Towards Reduced Emissions in a High-Stake District

REALU Project Design for Tanjung Jabung Barat (Tanjabar), Jambi, Indonesia

version 2.0


Prepared by:
Atiek Widayati, Suyanto and Meine van Noordwijk (editors)

World Agroforestry Centre – ICRAF
Southeast Asia - Indonesia

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Acknowledgements

This document is developed based on the execution of activities, data analyses, discussions and papers prepared for REALU II project – Indonesia, with the contributions of the following individuals (in alphabetical order):

Andree Ekadinata, Arif Rahmanulloh, Asep Ayat, Caroline Almeida Souza, Dri Handoyo, Elok Mulyoutami, Feri Johana, Gamma Galudra, Janudianto, Jasnari, Joy Navarro, Muhammad Sofiyuddin, Muhammad Thoha Zulkarnain, Ni'matul Khasanah, Noviana Khususiyah, Putra Agung, Rachmat Mulia, Ratna Akiefnawati, Subekti Rahayu, Suyitno, Tonni Asmawan, Ujjwal Pradhan and Yana Buana

Front cover photos: by Atiek Widayati

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0. Executive Summary

Climate-change mitigation should seriously take into account GHG emissions from deforestation and decline in forest carbon stock ('forest degradation') as part of total emissions from AFOLU (agriculture, forestry and other land uses). Efforts to reduce emissions from tropical land uses have been linked to financial investment and coinvestment by industrialized countries to compensate the developing countries that are willing to reduce emissions and are formalised under the name of REDD (Reducing Emissions from Deforestation and (Forest) Degradation) or REDD+ (the same, plus efforts to restore or enhance forest carbon stocks). There are big challenges to reach the objectives and in developing the incentive mechanism, particularly in the definition of forest and also in the inclusion of other land uses with regards to emissions and the recognition of potential carbon sinks or CO_2 removal.

Debates continue over basic concepts of scope of targeted actions to reduce land use based emissions related to the definition of forest. The debate has also developed in parallel to the NAMA (nationally appropriate mitigation actions) approach to deal with emissions at national scale through a combination of policy instruments. In anticipation and response to such debates, the ASB partnership created an initiative to address the issues of land-use definition or boundaries within REDD and introduced a more holistic landscape approach to land-based emission reduction efforts, formulated under the term Reducing Emissions from All Land Uses (REALU). It tries to ensure that NAMA's are based on Locally Appropriate Adaptation and Mitigation Actions (LAAMA), that address real needs of the rural economy alongside environmental targets.

There are three foundations to achieving REALU objectives: (1) Respect of the rights of indigenous people through free, prior and informed consent (FPIC); (2) Respect for national sovereignty within differentiated global responsibilities; and (3) Integrity of accounting systems based on AFOLU guidelines. To achieve these objectives, emission reduction and carbon enhancement in four different land use categories are laid out as the four pillars of REALU : 1) Reducing emissions from deforestation and forest degradation (REDD); 2) Reducing emissions through improved peatland management (REPeat); 3) Reducing emissions by carbon-stock enhancement (REStock); 4) