

1. INTRODUCTION: WHY MONITOR CARBON IN NUNUKAN?

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Land Use Change as Source of CO₂ Emission

In the last two decades climate change has become a prominent issue for the global community. During the last century the mean temperature of the earth has increased by 0.6 °C and the rate of change appears to increase. An increase of the atmospheric concentration of the greenhouse gases (GHG), carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) are identified as the main factor causing global warming. During the last decade net CO₂ emission doubled from 1400 million Mg year⁻¹ to 2900 million Mg year⁻¹. Meanwhile, the CO₂ concentration in the atmosphere in 1998 was 360 ppmv, up from a value of 280 ppmv a century earlier, with a yearly increment of 1.5 ppmv (Houghton *et al.*, 2001).

The elevated CO₂ concentration in the atmosphere is largely caused by human activities, particularly land use change and use of fossil fuel for transport, power generation and industrial activities. Accumulatively, the use of fossil fuel and forest conversion to other land use have both been responsible for about half of the human-induced CO₂ emission to the atmosphere, but the current impact is in a ratio of 3:1. Burning fossil fuel means returning carbon to the atmosphere that was fixed by plants in the geological past. Forest conversion and land use change imply that carbon stored as plant biomass or in (peat) soils is released to the atmosphere

through burning ('slash and burn') or decomposition of organic matter above and below ground. Logging removes stored carbon from the landscape, often resulting in rapid return to the atmosphere, depending on the use of wood. It is estimated that between 1990 - 1999, land use change has contributed around 1.7 Gt year⁻¹ to total CO₂ emission (Watson *et al.*, 2000).

Acknowledging this global problem of human-induced ('anthropogenic') climate change, the Rio de Janeiro Conference of 1992 identified CO₂ emissions to the atmosphere as one of the major global environmental issues of concern. World leaders adopted the United Nations Framework Convention on Climate Change (UNFCCC) that sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. The Kyoto protocol that came into force on February 17 2005 was developed as the first concrete step towards implementing efforts to stop the growth in emissions and return net emissions from the industrialized countries to below 1990 levels. As land use change can be both a source and a sink of atmospheric CO₂, the rates of deforestation and the regrowth of woody vegetation are part of the global debate.

Activities and projects that enhance afforestation and reforestation (AR) or avert deforestation (ADEF) can both reduce net CO₂ emissions, but have a different policy context from changes in fossil fuel use. AR

activities are defined as human-induced conversion of non-forest land use to forest, through planting seedlings and/or promotion of natural seed sources. ADEF projects are defined as activities that prevent carbon emission by protecting a forest threatened by deforestation or degradation. Smith and Scherr (2003) provide an in-depth study on risks and benefits of both projects. The Kyoto protocol makes a distinction between industrialized ('Annex I') countries who are obliged to account for all changes in carbon stocks as well as fossil fuel emissions, and developing countries without current obligation to reduce net emissions. In the debate on the global regulatory framework of net greenhouse gas emissions the relative merits of ADEF and AR in developing countries are still contested, as are the *de facto* opportunities to influence these processes. Especially for ADEF, there is little experience of how it can be achieved.

The Forest Resources Management for Carbon Sequestration (FORMACS) Project

The Forest Resources Management for Carbon Sequestration (FORMACS)¹ Project, funded by CIDA and implemented by CARE International Indonesia is an example of an ADEF project. FORMACS focuses its work on managing existing forest resource for carbon sequestration and storage by adopting socially acceptable programs of community-based management. Specifically, it promotes sustainable livelihoods through sustainable agriculture, agroforestry and sustainable forest management practices for the maintenance of existing carbon stocks and for the sequestration of atmospheric carbon. Community based project, such as agroforestry, small-scale plantations, agroforests and

secondary forest fallows have the highest potential for providing local livelihood benefits along with enhanced carbon storage and pose the fewest risks to communities (Smith and Scherr, 2003).

The FORMACS project study area is in Kabupaten Nunukan of East Kalimantan Province, Indonesia, specifically in Sebuku and Sembakung sub-district. The Nunukan area was a suitable and potential area to implement an ADEF project because of the following factors:

1. Forest conversion

Indonesia is ranked 9th amongst all the countries worldwide in GHG emissions (Brookfield, Potter and Byron, 1995) and over half of its emissions are due to forest conversion for agriculture, plantations, and timber production. Approximately 2 million ha of forest is currently being logged or converted each year, releasing an enormous amount of previously bound carbon into the atmosphere and reducing sequestration capacity. Although in the Kabupaten Nunukan forest conversion has not been extensive (within the project area, it is limited to transmigration areas), there are proposals for forests to be converted for plantations (primarily oil palm), agriculture, shrimp ponds (coastal mangrove) or mining. Proposals for converting forests to other land use pose a risk to carbon sinks, and may have other negative environmental impacts. In 1990 the district still had a forest cover of 98%. The mean population density in the district of 5 persons km⁻² is substantially below the average for Kalimantan of 34 persons km⁻².

Community Based Natural Resource Management (CBNRM) has the potential to limit forest conversion and maintain the forests for multiple uses, including timber production, production of non-timber forest products, conservation of biodiversity, providing a corridor between protected areas,

¹ See <http://www.rcfa-cfan.org/english/profile.19.htm> for more information about this project.

