been examined through a scenario analysis. The study analysed, through a Cellular Automaton Model , the likely changes to the different biophysical parameters if different land use choices were made- assuming 3 scenarios : business as usual (BAU), higher economic development and a situation prescribing to REDD-plus principles. While the results show that following the REDD-plus principles would be good for the forests and perhaps bring in revenues subject to a effectively-running carbon market, the analysis of field data and legal architecture indicate that several issues related to governance and equity need to be tackled to ensure acceptance of the scenario.

Relevance to the APN Goals and Science Agenda, Scientific Capacity Development and Sustainable Development

We believe that the project will contribute to the literature on vulnerability of human-environment systems, which is at the core of environmental policy given the unprecedented scale and pace of anthropogenically-induced land changes in the Asia-Pacific region. The assessment model we propose is, we believe , easily adaptable within a developing country research and planning context. By focusing equally on the issue of land use management from an environmental, social and economic perspective, we believe that what we propose as an analytical process- could be one of the tools to ensure sustainable use of forest ecosystems and ensure a more equitable relationship between the different stakeholders.

Self evaluation

The project allowed us to explore ecosystem changes within a similar geographical context under different political contexts. It also enabled us to network with academics and policymakers in the region. For the team of researchers, being from different disciplinary backgrounds- it was a learning experience to integrate disciplinary methods. Despite good progress in the project, we were severely challenged on time, due to the unforeseen catastrophe of the Japanese earthquake in March. Our planning schedules were affected by 3 months, which affected the social surveys for field data collection, since by the time we could go to the field, the respondents got busy with their seasonal activities. We therefore are still in the process of completing our data compilation and finalizing the development of a prototype of a decision support tool. Nevertheless, we are pleased with the quality of data that we have obtained and consequently the integrity of our inferences.

Potential for further work

There is much policy interest in exploring multiple benefits that can be obtained from management of forest ecosystems, as evidenced by the new toolkits that are being developed within the REDD-plus framework. Increasingly, researchers and policymakers are focusing on expanding REDD-plus to encompass the sustenance of various ecosystem services – provisioning, regulating, supporting and cultural. By focusing on factors affecting deforestation and degradation of forests as essentially a compromise between stakeholder interests from policy makers to businesses to local communities, our study gives a mosaic view of the issues involved in arriving at various land use and management decisions in the study areas. However, we are aware that the analysis can be strengthened further especially by including inputs from specialists such as conservationists and hydrologists. The work can serve as a basis for further analysis of institutional interplays and roles of various agents in decision making to enable more comprehensive decision making.

Publications (please write the complete citation)

1. Lu, Heli, 2011, Challenges of Proposed REDD+ Mechanisms on Carbon Stocks and Ecosystem-based and Social Benefits, UNU-IAS Working Paper No. 165 available at http://www.ias.unu.edu/sub_page.aspx?catID=7&ddlID=196

2. Ituarte-Lima, C & McDermott, CL (forthcoming) 'Operationalising equity in national legal frameworks for REDD+: the case of Indonesia'. To be submitted to the Environmental Science and Policy Journal.

3. Ituarte-Lima, C & Subramanian, S (forthcoming) 'Are there lessons for climate change legal negotiations from access and benefit sharing agreements?' in Linkages between Climate Change and Biodiversity, Edward Elgar Publishing.

4. Suneetha.M.S, Jamal Othman, Heli Lu, Joeni Rahajoe and Mastura Mohammed, (forthcoming), Integrated Planning Tool for Effective Monitoring and Implementation of REDD Plus', Proceedings of the International Symposium on Costs and Benefits of REDD plus: What, Who, How and When, Kualalumpur, Malaysia, Sep 19-20, 2011.

Presentations

Suneetha.M.S, Jamal Othman, Heli Lu, Joeni Rahajoe and Mastura Mohammed, 2011, Integrated Planning Tool for Effective Monitoring and Implementation of REDD Plus', at the International Symposium on Costs and Benefits of REDD plus: What, Who, How and When, Kualalumpur, Malaysia, Sep 19-20, 2011.

Joeni S. Rahajoe, Alhamd, L., Simbolon, H., Suzuki, E. and Kohyama, T, 2011, Carbon stock and Biomass production in various ecosystem types in Indonesia to support REDD Program, at the International Symposium on Costs and Benefits of REDD plus: What, Who, How and When, Kualalumpur, Malaysia, Sep 19-20, 2011.

Ituarte-Lima, C & Subramanian, S 2011 'Legal dimensions of equity in payment for ecosystem services', invited speaker at the Oxford Centre of Tropical Forests, University of Oxford, 17 June 2011.

Ituarte-Lima, C & Subramanian, S 2011 'Are there lessons for climate change legal negotiations from access and benefit sharing agreements?' in the Seminar Climate Change Legal Negotiations: Implications for Forest Governance, Equity and Livelihoods, United Nations University- Institute of Advanced Studies, Yokohama, Japan, 9 March 2011. The video of the presentation can be found at http://www.ias.unu.edu/sub_page.aspx?catID=159&ddlID=737.

References

Dambul, R. and Jones, P., 2007. Regional and Temporal Climatic Classification for Borneo, Geografia Online, Malaysia Journal of Space 3, 84-105.

FAO, 2011, State of the World's Forests 2011, FAO, Rome.

Jamaludin, J., 2002. Sarawak: peat agricultural use. European Commission Inco-Dev Final Report, Strategies for implementing sustainable management of peatlands in Borneo. Available at: http://www.strapeat.alterra.nl/download/Final%20report%20STRAPEAT.pdf

Miettinen, J., C. Shi, S.C. Liew, 2011. Deforestation rates in insular Southeast Asia between 2000 and 2010. Global Change Biology. Global Change Biology Volume 17, Issue 7, 2261–2270

Melling , L., Ambak, K., Osman, J. and Husni, A. 1999. Water management for the sustainable utilisation of peat soils for agriculture. Paper presented at the International Conference & Workshop on Tropical Peat Swamps, 27- 29 July 1999, Penang, Malaysia.

Millennium Ecosystem Assessment, 2005, Ecosystems and Human Well-being Biodiversity Synthesis, World Resources Institute, Washington D.C.

SCBD, 2010, Global Biodiversity Outlook 3, Secretariat of the Convention on Biological Diversity, Montreal.

Sarvision, 2011. Impact of oil palm plantations on peatland conversion in Sarawak 2005-2010.Available at: http://www.wetlands.org/Portals/0/publications/Report/Malaysia%20Sarvision.pdf

UNFCCC. Report of the Conference of the Parties on its Thirteenth Session, Heldin Bali from 3 to 15 December 2007. 3 to 15 December 2007, 2008.

Von Neumann, J. 1966. Theory of Self-Reproducing Automata. University of Illinois Press.

Wolfram, S. 1984. "Cellular Automata as Models of Complexity." Nature 311:419-424.

Acknowledgments

- Dr. Suwido Head, CIMTROP, Palangkaraya, Indonesia
- Secretary of Anjir Pasau Village and the local villagers of Anjir Pasau
- All respondents to social surveys
- Dr. Rizaldi Boer, CCROM, Bogor, Indonesia
- Dr. Herminia Francisco, EEPSEA, Singapore
- Dr. Sonya Dewi, ICRAF, Bogor, Singapore
- Dr. Muhammad Ardiansyah, CCROM, Bogor, Indonesia
- Wendy Elliott, UNU-IAS

TECHNICAL REPORT

Minimum 15-20 pages (excluding appendix)

Preface

Changes in land use and management systems are endangering the provision of various ecological services obtained from tropical forests. These are largely determined by factors that are economic, socio- cultural and political in nature - alluding to a multiplicity of actors and priorities in obtaining specific services from the lands, entailing several trade-offs among stakeholder preferences, rights and obligations.

Seeking to identify optimum land use management options in forest ecosystems in the tropics, we attempt to develop an interdisciplinary methodology that integrates methods from remote sensing techniques, and social science to capture historical changes to ecosystems, their services and drivers.

Table of Contents

1.0 Introduction

It is well acknowledged that changes in land use and management systems are endangering the provisioning of various ecological services obtained from tropical forests (Millennium Ecosystem Assessment, 2005; SCBD, 2010). Forest ecosystems are vulnerable to high land use conversions given their productivity and amenability to various activities of interest to economic growth (FAO, 2011). These land use changes are determined by a variety of factors that are economic, socio- cultural and political in nature (Braimoh *et al*, 2010).

This also alludes to the multiplicity of actors and their priorities in obtaining specific services from such productive lands. At a minimum this includes the government (with interest in conservation, ensuring economic development and fostering welfare of different groups of people); conservationists (with interests related to ensuring the protection of environmental resources), businesses (that are interested in exploring economic opportunities) and indigenous and local communities (who seek to obtain continued access to resources, sustained livelihood benefits, and cultural and aesthetic services). Clearly, sometimes interests overlap and at other times they are in contention between the stakeholders. Thus land use decisions entail several trade-offs among stakeholder preferences, rights and obligations.

REDD-plus and land use management

It is estimated that about 20-25% of global carbon emissions are a result of deforestation and loss in the quality of forests to provide different services (degradation). In an attempt to stem the widespread loss of forests, the UNFCCC came up with a market based incentive mechanism widely referred to as REDD (Reducing Emissions from Deforestation and Forest Degradation) (UNFCCC, 2007). REDD, and subsequently REDD-plus, attempts to provide financial incentives to reduce CO_2 emissions resulting from deforestation and degradation besides aiming to expand the role of forests as carbon pools as one of a mitigation strategy to climate change in developing countries. This is done through a transfer of funds from one stakeholder to another country where deforestation is avoided, through a market, market-linked or voluntary fund mechanism. Technically the value of the fund is calculated on the basis of the extent of carbon emissions avoided relative to the price of carbon, although various other models referring to opportunity cost foregone or voluntary donations are also negotiated. While considered as an incentive with a high likelihood of success, discussions on the implementation of the mechanism also recognized that these ecosystems are home to people whose livelihoods are linked to the resources within., and hence any implementation strategy should consider the potential impacts on people and other environmental benefits (such as biodiversity conservation).

In essence then, the problem REDD-*plus* tries to redress is to ensure an appropriate land use management strategy in forest ecosystems. It is expected to give due weightage to issues related to socio-economic concerns and biophysical concerns – the people and the nature.

Objectives of research

It is in the above context that we have set our research objectives. Through our research, we seek to identify optimum land use management options in forest ecosystems in the tropics, especially in the light of limiting carbon emissions from deforestation- arising from different land use decisions.

We seek to do this by developing an interdisciplinary methodology that integrates methods from remote sensing techniques, economics and other social science methods to capture historical changes to ecosystems, their services and the drivers of such change. This is an attempt to integrate methods from the biophysical and social science streams to develop a decision support tool that would enable practitioners and policymakers to assess the benefits and costs of various land use decisions. As the mechanism for implementing REDD+ fundamentally involves land use decisions, we believe that such integrated approaches will allow us to combine analysis of trends obtained from maps with adequate ground truthing.

Two study areas in Indonesia and Malaysia were selected for this study. One site is based in Pulang Pisau district in Central Kalimantan, Borneo, and the second site is in Sibu, in the state of Sarawak, also on Borneo island (Figure 1).

Figure 1: Study site location

Source: www.borneo.com.au

2.0 Methodology

The research attempts to integrate data obtained from remote sensing maps and records viz., meteorological and environmental records with data obtained from participatory socio-economic surveys. The changes to land-use data obtained from the maps and records will be analysed alongside drivers of such change obtained from the social surveys to derive a comprehensive forecasting model.

Remote sensing techniques can monitor changes in the forest areas and area changes within the forest degradation. The historical reference scenarios through an approach of spatially tracking of land use conversions over time can be monitored by a Landsat-type image of 30 m (medium resolution) for a minimum mapping unit of 1 to 6 ha.

A cellular automaton system (CA), in which the cell in regular grid changes to finite number of possible states according to a local interaction rule (Von Neumann 1966; Wolfram 1984), was utilized to predict land use changes. CA has been very successful in view of their operationality, simplicity and ability to embody both logic and mathematics-based transition rules, thus enabling complex patterns to emerge directly from the application of simple local rules. It presents a powerful simulation environment represented by a grid of space (raster), in which the consequences of trends and policy interventions are visualized by means of dynamic year-by-year land use maps. Transition possibilities depended on the state of a cell, and the state of its surrounding cells such as elevation, vegetation, soil, road, river etc.

Variables

For land use simulation in CA, a number of biophysical and socio-economic parameters act as the factors of land use change. In this study parameters are categorized into two main groups: bio-physical parameters and socio-economic parameters (Table 1).

Table 1. Parameters in CA

Category	Data description
Bio-physical parameters	Elevation
	Slope
	Aspect
	Soil type
	Forest biomass
	Soil carbon density
	Distance to river
	Distance to road
	Distance to previously deforested land
	Distance to village
Socio-economic parameters	Land tenure map
	Protected/restricted areas, including sacred areas, community lands
	Relative prices (or returns) of competing commodities
	Labor supply
	Government policy

A schematic diagram depicting the general approach in evaluating land use options utilizing the above variables is shown in Figure 2.

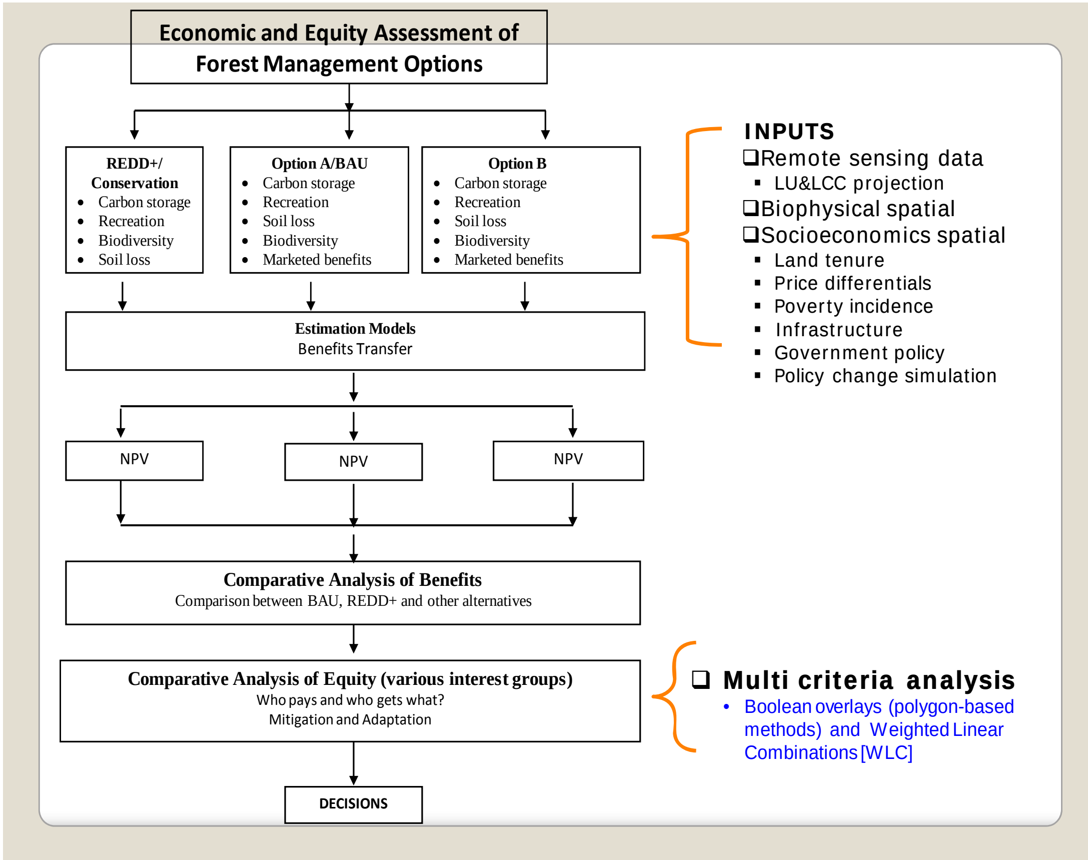


Figure 2: Economic and equity assessment of forest management options

3.0 Results & Discussion

From the field

Both Malaysia and Indonesia are endowed with rich forests, which however are showing signs of deforestation and degradation, primarily to meet various consumption requirements for humans. Over the last two decades, forest area in Indonesia has reduced at the rate of 0.71 % per annum (from 118.54 Million hectares) and at the rate of 0.42 % in Malaysia . They are primarily designated as production forests (62 % of forests in Malaysia and 53 % of Indonesia forests) with some emphasis on conservation of biodiversity and multiples uses (FRA, 2010). The share of planted forests to primary and naturally renewed forests is rising in both countries resulting in an annual rate of carbon-stock reduction in living forest biomass at the rate of 1.7% per annum (Indonesia) and 0.8% (Malaysia) during the period 2005-2010*)*. Conversion has been most rapid from the 1990-2000 period, with rate of conversions peaking in Indonesia around 2000 (FRA, *ibid)*. While in both countries, the forests are predominantly considered as publicly owned, their administration appears to be shared by the government or public bodies (90% in Malaysia .; 43% in Indonesia) and business interests (10% in Malaysia and 57% in Indonesia) , indicating pressures from different sets of stakeholders. Several factors determine continued momentum of deforestation- almost all of which are related to human activity.

Southeast Asia is home to 25 million hectares of peatlands, or 60% of all tropical peatlands. Borneo island has some of the most biodiverse peat swamp forests, 80% of which are in Kalimantan, Indonesia; 11% in Sarawak, Malaysia and a small percentage in Belait, Brunei Darussalam. Peat swamp forests have high root to shoot ratios and occur on organic-rich soils that can be up to several meters deep (Komiyama et al. 2008, Fujimoto et al. 1999, Page et al. 2002). There are about 441,000 Km of tropical peatlands ~11% of the total peatland area; volume is ~18 -25% (Page et al. 2010).Total Carbon (C) stored in these ecosystems may be among the largest forest C pools on earth. Peat swamp forest also provides a vast number of ecosystem services, but in this ecosystem, deforestation rates are very high resulting in high levels of carbon emissions. Consequently, peat and mangrove forests are especially valuable as sites for REDD strategies.

Malaysia

Sarawak, as the largest state in Malaysia, has the biggest reserve of peat land, with approximately 1.5 million hectares of peat land. Presently, an increasing area of the peat land is converted into agricultural land (Jamaluddin, 2002). There are approximately 554,775 ha of peat under cultivation in the state of Sarawak (Melling and Ambak, 1999), mostly as oil palm.

A study by Sarvision (2011) reported that the deforestation rate over entire Sarawak showed an increasing trend for the period 2005-2010. From 2005 to 2007, 1.89% of the total forest cover was cleared, compared to 2.14% from 2009-2010. Miettinen et al (2011) found that an average of 7.7% of peatland has been cleared annually during the period 2000-2010.

Meteorological data such as total monthly rainfall and mean monthly temperature were studied for a 30 year period from 1980 to 2010 for Sibu in Sarawak.

According to Dambul and Jones (2007), based on preciptation data from 1968-2001, Sibu falls under a Samarahan climatic group, while Pulang Pisau in central Kalimantan falls under the Sintang climatic group. The Samarahan climate has its lowest precipitation during the late southwest monsoon, while its highest rainfall occurs during the northeast monsoon. The driest 3 months occur from May to August, while the wettest months occur from December to February. The Sintang climatic group receives its lowest precipitation during the northeast monsoon, while maximum precipitation occurs during both the northeast and southwest monsoons. The driest months occur from June to September (Dambul and Jones, 2007).

Ground truthing and rapid social impact appraisals of the study areas in Sibu and Mukah districts in Sarawak Malaysia shows very clear links between infrastructural development such as bridges and highways on deforestation for oil palm expansion. Socio economic variables such as land tenure and labor availability from neighboring Kalimantan (Indonesia) also add to the dynamics of forest conversion in Sarawak. Specifically, when land is alienated to private companies including state-owned companies, more pronounced expansion of oil palm areas from forest conversion is seen. On the other hand, oil palm cultivation among the natives is mainly in the form of scattered, unorganized, small farm holdings. There are also cases where the natives attempted to forge partnerships with the private companies to develop the Native Customary Rights (NCR) areas for oil palm development. Overall, while oil palm expansion has been able to generate new value adding activities to the state economy, there is little indication that such developments have been instrumental in providing stable employments and hence poverty alleviation impacts among the poor indigenous communities. There is also no certainty if oil palm expansion in the state which affects the mainly biodiversity rich and environmentally sensitive peat lands areas would result in net economic benefits to the state and the country at large when the non-marketed benefits and costs are taken into consideration in the economic appraisals.

Figure 3 a and b : Photos of new oil palm plantations in Sibu, Malaysia

Figure 4: Forest clearing for plantations

Figure 5: Sacred areas for communities in Mukah, Sibu

Figure 6: Long House, Selangau, Sibu

Indonesia

Central Kalimantan is the biggest province of Kalimantan, It occupies about 153,800 Km2, and lies on the equator lines of 0°45 NL to 3° 30 SL, and 111° to 116°EL. About 67% of the area is covered by forest, while swamps, rivers, lakes cover approximately 2%, and agriculture land is about 7%, plantation about 4.3 %, settlement and building about 0.81%. Palangkaraya is the capital city of this province, which is located in the upstream regions of Kahayan River. The town occupies an area of about 2,400 Km2. Plantation area covers 3,139,000hectare including commodities of palm-oil, rubber, rattan, coffee, cocoa and coconut. Food crops cover an area of 5,980,750 Hectares with commodities of paddy, cassava, pineapples, corns, bananas, rambutan and cempedak (local fruit).

Forests in Central Kalimantan are chiefly peat swamp forest, with peat depth varying from 2 – 12 m. Given that peat swamp forest stores the most carbon among different forest types, this province was selected for a pilot project on REDD in Indonesia supported by funds from Norway.

Central Kalimantan also faces landuse change problems. Based on the plantation distribution data (2010), the rubber and oil palm plantation have increased since 2007. Currently, the total plantations were about 1.8 million ha, 70 and 25% of them are oilpalm and rubber plantation respectively.

Pulang Pisau District

Pulang Pisau Regency is part of Kalimantan Tengah Province, located between 10º - 0º S and 110º - 120º E. In 2002, Pulang Pisau became a new regency separated from Kapuas Regency as the main regency and consisted of 6 districts. After the passing of the Autonomy Region Acts, Pulang Pisau was further subdivided into 8 districts- Kahayan Hilir, Kahayan Tengah, Kahayan Kuala, Pandih Batu, Maliku, Banama Tingang, Jabiren Raya and Sebangau Kuala.

Total area of Pulang Pisau Regency is 8.997 km² or 899.700 Ha (5,85 % from the total area of Kalimantan Tengah Province), which is divided into two big areas, the ebb tide area (in the south area) potentially suitable for food crops agriculture, while the non ebb tide area (in the north area) is suitable for estate crops area. The areas are divided into: Protected area: 1.961 km², Peat swamp forest (2.789 km²), mangrove (280 km²) and Wetland (65 km²). Gross Regional Domestic Product of Pulang Pisau Regency by industrial origin at current market prices from 2002 – 2007 shows that most returns came from agriculture industrial origin at a magnitude of 538.050 million Rupiah which has increased from the previous year and the least from mining (around 2.484 million Rupiah). River/water transportation is used to trade agriculture product in the capital city of Pulang Pisau.