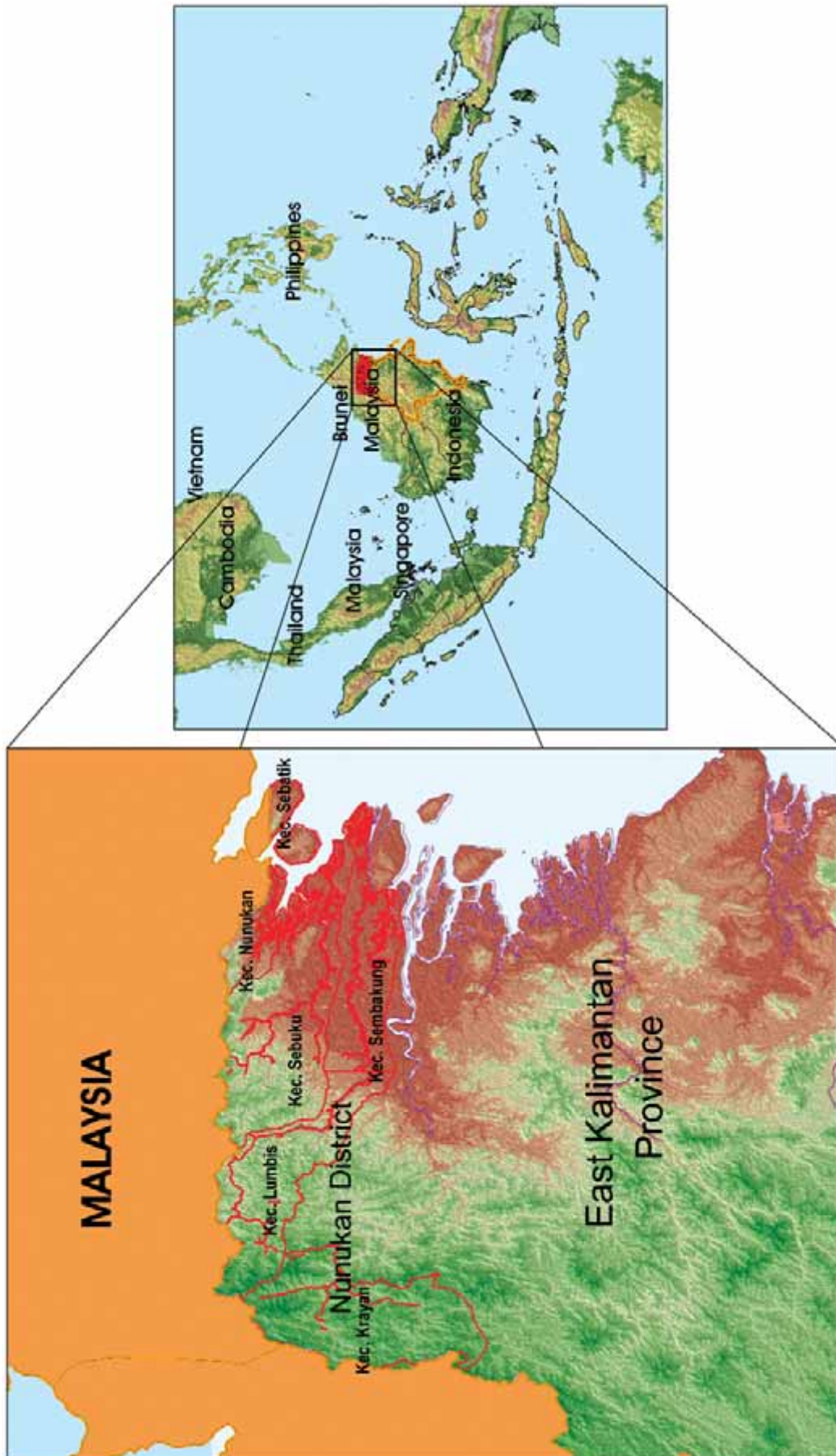


Figure 1.1. Map of Nunukan, East Kalimantan. The study site of the FORMACS project

maintaining watershed functions and maintenance of carbon stocks.

2. Illegal logging

It is estimated that more than 70% of the timber used in and exported from Indonesia comes from illegal logging, and that illegal logging is destroying at least 700,000 ha of tropical forests a year. Illegally logged timber is being smuggled to Malaysia where it is processed and exported to the US, Japan, Europe and China. Approximately five million cubic metres of timber flows into Malaysia each year (EIA and Telapak Indonesia, 2001). Besides causing loss of biodiversity and ecological damage to the ecosystem, illegal logging also leads to economic and health costs resulting from fires associated with land use change and land clearing which often follows illegal logging. A low-end estimate of royalties, reforestation fund and export taxes payments that are not being paid to the Government of Indonesia (GOI) on timber stolen each year amounts to US\$600 millions².

The situation in the Kabupaten Nunukan mirrors the national problem and reflects the same issues. The situation is magnified by the District's close proximity to the state of Sabah in East Malaysia. Saw logs continue to flow over the border in spite of the ban on log exports.

The FORMACS Project addressed the issue of illegal logging at the village, sub-district and district level, where it can most likely have impacts. At present, forests under concessions granted to large companies are viewed as open-access resources where people are competing to get a share of the resources before someone else takes the resources. The way forward is to change this concept to

community-based forest management, where the forests are allocated to indigenous communities. The resources will then have recognized local owners, with adat regulation of the use rights of the resources, and the people will guard their own resources. This will mean indigenous communities working in cooperation with local law enforcement and government agencies.

The forest lands adjacent to most villages have been logged-over by forest companies, and the availability of timber is on the decline. Once the area has been completely logged and the most valuable commercial timber removed, illegal logging becomes less an issue. As the local people know that they can no longer depend on illegal logging for a livelihood, sustainable agriculture and community-based forestry activities, are perceived as viable alternatives. CBNRM will be able to provide the people with economic alternatives to illegal logging and to shift forest management from large-scale industrial forest management, to small-scale multi-purposed management which combines timber production with the conservation of biodiversity, the maintenance of ecosystem functions, and carbon sequestration.

3. Fire

Large-scale fires and droughts have devastated parts of East Kalimantan over the past two decades. Although fires occur yearly, large-scale fires are related to the ENSO (El Niño Southern Oscillation), which currently has a three to five year cycle. During the fire event in 1997/1998, the amount of carbon released to the atmosphere as a result of burning peat and vegetation in Indonesia was estimated between 0.81 and 2.57 Gt (Page *et al.*, 2002). This is equivalent to 13-40% of the mean annual global carbon emissions from fossil fuels, and contributed greatly to the largest annual increase in atmospheric CO₂ concentration detected since records began in 1957 (Houghton *et al.*, 2001) The majority of

² Press release from the World Bank on Deceleration of Forest Law Enforcement and Governance <http://siteresources.worldbank.org/INTINDONESIA/FL/EG/20172547/FLEG+Conference+Press+Release.pdf>. Accessed on 21 March 2005

these fires occurred in managed or degraded lands: agriculture, logged-over forests, scrub forest and grassland (Tacconi, 2003). Almost all fires were started intentionally to clear land for planting, primarily for large plantations, but also for slash and burn agriculture. Arson was also a factor, as local people used fire as a weapon to resolve conflicts (Tomich *et al.*, 1998).