The temperature in Pulang Pisau on an average is about 21º C to 23º C and the highest temperature reaches 36º C. The highest rainfall occurs between October to March, with the rainfall volume about 2,000 mm to 3,500 mm every year. Pulang Pisau Regency also has two rivers Kahayan River (± 600 km), Sebangau River(± 200 km) and a coastal area of Java Sea, (± 153,4 km). There are 92 villages in Pulang Pisau Regency.

Sebangau Kuala district is the biggest district of Pulang Pisau administrative region. With an area of 3.801 km² (around 42,25 % of total area), Sebangau Kuala has eight villages. The smallest district is Kahayan Hilir, which only has 360 km² (around 4% of total area), although it has the highest population density (68 inhabitants per square kilometer). Pulang Pisau Regency was a predominant area for transmigration of population from Java Island in 1980's. As mentioned, in the Pisau Regency, the percentage of forest area is bigger than agriculture or estates area, providing various forest products in Pulang Pisau such as rattan, honey and sawn timber.

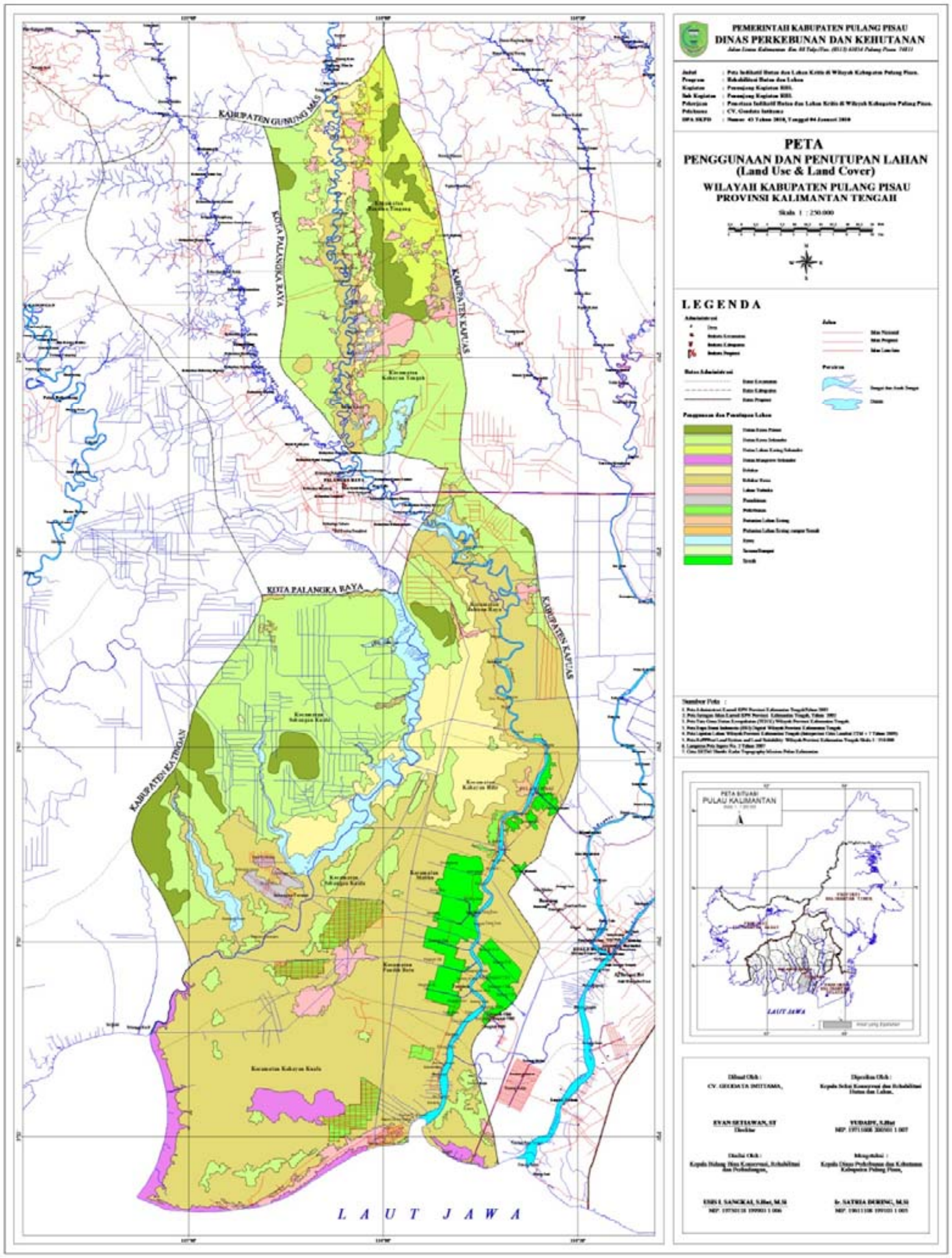
Study Site : Anjir Village in Kahayan Hilir District.

Anjir Village is the Capital City of the Pulang Pisau Regency. Anjir Village belongs to the Kahayan Hilir District. Table 2 below shows the Demography of Kahayan Hilir District.

Table 2 Demography of Kahayan Hilir District

	House Hold	Man	Women	Total	Village area Sq.km	Density (per km^{2-})
KAHAYAN HILIR	**5.648**	**12.308**	**11.597**	**23.905**	**360,00**	**66,40**
01. Buntoi	609	1.146	1.154	2.300	90,00	25,56
02. Mintin	587	1.161	1.305	2.466	48,00	51,38
03. Mantaren II	460	1.036	993	2.029	4,99	406,61
04. Mantaren I	361	630	690	1.320	55,01	24,00
05. Pulang Pisau	1649	3.908	3.162	7.070	66,40	106,48
06. Anjir Pulang Pisau	757	2.004	1.995	3.999	22,20	180,14
07. Gohong	669	1.252	1.208	2.460	60,00	41,00
08. UPT. Anjir P.Pisau	395	795	782	1.577	7,80	202,18
09. Kalawa	161	376	308	684	5,60	122,14

Figure 7 Pulang Pisau Spatial plan (Pulang Pisau Statistical Bureau, 2010.)



Participatory Rural Appraisal (PRA) was conducted in Anjir Pulang Pisau Village based on a semi-structured questionnaire (Figure 2).

Figure 3. Discussion in the secretary of Anjir Pulang Pisau Village (left), rubber tree plantation behind the houses in the Anjir Pulang Pisau Village (right).

Effect of Landuse change in Pulang Pisau and comparative study in Klampangan Village

Klampangan

In 1995, a million ha mega rice project was established in the peat swamp forest in Klampangan about 60 km from Palangkaraya (Capital City of Central Kalimantan Province), that involved building of water channels and roads to enable rice cultivation. Biological and physical factors underwent changes including: decreased biodiversity, decreased water level in the peat swamp forest, subsidence in the peat swamp forest and frequent forest fires in this area. These are attributed to the forest degradation and establishment of canals for water irrigation in the project area (Figure 4). The length of canals from Kahayan to Sebangau Rivers is about 4,470 Km, whose establishment has decreased water levels especially during the dry season. Therefore the local government and university tried to block the canals by using small dams. However, the establishment of dams to block water further affected water levels. About 16 years after establishment of canals, resettlement of people from the streets of Klampangan village to the Sebangau river area has been proposed (see Figure 5). This is expected to affect the ecosystem and biodiversity of the forests, due to chances of increasing forest fires and impacts of human disturbance.

Figure 8. Canal in the Klampangan during dry season (left) and dams were established to protect the water level in the canal which were built during the Mega rice project in Klampangan (right).

Figure 9. Resetlement was established along the canal (Left) and canoe for the transportation along the canal (Right).

Anjir Village (Pulang Pisau District)

Pulang Pisau area is far from Million hectare mega rice project. This Regency is located in the down stream of Kahayan Watershed. Almost all areas along Kahayan watershed was converted to rubber tree plantation since Holland colonialism. With the booming of oil palm plantation in Kalimantan, some of the area was converted into Oil palm Plantation. The plantations mainly belong to Private Companies. Some of the oil palm plantations are new as seen in the figure 10. The palms are cultivated in large area and some times in combination with rubber tree (Figure 11, 12).

Figure 10. New oilpalm Plantation in Pulangpisau Dictrict, Central Kalimantan.

Figure 11 Mixed Oil palm and rubber plantation in the Pulang Pisau Regency.

Figure 12. Small canal near Oil palm plantation for irrigation.

The oilpalm plantations distributed in the Pulang Pisau region are new plantations as seen in the data from the BPS (Center for Statistical Bureau, 2010). Oil Palm plantation in Pulang Pisau Regency is one of the lowest in the area (Figure 9), possibly due to the establishment of rubber plantation since Holland Colonialism (besides the competitive price of rubber). The major crops cultivated in the area are coconut, rubber and paddy as highlighted below.

Figure 13: Oil Palm distribution in Pulang Pisau, (2010)

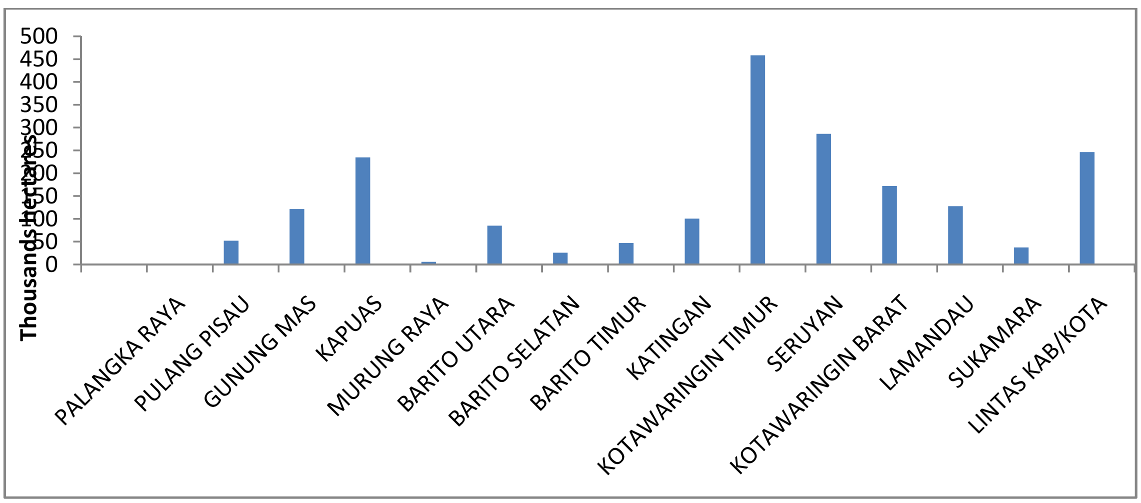
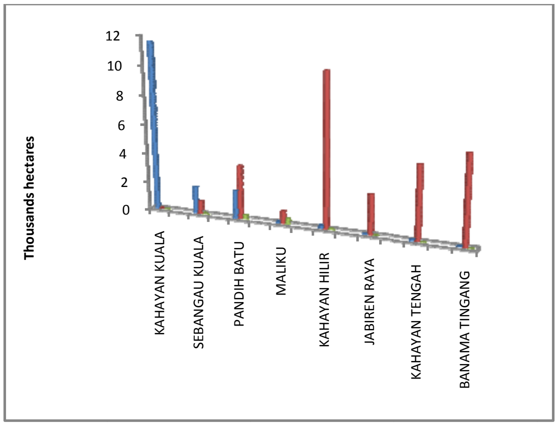


Figure 10. Coconut, rubber and coffee plantation in hectares (2007)

Figure 11. Coconut, rubber and coffee production in ton (2002-2007)



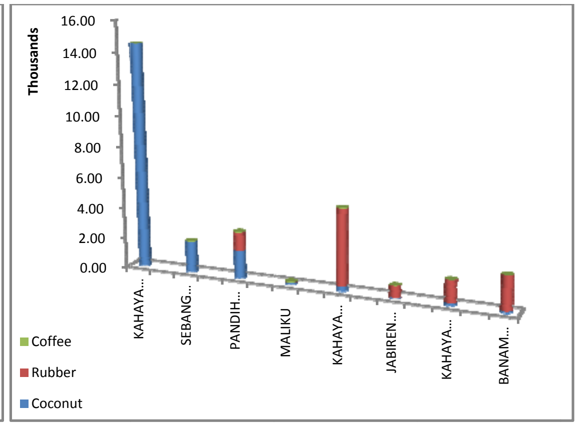
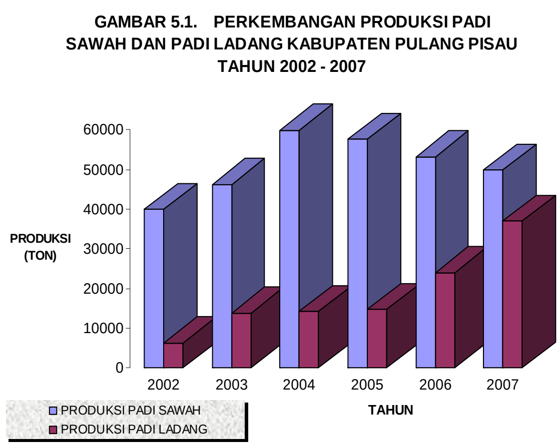


Figure 12. Rice production in the Pulang Pisau District in 2002 – 2007.