Generally, few fires are able to invade good quality forest, due to its higher humidity levels and low levels of dry undergrowth for fuel, but in the later phase of the 1997/1998 fire event in Kalimantan unlogged forests fell victim as well. Addressing issues related to forest conversion, degradation of forests from legal and illegal logging and preserving areas of natural forests as natural fire breaks are important for the maintenance of carbon stocks within existing sinks and increasing carbon sequestration in logged-over forests.

4. Land tenure and local institutional capacity

Land tenure, especially in relation to forest lands, is not clearly defined in the Kabupaten Nunukan, and this threatens the existence of forests as carbon sinks. This situation is similar to the land tenure situation throughout East Kalimantan. Security of tenure is a prerequisite for CBNRM, since it provides the incentive for maintaining the resource and for reforestation. Land use planning and subsequent regulation of land tenure by the community together with government institutions provides the basis for land use activities such as agriculture, agroforestry, reforestation, industrial plantations and natural forest management. This process results in the legalizing of participatory land use plans and adat-based land tenure on state-owned land. Thus, the FORMACS Project is approaching the land tenure issue through building the capacity of local government and people on land use planning and institutional capacity as well as facilitating dialogue

between the two parties. The new paradigm in governance, District Autonomy, provides a conducive condition that enables local government and local people to reach mutual and beneficial understanding.

5. Current agricultural practices

Current farming systems are based mainly on slash and burn agriculture, and the use of steep slopes and land adjacent to rivers and streams. In the past, when natural forests were extensive and under-utilized, shifting cultivation was a viable and sustainable land use system. However, this changed in the 1960s when most of the lowland forests in Kalimantan (and other parts of Indonesia) were declared 'state forests' and given to forest companies in the form of forest concessions. Under this system, the government recognized lands under permanent cultivation (food crops and tree crops) as agricultural lands belonging to traditional communities, but did not recognize long-term fallows as agricultural lands belonging to the community. Thus, in the Project area, the best way for traditional communities to gain recognized use rights for land is to plant tree crops along with food crops (mixed cropping) and leave the trees to grow once the field is no longer used for food crops. This is important since target villages are located in an area with considerable potential for agricultural development. The proposed Trans-Kalimantan Highway will transect the area, opening it up for development. If the local people fail to take advantage of the economic potential of the area and establish use rights through the planting of trees, outside people will.

The FORMACS Project aims to help local people establish use rights over their traditional lands, and develop the economic potential of the land, while maintaining carbon stocks. To achieve this the FORMACS Project, in cooperation with local communities, developed agroforestry, tree-

crop agriculture and low external input sustainable agriculture (LEISA) technologies that also complement the effort for community-based forest management. The use of these technologies will also reduce the use of fire as a tool in local land use systems, reducing fire risks.

6. Lack of economic alternatives

According to the Indonesian Bureau of Statistics, in 1998 mining (31.7%) and manufacturing (42.8%) are the most important inputs to the Gross Domestic Regional Product of East Kalimantan. The majority of the medium and large-scale manufacturing sector is based on wood and pulp products. Although the province is extremely wealthy in natural resources, the local population is largely marginalized with little access to proper health care, education and extension services for improving agricultural production. Cutting timber has been seen as the answer to economic problems by both local communities and local governments. This was the case in the Sebuku and Sembakung area where, until recently, household incomes were largely dependent on illegal logging, and food supplies from small-scale agriculture. However, the supplies of commercial size timber are being exhausted at a rapid rate, and it is now difficult for villagers to gain

sufficient income from timber to meet their family's basic needs.

Villagers and district government are aware that timber can no longer be relied upon as the sole source of family income. At this point in time, agricultural development is the main alternative for generating local resources. However, because of distance and transportation costs, agricultural options are also limited.

The FORMACS Project and its partners carried out research on local commodities and marketing that served to identify commodities that are suitable for the project area. Opportunities for ecotourism based on conservation of resources, including biodiversity, were also explored through workshops and awareness campaigns. District government and local people are becoming more aware of the potential benefits that can come from the conservation of natural ecosystems.

Figure 1.2 described schematically the framework of FORMACS activities. Simply put, FORMACS activities are based on providing the local people with better livelihood options that can suppress drivers of forest conversion and will lead to poverty reduction as well as carbon stocks increment.

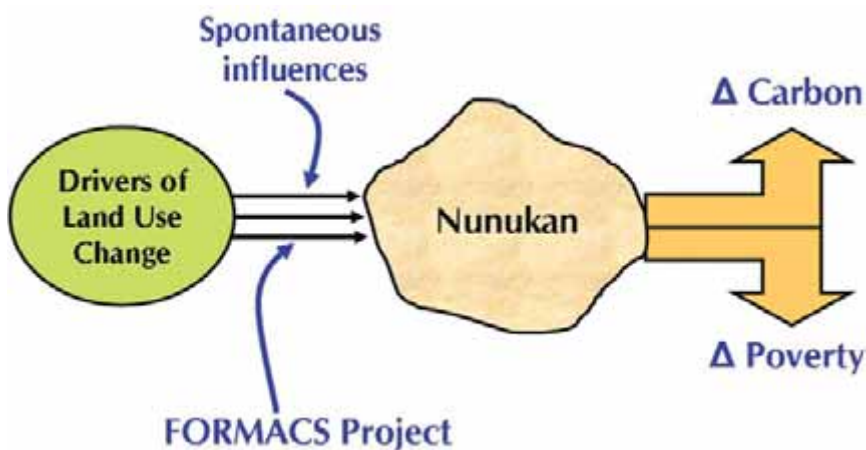


Figure 1.2. Schematic diagram of the FORMACS project framework

Carbon Monitoring Activities in Nunukan

FORMACS recommended agroforestry, tree-crop agriculture and low external input sustainable agriculture (LEISA) technologies as options to the farmers in managing their land. The rationale of this recommendation is that these options would provide sustainable livelihood for the farmers as well as increase or maintain carbon sequestration.

The performance of these recommended land use systems that are expected to function as carbon sinks need to be assessed and monitored. This process is dealt with in carbon monitoring activities. As the project interventions were targeting the district as a whole and there are many interactions in land use change linked to the opportunities for the local community to obtain returns to their labour, the assessment of net effects of project interventions has to be done at (sub) district scale.

Ponce-Hernandez *et al.* (2004), developed methods, models and software tools to assess carbon stocks and design scenarios using projects in Mexico and Cuba as an example. Their methods integrate the use of biophysical assessment and land use change models.

The FORMACS project implemented the Rapid Carbon Stocks Appraisal (RaCSA)³ approach to monitor carbon stocks in Nunukan. The carbon monitoring activity using the RaCSA approach has three main objectives:

1. To estimate carbon stocks in Nunukan for the main land use practices at plot level as well as their integration at landscape level.

³ Rapid Carbon Stocks Appraisal (RaCSA) is developed by ICRAF to assess carbon stocks in a landscape. ICRAF has also developed Rapid Hydrological Appraisal (RHA) to assess hydrological function of a watershed and the impacts of land use change on key functions. Currently being tested and developed is a Rapid (Agro)Biodiversity Appraisal (RaBA) method to assess biodiversity of a landscape from local well as external perspectives. These are three basic tools that can be used to assess environmental services of a given area.

2. To assess the performance of existing land use systems managed by farmers in Nunukan as carbon sinks.
3. To appraise landscape carbon stocks dynamics in Nunukan in relation to 'drivers' of change, as a basis for selecting interventions that enhance people's welfare as well as the carbon stocks of the area.

To achieve these objectives four activities were carried out:

1. Socio-economic survey at household level. This was conducted in Sebuk and Sembakung sub-district, to explore the land use systems managed by farmers in the area as well as their productivity and profitability. The productivity and profitability of a land use system are considered as part of the main factors that drives farmers to practice it in his land. Thus, these factors also determine the amount of carbon sequestered or maintained over time.
2. Carbon stocks measurement at plot level. Samples plot were set up at each existing land use systems in the study area. Carbon stocks were measured and will become the basis for assessing the performance of each land use systems to function as carbon sinks.
3. Land use/land cover change using remote sensing analysis. Satellite images were obtained and analyzed to produce land cover maps of Nunukan. Land cover change are estimated using land cover maps from two different periods. Using the result from plot level study of carbon stocks (activity 2), landscape level carbon stocks and its changes over a period of time can be estimated.
4. Landscape simulation modelling. To predict the dynamics of landscape carbon stocks, a landscape simulation model FALLOW⁴ was applied. This model