The wetland paddies production in the Pulang Pisau District increased since 2002 – 2004 and decreased gradually until 2007, while the dryland paddies production increased since 2002 until 2007 (Figure 12). The harvested area of wet land paddies in 2007 were 15.157 hectares with production around 49.896 tons. Meanwhile the harvested area of dry land paddies in 2007 were

12.722 hectares with total production around 36.928 tons. This preference for upland rice is rising due to increasing crop destruction from unseasonal flooding.

Legal dimensions of forests and equity in the context of REDD-plus

In Malaysia and Indonesia, equitable legal relationships between forest-dependent people with one or a combination of other REDD+ actors will not develop automatically. Instead, equitable environment-related legal negotiations and policies need to be actively fostered. In REDD+, this implies effective mechanisms to overcome power imbalances in negotiations and difficulties of forest-dependent people in complying with legal requirements.

In the context of payment for ecosystem services, the research has aimed to further the understandings of how equity is or is not addressed in existing land use and climate legislation, especially those aspects related to the content of legal provisions concerning REDD+.

The UNFCCC and associated decisions have not yet spelled out the process for implementing the equity dimensions and social safeguards in REDD+ projects especially at the sub-national level, although efforts appear to be ongoing (UNREDD, 2011)). Hence, it has not been the location where the parameters of equity are being set in practice. In Indonesia, legal dimensions of REDD+ are being shaped, in practice, through REDD+ Ministerial Decrees, as well as by national and pre-exisiting legal instruments such as the Constitution and the Forest Law. (see attached Manuscript)

The analysis of the Indonesian REDD+ Decrees within a multidimensional equity framework reveals how these legal instruments provide specific guidance framing the implementation of REDD+ carbon projects in Indonesia such as articulating various REDD+ stakeholders and and prescribing the distribution of benefits generated by carbon projects. Yet, the equity outcomes of the procedural and distributive rights articulated in these Decrees depend on the broader contextual dimensions of equity such as rights to land, resources and required legal status to engage in contractual negotiations. (see attached Manuscript)

Analytical framework

While some of the data constructs from the field are still being compiled and subjected to analysis, a pilot testing of the model was carried out with benchmarking data from Bawan village study site in Central Kalimantan region of Indonesia. The process of model building and results are highlighted below.

REDD plus payments for reducing carbon and improving ecosystem services aim to set up a development mechanism involving stopping deforestation and promoting sustainable forest management. As mentioned earlier, we aim to integrate biophysical and social variables evaluating potential REDD –plus measures into a land use option framework. It aims to evaluate REDD+ effectiveness on carbon emissions, ecosystem services, biodiversity and social-economic aspects under difference land use scenarios.

Table 3 . Overview of data types and classes used in the study

Data types	Data classes	Source
Land use	Dense forest	Land use maps

	Peatland	
	Sparse forest	
	Cropland	
	Road	
	River	
Biophysical	Elevation	SRTM data from NASA
	Slope	
	Aspect	
Accessibility	Distance to river	Derived from land use maps
	Distance to road	
	Distance to previously deforested land	
	Distance to village	

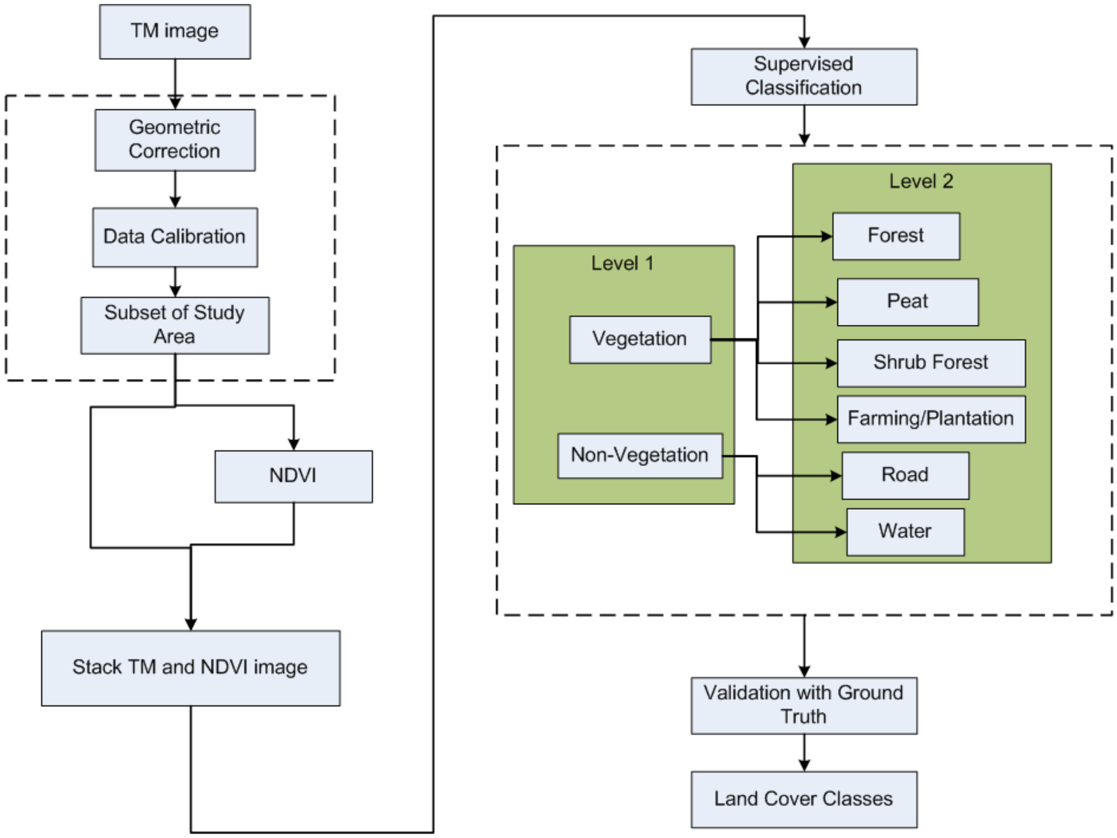
This was done using the following methods:

1 Mapping historical deforestation

In order to map historical deforestation, Landsat images in 1989, 2000, 2005 and 2009 were classified into 6 land use classes: dense forest, peatland, sparse forest, cropland, road and water. According to FAO (1993, 2001), 'deforestation refers to a conversion of forest to other land use such as new agricultural land or unsustainable plantation, or a long-term reduction of the tree canopy cover'. As such changes from dense forest, peatland and sparse forest were included in 'deforestation' category.

The biggest challenge for identifying land use classes in the study area resides in capturing the vegetation variability in dense forest, peatland, sparse forest and cropland. The development of vegetation indices from satellite images like NDVI ameliorated the difficulty to differentiate vegetation's structure and composition through combination of its normalized difference formulation and use of the highest absorption and reflectance regions of chlorophyll (Martinuzzi et.al. 2008; R. D. Jackson et.al. 1993). This led to the utilization of a supervised classification method on combination of Landsat and NDVI data for delineating vegetation classes (Figure 2). Ground truth information through field survey and Google Earth was used to identify areas that corresponded to various classes on the ground, and information about each class was derived from this representative set. This information was located by fieldwork or high resolution air photographs on Google maps.

Fig 13Procedure of remote sensing interpretation



2 Modelling future land use

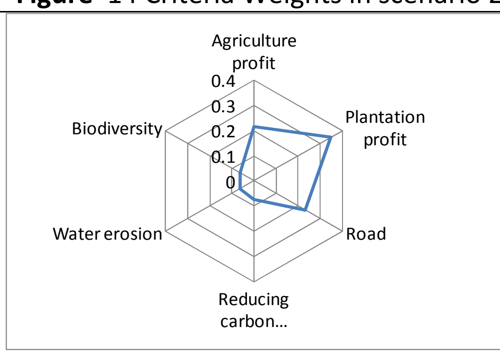
REDD+ can be described as value sets (carbon emissions, ecological services and socio-economic values, etc.) that could be achieved through reasonable land use policy. Its effectiveness could be evaluated by combining multi-criteria evaluation (MCE) and cellular automaton system (CA) techniques under different land use scenarios.

The purpose of the MCE module is to investigate a number of choice possibilities in light of multiple criteria and conflicting objectives (Voogd 1983). The core principle behind MCE is the concept of compatibility for multiple land uses rather than single use. Appropriate criteria are identified after setting the objective. It should be noted that this selection is not exhaustive, and only those criteria for which information is available are considered (Mohd H.vI. 2009). For this reason, agriculture profit, plantation profit, carbon emissions, water erosion and biodiversity were chosen as criteria in this study. The next step involves allocation of criteria weight. It was carried out through pairwise comparison method and analysis hierarchy process (AHP). Pairwise comparison method compares two criteria and allows comparison of two criteria at a time. Meanwhile, AHP provides a mathematical method of translating subjective assessment of relative importance into a linear set of weights (Saaty 1980). Consistent ratio (CR) was used to examine the consistency of selection of pairwise comparisons.

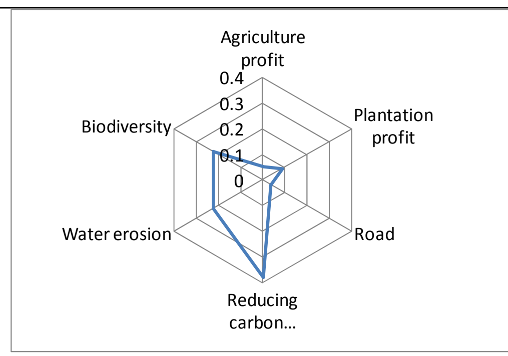
The predictive deforestation module should address two key issues: how much deforestation will take place in the future and where the predicted deforestation will occur. For the first issue, the deforestation rate was determined by demands of agriculture, plantation and road. A cellular automaton system (CA), in which the cell in regular grid changes to a finite number of possible states according to a local interaction rule (Von Neumann 1966; Wolfram 1984), was utilized to predict deforestation location. Transition possibilities depended on the state of a cell, and the state of its surrounding cells such as elevation, vegetation, soil, road, river, etc.

Depending on land use options, a number of scenarios could be generated, leading to different deforestation results for the future. In this study, three important scenarios of business as usual (BAU), economic development and REDD+ were considered, based on the government's policy during the period 2011–2020. Scenario 1 provides a BAU forecast, assuming that the study area will develop at historical deforestation rate. Scenario 2 presumes that the major goal is to maximize production to alleviate the population pressure and increase profit for villagers by focusing on economic development. For this reason, agriculture and plantation area will increase dramatically. Scenario 3 concerns implementation of REDD+. The REDD+ principle calls for minimizing carbon emission and promoting ecosystem services simultaneously through a compensation mechanism, so that sustainable development could be assured. In this respect, reducing carbon emission, reducing water erosion and improving biodiversity are main considerations. Criteria weights in scenario 2 and scenario 3 are presented in Figure 4.

Figure 14 Criteria Weights in scenario 2 and scenario 3



Scenario 2: economic development



Scenario 3: REDD+

3 IPCC inventory method

The methodology in the IPCC guidelines (2006) assumes that net emission is equal to carbon stock changes in the existing biomass between two time-series points. Such carbon stock is obtained through multiplying land area by representative value of carbon density in the corresponding ecosystem. According to IPCC, five carbon pools of C-above, C-below, C-dead, C-litter and C-soil were used in this study. However, only those needed were calculated, depending on their land use change categories (Table xx). According to IPCC guidelines the sign of C gains is always negative (-) and that from emission/losses is positive (+).

Table 4 Guidance to carbon pool selection depending on land use change (modified from Brown, S. 2007)

Land-use change	Biomass		C-dead	C-soil
	C-above	C-below		
From dense forest to cropland	+++	++		
From sparse forest to cropland	+++	++	+	
From peatland to cropland	+++	++	+	

+++ means "always include", ++ means "inclusion recommended" and + means "inclusion possible", blank means "not include".

4 RUSLE model

REDD+ interventions produce more benefits aside from reducing carbon emissions through enhanced ecosystem services. For example, available water holding capacity (AWC) and water quality increase proportionately with forest area. In this study, Revised Universal Soil Loss Equation (RUSLE) was used to evaluate water erosion potential. RUSLE model, which has been widely used to assess water erosion risk related to changes in nature and anthropogenic activities, represents how climate, soil, topography, and land use affect rill and interrill soil erosion caused by raindrop impact and surface runoff (Renard et al. 1997). It is a popular method for measuring the annual water erosion value in tropic regions like Indonesia (Ambar 1986). RUSLE computes average erosion as (Renard 1997):

$$A=R*K*L*S*C*P$$

Where:

A = water erosion indicator of annual soil loss

R = rainfall-runoff erosivity factor

K = soil erodibility factor

L = slope length factor

S = slope steepness factor

C = cover-management factor

P = conservation factor

R factor represents the climate input that drives the sheet and rill erosion process, and differences in R values depict differences in erosivity from precipitation, which was derived from the National Centers for Environmental Prediction (NCEP) Reanalysis data in the study area.

LS factor accounts for the erosion effect from topography, which was computed through Digital Elevation Model (DEM) data from the United States Geological Survey (USGS). The slope length was assumed to be fixed as 15 m according to Ogawa et al. (1997). The topographical factor LS was determined by using the equation recommended by Morgan & Davidson (1991).

C factor is very important as it measures the effects of all the interrelated cover and management variables, which are easily influenced by humans (Renard et al. 1991). It is assumed that abundant vegetation cover associated with a complex stand structure results in less water erosion, whereas bare land lacking vegetation cover protection induces higher soil loss (Kenneth G. Renard et. al. 1991). In the original equation, the factor C is defined as the ratio of soil loss from land cropped under specific conditions to the corresponding loss from clean-tilled, continuous fallow (Wischmeier & Smith 1978). In this study, C factor was estimated based on analysis of NDVI, which gives an indication for differences in green vegetation coverage.

NDVI was scaled to approximate C factor using the following formula, developed by the European Soil Bureau:

$$C = e^{-\alpha \frac{NDVI}{\beta - NDVI}}$$

where α, β are the parameters that determine the shape of the NDVI-C curve. An α-value of 2 and a β-value of 1 seem to give reasonable results (Van der Knijff et al. 1999).

K factor represents the susceptibility of soil to erosion under standard plot conditions, which is determined by the proportions of sand, silt and clay in the soil, the organic matter content, soil structure and permeability. In the study area, information on soil structure and profile permeability was not available. Therefore, it was regarded as a constant in the calculations for the entire area.

P factor is the ratio of soil loss with a specific support practice to the corresponding loss with up and down slope cultivation, which is unusual in this area. Therefore, it was excluded from the calculations.

5 Landscape metrics

Landscape metrics measure the spatial structure of landcover metrics in terms of composition (number, proportional frequency, and diversity of landscape elements within the landscape) and configuration (spatial position and distribution of the elements within the landscape) (F. Giordano and A. Marini 2008). A number of forest fragmentation metrics that describe the forest composition and configuration are listed as follows (McGarigal and Marks 1994): Number of Patches (NP), Patch Density (PD), Largest Patch Index (LPI), Mean Area (AREA_MN), Mean Shape Index Distribution (SHAPE_MN), Area-weighted Mean of Shape Index Distribution (SHAPE_AM), Mena Euclidean Nearest-Neighbor Distance (ENN_MN) and Interspersion and Juxtaposition Index (IJI).

Calculation of forest fragmentation metrics was undertaken using Fragstats, a programme developed by the Department of Natural Resources Conservation, University of Massachusetts (McGarigal and Marks 1994). This study mainly focused on the woody vegetation class including dense forest, peatland and sparse forest, and fragmentation analysis was performed on the land use maps.

6 REDD+ compensation

The so-called “ton-year approach”, which has been discussed in the Intergovernmental Panel on Climate Change (IPCC) Special Report on Land Use, Land-Use Change and Forestry (Watson et al. 2000), was adopted in this study for computing REDD+ compensation. Under this payment framework the compensation fund would be paid year by year by checking the forest management practices on carbon accumulation in order to ensure permanence and to assign liability, rather than verifying the existence of trees in the area and paying only once.

The profits from stopping deforestation through REDD+ compensation mechanism involves two factors: carbon price (USD/ton CO_2) and the amount of CO_2 from avoiding emissions. While forest conservation represents a prime source of low-cost reductions of GHG emissions, especially over the next ten or twenty years, there is no place for these tons in existing carbon market policy frameworks (the Kyoto Protocol, the current EU Emissions Trading Scheme) (EDF 2008). However, substantial progress in measuring forests and addressing leakage would allow REDD+ credits to be used for compliance in cap-and-trade programmes. This could accomplish several goals at once: it would create a powerful incentive for the protection of tropical forests, transform the dynamics for forest protection world-wide, encourage large emissions reductions in tropical forest developing nations, and help preserve the world’s options to avert global warming of more than two degrees above preindustrial levels. In addition, REDD+ credits could help to manage the costs of compliance in countries that take on economy-wide caps helping to create and maintain the political will to achieve deep reductions in emissions (EDF 2008). With the assumption that forest carbon credits in the compliance market would allow all forestry activities in developing countries, including afforestation and forest management as well as reduced tropical deforestation after 2010, the projected carbon price from the Environmental Defense Fund (EDF) was adopted, in which carbon price begins at USD16/ton CO_2 in 2012, then rise to USD24/ton CO_2 in 2020 and maintain at

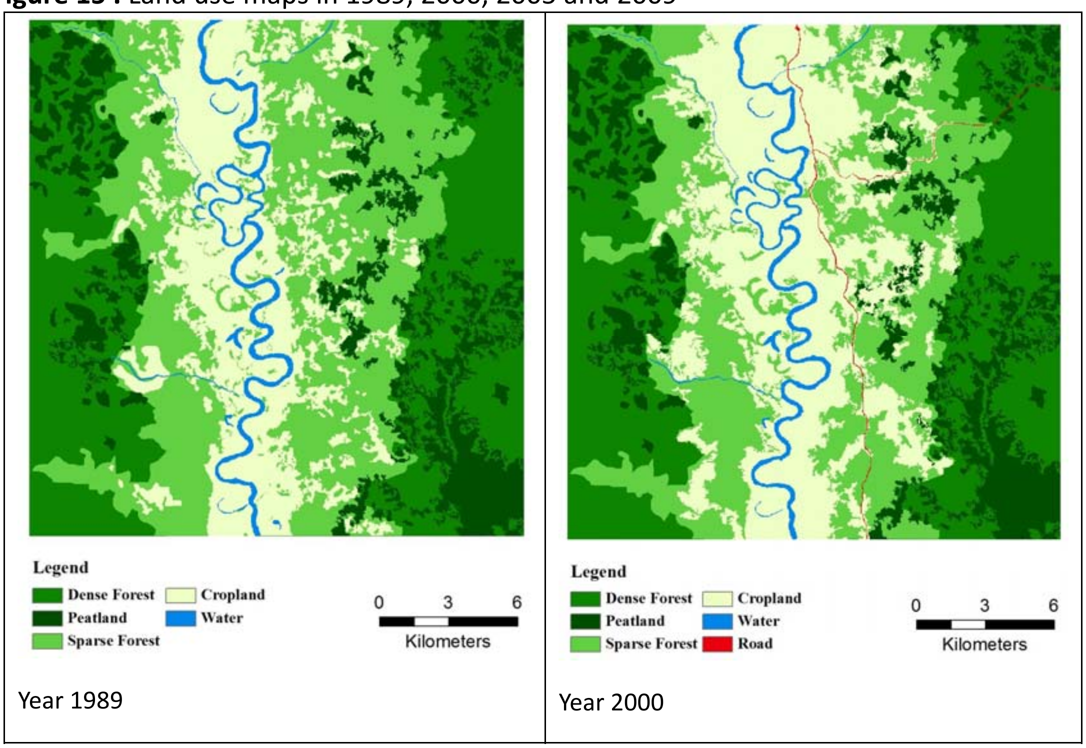
USD40/ton CO_2 till 2035 (EDF 2008). Such profit should remove the initial REDD+ project cost of USD25 per hectare and USD10 per hectare for annual maintenance fee (Thoumi 2009).