⁴ FALLOW (Forest, Agroforest, Low-value Land Or Waste-land?) is a landscape dynamic model developed by ICRAF. For more information see <http://www.worldagroforestrycentre.org/sea/products/models>

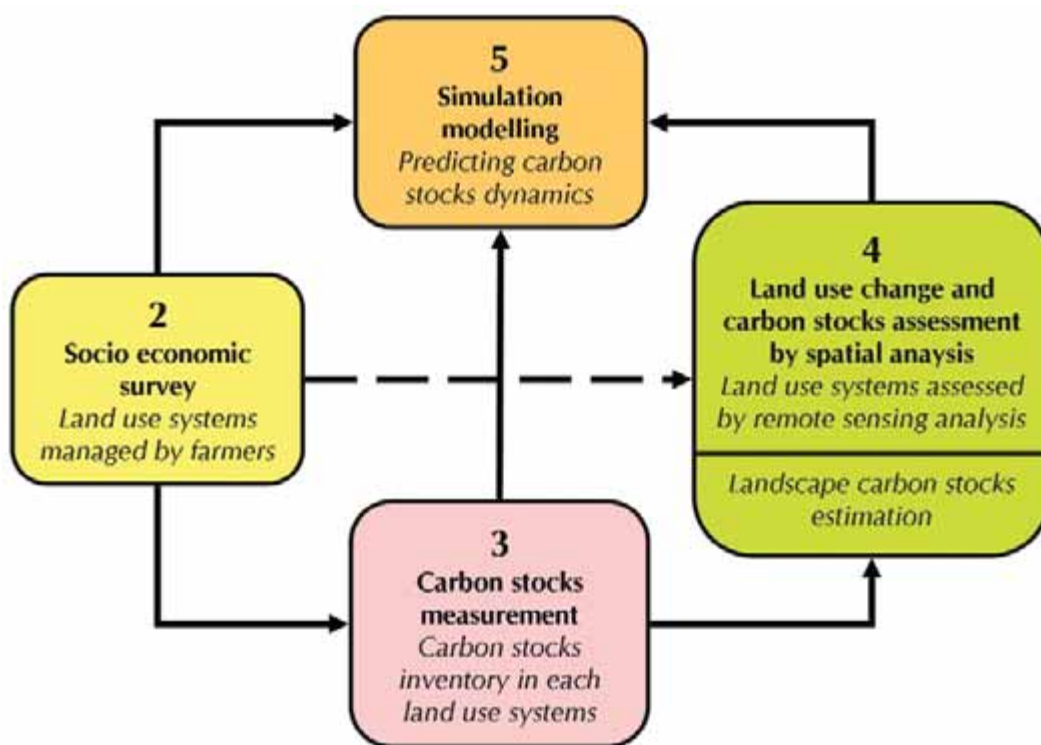


Figure 1.3. Link between the various chapters in this report (number in the figure refers to chapter number in this report).

simulates the impact of farmers decision in managing their land to the landscape carbon stocks dynamics. A range of possible pathways that farmers may decide to act in response to existing opportunity were evaluated.

The four activities within the RaCSA activity are compiled in this report. Figure 1.3 shows how the various activities and chapters in this report are linked together.

Chapter 2 provides a background on Nunukan as the study site for this project and describes the main land use systems that exist and managed by farmers. Carbon stocks measured in the various land use systems is reported in Chapter 3. This chapter also analyzed the performance of each land use systems in sequestering carbon over time. In addition to that, the chapter documented tree species found in each land use systems.

Chapter 4 describes carbon stocks assesment at landscape level using remote sensing analysis. A simulation modelling activity that integrates all the results obtained from Chapter 2, 3 and 4 is reported in Chapter 5. The activity simulates the carbon stock dynamics as the landscape changes over time due to farmers behaviour in adjusting their options to manage their land.

The studies reported here is an example of an integrated approach to carbon monitoring being applied in the field. The outcomes of this activity, that is estimation carbon stocks dynamics over a range of possible pathways, are expected to provide a starting point for dialogue with farmers on the range of options that are beneficial for their livelihood and environment. It is also a starting point for dialogue with policy makers at local as well as national level, on providing the local people with policies that enable them to manage their land and its surroundings in sustainable ways.