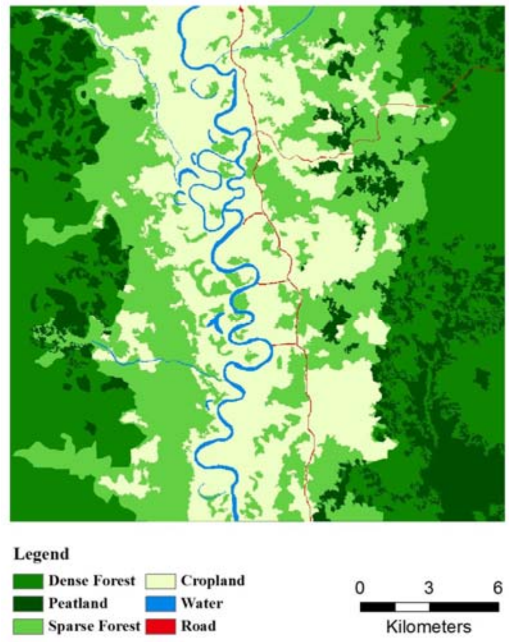
Historical deforestation

Carbon emissions

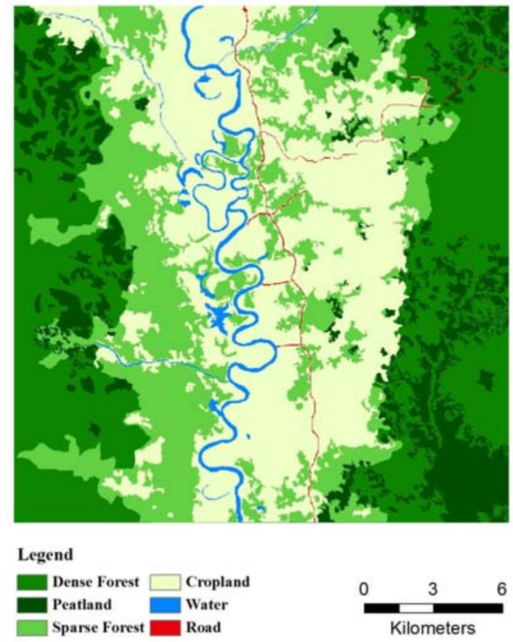
In 1989, forests covered 36,147 hectares, or 75.4% of the total study area (Figure 5). During the period 1989–2009, intensified anthropogenic activities mainly aggregated in agriculture, rubber plantation and illegal mining. Land use maps derived from Landsat satellite images show a rapid decrease in forest area with an average annual change rate of 2.92%. Farming and plantation together revealed an increase of 2.65% annually while roads also increased in this period. With area increase of 8,403 hectares in 21 years, due to conversion from sparse forest, farming and plantation were the dominant activities causing deforestation. Deforestation was distributed along rivers and roads, where humans could reach easily. Total carbon storage showed a substantial decrease in the period under analysis. This is to be expected given the consistent reduction in the area of forest with larger biomass content. The results concerning carbon emissions, 859.9 thousand metric tons CO_2 for 1989–2000, 273.0 thousand metric tons for 2000–2005 and 1,471.3 thousand metric tons for 2005–2009, present an increasing trend in recent years.

Figure 15 . Land use maps in 1989, 2000, 2005 and 2009





Year 2005



Year 2009

Forest fragmentation

Table 5 Forest fragmentation metrics in 2005 and 2009

Year	NP(#)	PD(#/100a)	LPI(%)	AREA_MN(ha)	SHAPE_MN(-)	SHAPE_AM(-)	ENN_MN(m)	IJI(%)
2005	52	0.11	66.46	639.72	2.10	7.95	222.55	27.84
2009	68	0.14	29.73	449.87	2.26	5.90	103.78	21.87

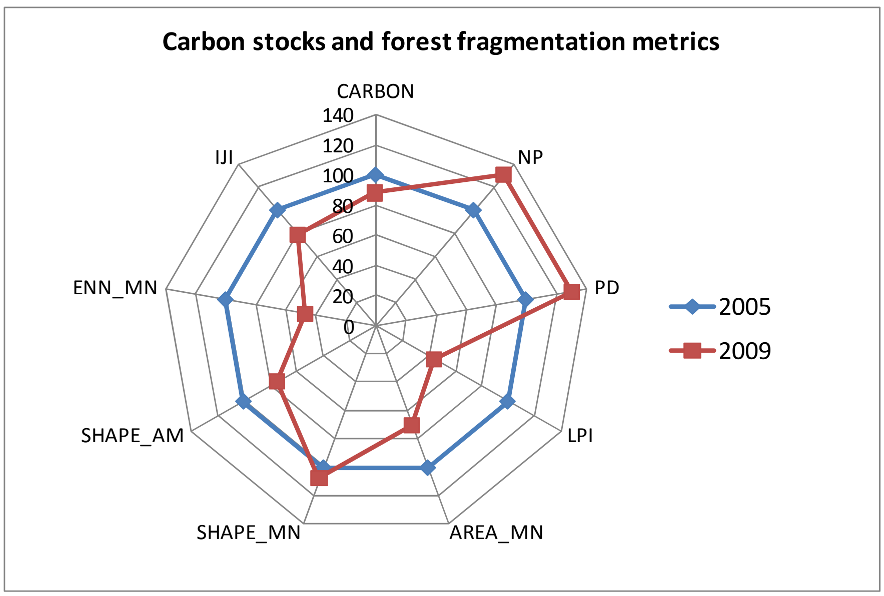
Habitat fragmentation affects the ecology of tropical forests by changing the composition and configuration, leading to genetic isolation of plants and animal species, reducing genetic biodiversity of species (W. F. Laurance & R. O. Bierregaard 1997). For instance, reduced dense canopy cover in tropical forests may result in greater mortality of drought-sensitive plants (Benitez-Malvido 1998; Sizer & Tanner 1999).

During the period 2005–2009, the NP substantially increased, suggesting the breaking up of vegetation areas into smaller parcels (from 52 to 68 patches) (Table 3). This view that extensive land transformation occurred in the forest is further supported by the LPI, which was reduced from 66.45% to 29.73% of the landscape. The AREA_MN decreased from 639.72 to 449.8663. This indicates that forest patches increased and became less contiguous in distribution (D. Geneletti

2004). Regarding patch shape, SHAPE_MN of woody vegetation class for 2005 and 2009 were greater than 1, indicating that the average vegetation patch shape in all landscapes is non-squareshaped. The 2009 patches (more fragmented) were slightly less irregular in shape than the 2005 patches (less fragmented). Measure of decreasing SHAPE_AM indicates increasing complexity and variability in patch shape, representing negative impacts on biological integrity. The ENN_MN for the 2005 and 2009 images decreased from 222.55m to 103.78m. These values indicate decreasing inter-patch connectivity due to fragmentation. The 2005 image had higher IJI than the 2009 image (27.84 against 21.87) indicating that the vegetation patches in the former were well interspersed or equitably distributed among patch types (i.e., equally adjacent to each other). The 2009 landscape indicates more disproportionate distribution of vegetation patch adjacencies, implying that the forest underwent considerable fragmentation of vegetation.

Relationship between carbon emissions and forest fragmentation

Figure 16 Carbon stocks and forest fragmentation metrics in 2005 and 2009



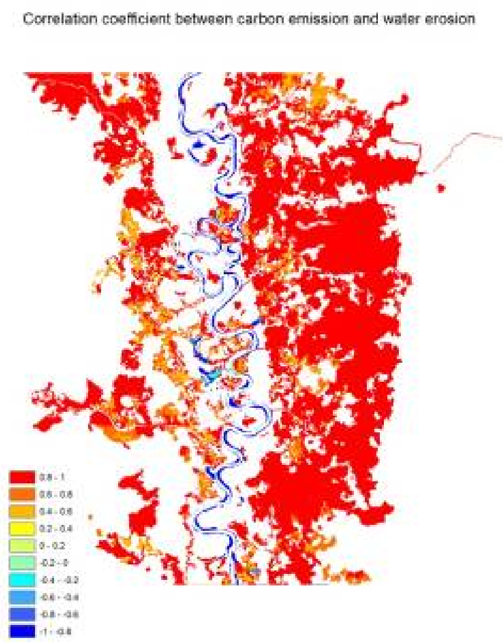
Percentage changes could provide consistent and comparable measures of carbon emissions and forest fragmentation. Figure 6 shows that the percentage changes between 2005 and 2009 in carbon stocks and forest fragmentation metrics. The percentage change in the carbon stocks is 11.9%. Such decrease was accompanied with 30.8% increase in NP, 30.7% in PD and 7.6% in SHAPE_MN, suggesting that the forest ecosystem was changing in both carbon storage and forest landscape structure. Meanwhile, LPI, AREA_MN, SHAPE_AM, ENN_MN and IJI decreased by 55.3%, 29.7%, 15.8%, 53.4% and 21.5%, respectively. In this sense, carbon emission and forest fragmentation were well integrated.

Relationship between carbon emission and water erosion

Relationship between carbon emission and water erosion was investigated analytically through correlations. The correlation coefficient in each pixel between carbon emission and water erosion was calculated and classified, to assess this relationship. A correlation map (Figure 7) was produced with intensity in blue defined as increasing negative correlation, and intensity in red defined as increasing positive correlation. Overall, high correlation between carbon emission and water erosion in the whole study area (r= 0.84) was found. Whilst the area in most parts of the research area indicated positive correlation coefficients, the area along the river showed negative correlation. The areas with positive correlation were approximately 8880.58 hectares corresponding to 96.0% of the changing forest. In these areas, the portions showing strong correlations (0.8 to 1.0, 0.6 to 0.8 and 0.4 to 0.6) were 95.8%. The negative correlation areas accounted for 4.0% (374.1 ha) of the changing forest. This result supports the view that there are strong synergies between carbon loss and soil erosion in tropical forests.

This result is not unexpected, given that forests play a key role both in carbon sinks and soil conservation. Some work indicates that the secondary forest cover from logging does not protect soil as primary forest does, nor can it easily compensate the physical damage already inflicted on soil (compaction, loss of soil-structure, removal of organic litter) (Abdulhadi et al. 1981). And if logging is followed by fire, erosion is even greater (Ewel & Conde 1980).

Figure 17 Correlation between carbon emission and water erosion during 1989-2009



Correlation coefficient	Percentage
0.8 to 1.0	82.99%
0.6 to 0.8	6.85%
0.4 to 0.6	5.97%
0.2 to 0.4	0.03%
0.0 to 0.2	0.11%
-0.2 to 0.0	0.11%
-0.4 to -0.2	0.20%
-0.6 to -0.4	0.32%
-0.8 to -0.6	0.10%
-1.0 to -0.8	3.31%

Model results

Scenario analysis

Scenario 2, economic development, would result in 28.8% (3,615 ha) more deforestation area than that in the BAU scenario. By comparison, forest area would increase by more than 36.0% (4,517 ha) in the REDD+ scenario (Figure 8). In the study area, the REDD+ scenario would lead to avoided emissions of approximately 4,846.9 thousand metric tons of CO_2 during the period 2011–2020 relative to the BAU scenario, which would amount to USD72.3 million of compensation from the world carbon market (Figure 9). In contrast, the economic development scenario would increase by more than 3,982.3 thousand metric tons of CO_2 over BAU. For ecosystem co-benefits, water erosion under the REDD+ scenario would decrease by 10.0% and increase by 8.1% under the economic development scenario.

Figure 18. Deforestation area, carbon emissions, water erosion and Patch Density (PD) under 3 scenarios

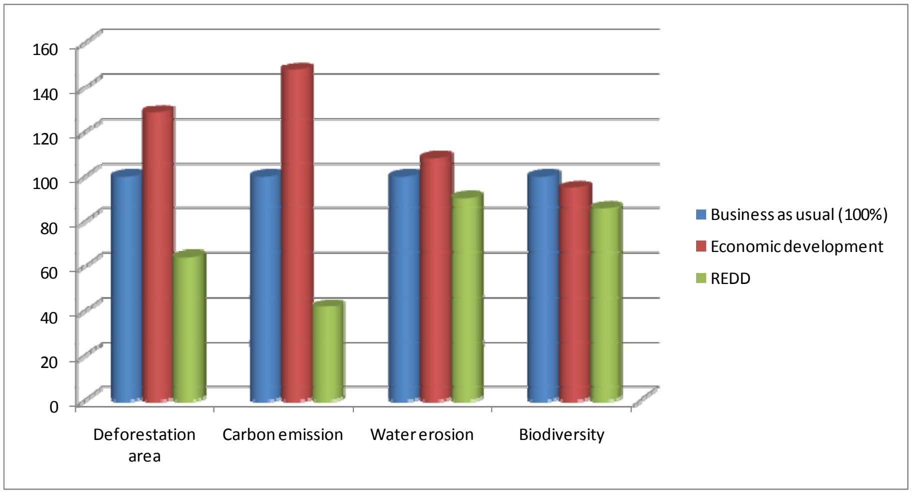
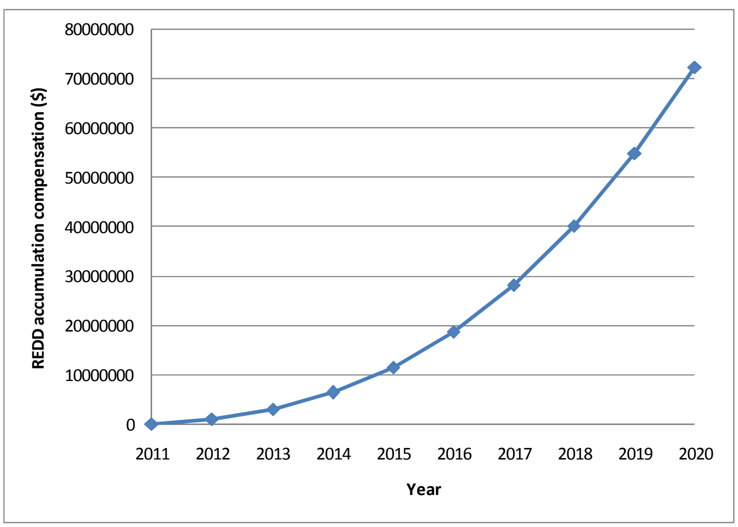


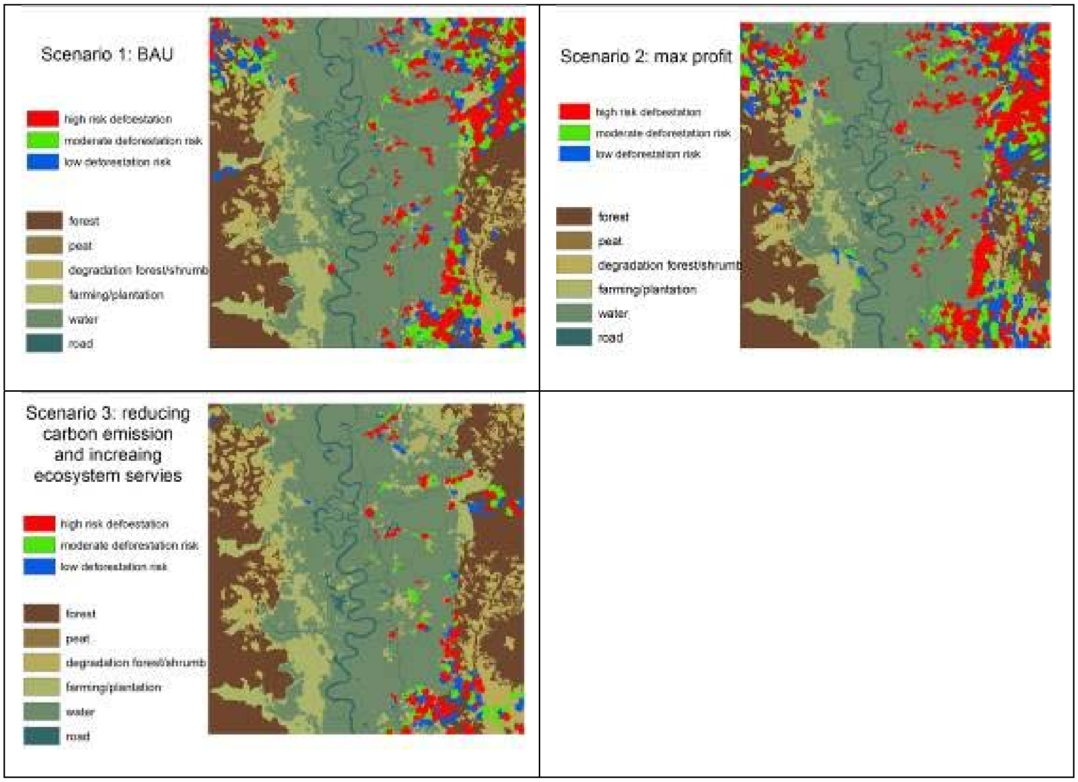
Figure 19. REDD+ accumulation compensation during the period 2011-2020



Hotspots

One of the objectives of this study is to provide practical suggestions allowing policymakers to evaluate deforestation risk. As such, accessibility was quantified by weighting and aggregating human disturbance characteristics in the study area. For example, an area with easy access to road and river would have a high risk of deforestation, in comparison to remote areas. The results were classified into 3 categories: low risk, moderate risk and high risk. Risk maps (Figure 10) clearly present which areas of forest are under high deforestation threat and thus inform policymakers to avoid further deforestation.

Figure 20 . Hotspots under 3 scenarios



4.0 Conclusions

The study aimed to evaluate the tradeoffs between conservation and development goals in forest ecosystems using case studies from Malaysia and Indonesia.

From the field impressions, it is quite evident that economic and political drivers play a significant role in the determination of land use options in an ecosystem or landscape, in turn affecting social and natural system integrity. As can be seen from both regions, policy decisions related to relocation of people or undertaking unsuitable land use activities such as establishment of rubber or oil palm plantations, opening lands for cultivation or new infrastructure – have resulted in loss of biodiversity and ecosystem services and reduction in the welfare of the populations especially dependent on the ecosystem. While duly acknowledging that policymakers are also under pressure to increase potential revenues from available natural assets (tropical forests being a good example), our research also points out that in such cases it is important that a comprehensive assessment of the consequences of implementation to the biophysical richness of the ecosystem and the socio-cultural ties to it is essential to enable us to carefully evaluate the potential benefits and costs derivable from any land use option.

The modelling exercise that was piloted helped identify the historical deforestation at Bawan village in Central Kalimantan, where deforestation is a major contribution to GHG emissions, biodiversity losses, and water erosion. The analysis on the relationship between carbon emission and water erosion supports the expectation that the detachment and removal of soil material will increase with lost carbon simultaneously. Indeed, high correlation between biomass carbon loss and water erosion was found in the study area indicating that when forests are lost or degraded, the ecosystem-based benefits they deliver would disappear with the carbon stocks they contain. While uncertainty exists, it is believed that the combination of high resolution satellite images such as Landsat TM and NDVI is suitable to support credible deforestation monitoring in the tropics. A predictive model was developed to project the forest that would disappear and identify the high, moderate and low risk deforestation areas under different land use scenarios. The model shows that if this deforestation rate continues unabated, a further 12,555.5 hectares of forest would disappear from 2011 to 2020. Furthermore, under the scenario of economic development, deforestation area would increase by more than 3,615 hectares. This would trigger a catastrophe in heath forest and peat swamp in this area. On the other hand, significant emissions reductions could be achieved under the REDD+ scenario, with more than 4,846.9 thousand metric tons of CO_2 reduction relative to the BAU scenario. Spatially explicit models can reveal where, when and how much forests would be converted to other lands under different land use policies, and also presents deforestation risks from anthropogenic activities. Areas with high deforestation risk should receive special attention in land planning priorities. As a result, an optimal land use strategy could be achieved, thereby assuring emissions reduction from deforestation and forest degradation and long-term environmental conservation. Although the modeling exercise might be a simplification of the complex realities of land use decision making in forest ecosystems, such an integrated exercise allows a comprehensive assessment and projection of land use change over a period of time including the drivers of change, and thence ways forward for better land use decisions.

5.0 Future Directions

The data from the study areas are still being analysed fully to develop a comprehensive decision support tool for land use management in forest ecosystems. We realize that, increasingly discussions related to REDD-plus are taking note of the fact that for the scheme to be successful, an optimization of land use priorities needs to be undertaken referred to variously as Multiple Benefits or with additional –plus suffixes. The next stage of our research would be to develop a prototype of a decision support tool that would enable more comprehensive decisions related to forest land use management, accounting for ecological and social pressures and priorities. We expect this tool to be ready by middle of 2012, and then hope to make it a web based application. However, we also realize that this research would still be work in progress, and hope to build new research collaborations with relevant partners to refine our arguments and strengthen this area of research further.

References

Abdulhadi, R., Kartawinata, K. &Sukardjo S. 1981. Effects of mechanized logging in the lowland dipterocarp forest at Lempake, East Kalimantan. The Malaysian Forester 44, 407-418.

Ambar,S. 1986. Aspects of vegetation and land use in the erosion process in the Jatiluhurlake catchment, West Java. Unpublished Ph.D. dissertation, Padjadjaran University, Bandung, Indonesia.

Angelsen, A. (ed.) 2008 Moving ahead with REDD: Issues, options and implications.CIFOR, Bogor, Indonesia

Benitez, M., J. 1998. Impact of forest fragmentation on seedling abundance in a tropical rain forest. Conservation Biology 12:380–389

Braimoh, Ademola K, Suneetha Subramanian, Wendy Elliott and Alexandros Gasparatos, 2010, Climate and Human Related Drivers of Biodiversity Decline in Southeast Asia, UNU-IAS Policy Report, Yokohama.

Brown, S., F. Achard, R. de Fries, G. Grassi, N. Harris, M. Herold, D. Mollicone, D. Pandey,T. Pearson, D. Shoch, 2007. Reducing Greenhouse Gas emission from deforestation and Degradation inDeveloping Countries: A Sourcebook of Methods and Procedures for Monitoring, Measuring and Reporting

Chomitz, K.M., Buys P., de Luca, G., Thomas, T.S. and Wertz-Kanounnikoff,S. 2006 At loggerheads? Agricultural expansion, poverty reduction,and environment in the tropical forests.Policy Research Report.WorldBank. Washington. DC. http://go.worldbank.org/KVK3ZDK510(26 Nov. 2008).

Dambul, R. and Jones, P., 2007. Regional and Temporal Climatic Classification for Borneo, Geografia Online, Malaysia Journal of Space 3, 84-105.

Dixon, R.K., S. Brown, R.A. Houghton, A.M. Solomon, M.C. Trexler, and J. Wisniewski, 1994.Carbon pools and flux of global forest ecosystems. Science 263: 185-190.

Environmental Defense Fund (EDF). 2008. Reducing emissions from Deforestation and Forest Degradation in Developing Countries (REDD): Implications for the Carbon Market. New York, NY.

Ewel, J. &Conde, L.F. 1980 Potential Ecological Impact of Increased Intensity of Tropical Forest Utilization.BIOTROP Special Publication No. 11, Bogor, Indonesia.

FAO 1993 Forest Resources Assessment 1990: Tropical CountriesFood and Agriculture Organisation Rome http://www.fao.org/docrep/007/t0830e/T0830E00.htm accessed on 22July 2010

FAO 2001.State of the world's forests 2001. Rome. 181 pp.

FAO, 2011, State of the World's Forests 2011, FAO, Rome.

Field, C.B., M.J. Behrenfeld, J.T. Randerson, and P. Falkowski, 1998. Primary production of the biosphere: integrating terrestrial and oceanic components. Science 281: 237-240.

Geneletti, D., 2004Using spatial indicators and value functions to assess ecosystem fragmentation caused by linear infrastructures, International Journal of Applied Earth Observation and Geoinformation, vol. 5, no. 1, pp. 1–15.

Giordano, F. and Marini A., A landscape approach for detecting and assessing changes in an area prone to desertification in Sardinia (Italy), International Journal of Navigation and Observation 2008 (2008).

Houghton, R. A. 2003. Emissions (and Sinks) of Carbonfrom Land-Use Change. Report to theWorldResources Institute from theWoods Hole ResearchCenter. Falmouth, MA:Woods Hole ResearchCenter.

Houghton, R. A., and J. L. Hackler 2001, Carbon flux to the atmosphere from land use changes: 1850 to 1990, http://cdiac.ornl.gov/epubs/ndp/ndp050/ndp050.html, Carbon Dioxide Inf. Anal. Cent., Oak Ridge Natl. Lab., Oak Ridge, Tenn.

IPCC. 2000. Land Use, Land-Use Change, and Forestry.Special Report of the IPCC, edited by R.Watson,I. Noble, B. Bolin, et al. Cambridge, UK:Intergovernmental Panel on Climate Change.

IPCC: 2006 IPCC guidelines for National Greenhouse Gas Inventories, Agriculture, Forestry and Other Land Use, edited by: Eggleston, S., Buendia, L., Miwa, K., Ngara, T., and Tanabe, K., http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html, 2006.

Ismail, M. H. 2009. Developing Policy for Suitable Harvest Zone using Multi Criteria Evaluation and GIS-Based Decision Support System.International Journal of Economics Finance, 1 (2). pp. 105-117. ISSN 1916-971X

Jackson, R. D., Slater, P. N. and Pinter, P. J.. 1993. Discrimination of Growth and Water Stress inWheat by Various Vegetation Indices through Clear and Turbid Atmospheres. RemoteSensing of the Environment 15:187-208,

Jamaludin, J., 2002. Sarawak: peat agricultural use. European Commission Inco-Dev Final Report, Strategies for implementing sustainable management of peatlands in Borneo. Available at: http://www.strapeat.alterra.nl/download/Final%20report%20STRAPEAT.pdf

Kenneth G. Renard, George R. Foster, Glenn A. Weesies, and Jeffrey P. Porter. 1991. Journal of Soil and Water Conservation Januaiy-Februa'y 1991. Volume 46. Number 1

Laurance, W. F. and Bierregaard, R. O. , Eds., 1997. Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities Univ. of Chicago Press, Chicago, IL.

MarkkuKanninen, Daniel Murdiyarso, Frances Seymour, ArildAngelsen, Sven Wunder, Laura German. Bogor. Do trees grow on money? The implications of deforestation research for policies to promote REDD. Indonesia: Center for International Forestry Research (CIFOR), 2007. ISBN 978-979-1412-42-1

Martinuzzi S, W.A. Gould, O.M. Ramos González, A.Martinez Robles, P. Calle Maldonado, N. Pérez-Buitrago,and J.J. FumeroCaban. 2008. Mapping tropical dryforest habitats integrating Landsat NDVI and topographicinformation. Rev. Biol. Trop. 56:625-639.

Mcgarigal, K. and Marks, B.J., 1994, FRAGSTATS: Spatial Pattern Analysis Program for Quantifying Landscape Structure (Vesion 2.0) (Corvallis: Forest Science Department, Oregon State University).

Melillo, J.M., A.D. McGuire, D.W. Kicklighter, B. Moore, C.J. Vorosmarty, and A.L. Schloss, 1993. Global climate change and terrestrial net primary production. Nature 363: 234-240.

Melling , L., Ambak, K., Osman, J. and Husni, A. 1999. Water management for the sustainable utilisation of peat soils for agriculture. Paper presented at the International Conference & Workshop on Tropical Peat Swamps, 27- 29 July 1999, Penang, Malaysia.

Miettinen, J., C. Shi, S.C. Liew, 2011. Deforestation rates in insular Southeast Asia between 2000 and 2010. Global Change Biology. Global Change Biology Volume 17, Issue 7, 2261–2270

Millennium Ecosystem Assessment, 2005, Ecosystems and Human Well-being Biodiversity Synthesis, World Resources Institute, Washington D.C.

Morgan, R.P.C., and Davidson, D. A.: Soil Erosion and Consevation, Longman Goup, U.K, 1991.

Ogawa, S., Saito, G., Mino, N., Uchida S., Khan, N. M., and Shafiq, M, 1997. Estimation of soil erosion using USLE and Landsat TM in Pakistan (ACRS 1–5). Retrieved from GIS development.net.

Page S.E., Siegert, F., Rieley, J.O., Boehm, H.D., Jaya, A., and Limin, S. 2002 The amount of carbon released from peat and forest fires in Indonesia during 1997. Nature, 420, 61-65.

Parish, F., Sirin, A., Charman, D., Joosten, H., Minaeva, T. &Silvius, M. (eds) 2008. Assessment on peatlands, biodiversity and climate change.Global Environment Centre, Kuala Lumpur and Wetlands International Wageningen, 179 p.

Ramankutty N, Gibbs H K, Achard F, DeFries R, Foley J A and Houghton R A 2007 Challenges to estimating carbon emissions from tropical deforestation Glob. Change Biol. 13 51–66

Renard, K. G., Foster, G. R., Weesies, G. A. & Porter, J. P. 1991. RUSLE. Revised universal soil loss equation. J. Soil Water Conserv. 46(1), 30–33.

Renard, K.G., Foster, G.A., Weesies, D.K., McCool, D.K., and Yoder, D.C. 1997. Predicting soil erosion by water: A guide to conservation planning with the revised universal soil loss equation. Agriculture Handbook 703. United States Department of Agriculture Washington DC.

Saaty, T. L, 1980. The Analytic Hierarchy Process, New York: McGraw Hill.

Sarvision, 2011. Impact of oil palm plantations on peatland conversion in Sarawak 2005-2010.Available at http://www.wetlands.org/Portals/0/publications/Report/Malaysia%20Sarvision.pdf

SCBD, 2010, Global Biodiversity Outlook 3, Secretariat of the Convention on Biological Diversity, Montreal.

Schweithelm, J. 1998 The Fire this Time: An Overview of Indonesia's Forest Fires in 1997/1998. World Wide Fund for Nature Indonesia, Discussion Paper. WWF Indonesia programme, Jakarta.

Sizer, N. & Tanner, E. V. J. 1999.Responses of woody plant seedlings to edge formation in a lowland rainforest, Amazonia. Biological Conservation 91:135–142

Thoumi, G.A. 2009 Emeralds on the equator: an avoideddeforestation carbon markets strategy manual. Master of ScienceThesis.University of Michigan, Ann Arbor, Michigan.

UNFCCC. Report of the Conference of the Parties on its Thirteenth Session, Heldin Bali from 3 to 15 December 2007. 3 to 15 December 2007.

UNREDD, 2011, UN-REDD Programme Social and Environmental Principles and Criteria, version 3 Draft for Consultation, UN- REDD Programme available at http://www.un-redd.org/Newsletter17/Social_Environmental_Principles/tabid/54002/Default.aspx.

Van der Knijff, J.M., Jones, R.J.A., Montanarella, L.,1999, Soil erosion risk assessment in Italy, European Soil Bureau, EUR 19044 EN.

Von Neumann, J. 1966. Theory of Self-Reproducing Automata. University of Illinois Press.

Voogd, H. 1983 Multicriteria Evaluation for Urban and Regional Planning, Pion, Londres.

Watson, R.T., Intergovernmental Panel on Climate Change, Noble, I.R.,Bolin, B. 2000 Land use, land-use change, and forestry: A special report ofthe Intergovernmental Panel on Climate Change. Cambridge UniversityPress, Cambridge, UK. 377p.

Wischmeier, W. H. & Smith, D. D. 1978. Predicting Rainfall Erosion Losses to Conservation Planning.US Department of Agriculture Handbook no. 537. Washington DC, USA.

Wolfram, S. 1984. “Cellular Automata as Models of Complexity.” Nature 311:419-424.

World Resources Institute. 2005. Navigating the Numbers: Greenhouse Gas Data, 2005. Washington, D.C., p.13.

WRI. 2008. CAIT: Climate Analysis Indicators Tool.Washington, D.C.:World Resources Institute

Appendix

<u>Conferences/Symposia/Workshops</u>

Agenda/Programme (including title, date and venue)

- **See attached_**

Participants list (comprising contact details of each participant, including organisation, address, phone number, fax number, and email address)

- **<u>See Attached-</u>**
-

<u>*Funding sources outside the APN*</u>

A list of agencies, institutions, organisations (governmental, inter-governmental and/or non-governmental), that provided any in-kind support and co-funding for the project and the amount(s) awarded. If possible, please provide an estimate amount.

1. UNU
2. UKM
3. LIPI
4. CIMTROP

<u>List of Young Scientists</u>

Include brief detail (full name, involvement in the project activity) and contact detail (name of institution/country and email address) of your scientists involved in the project. Also include short message from the young scientists about his/her involvement in the project and how it helps develop/build his capacity and the knowledge he gained.

1. Vera Budi Lestari Sihotang, S.S

Country: Indonesia

Institution: Botany Division-Research Center for Biology-Indonesian Institute of Sciences

Involvement in the project: I conducted the Focus Group Discussion activity from ecological mapping, from the past and present, also about the land use in Anjir Pulang Pisau Village, Pulang

Pisau District, Central Kalimantan. I also conducted ethnobotany research about the usage of the plants.

Message: I think the APN project is very useful for my research interest about ethnobotany. First, it helps me more to learn the method about how to communicate with local people since my research always related with local people. Second, this project helps me to know how the local people manage and interact with their natural resources from the past to present. And the last one, it also help me to understand more about how people use the natural resources through the effect of ecosystem service changing

2. Name: Dr. Laode Alhamd

Country: Indonesia

Institution: Botany Division-Research Center for Biology-Indonesian Institute of Sciences

Involvement in the project: He conducted the Focus Group Discussion activity from ecological mapping, from the past and present, also about the land use in Anjir Pulang Pisau Village, Pulang Pisau District, Central Kalimantan. He also conducted ecological research. He also involved in PRA activity in Bawan Village, Central Kalimantan.

3. Name: Bayu Arief Pratama, S.Hut

Country: Indonesia

Institution: Botany Division-Research Center for Biology-Indonesian Institute of Sciences

Involvement in the project: he conducted the Focus Group Discussion activity from ecological mapping, from the past and present, also about the land use in Anjir Pulang Pisau Village, Pulang Pisau District, Central Kalimantan. He also conducted ecological research about the type of the land and about the biodiversity

4. Dr. Mohamad Affendy Arif

Country: Indonesia

Institution: Faculty of Economics and Business, Universiti Malaysia Sarawak (UNIMAS)

Message: I am a Sarawakian. My research area has been in trade and finance. This project creates a strong awareness in me about the importance of resource sustainability and societal welfare, specially among the indigenous communities in my own state.

Glossary of Terms
Include list of acronyms and abbreviations

In the Appendix section, the report may also include:
Actual data or access to data used in the study
Abstracts, Power Point Slides of conference/symposia/workshop presentations
Conference/symposium/workshop reports

- **See attached -**

The final project report must follow the template outlined in this document. Use Calibri font size 12 for all the headings and font size 11 for the text.

The report is to be submitted **one month before the end the Contract Period** in the following formats:

1. By airmail to the address below:

a. **Soft Copy – 2 CD-ROMS**, appropriately labeled and covered using the design and information on the cover page of the Report Template

b. **Hard Copy – 2 bound copies** appropriately labeled and covered using the design and information on the cover page of the Report Template

Dr. Linda Stevenson
APN Executive Science Officer
APN Secretariat
4F East Building
1-5-2 Wakinohama Kaigan Dori
Chuo-Ku, Kobe 651-0073 JAPAN

2. By e-mail and addressed to Dr. Stevenson (lastevenson@apn-gcr.org) and Ratisya Radzi (arradzi@apn-gcr.org).

Kindly note that our server can also receive attachments of up to 8MB file size. In case that the final project report file size exceeds 8MB please try any of the following options:

a. For a file size of more than 8MB but less than 10MB please send the report to our Gmail account at apngcr@gmail.com and notify us in our APN account so we could check for it immediately.

b. For a larger file size please try the following:

- Upload on your institution's ftp server and provide to us the download details (i.e. IP address, login details, etc)
- Send through any of the free file hosting available in the internet. Please note that these free file hosting save your files for a limited number of days so it is very important to notify us immediately. Some of these are the following:
  - http://www.filefactory.com/
  - http://www.mediafire.com/
  - http://www.yousendit.com/

A separate CD containing other project outputs (i.e. publications, photos, etc)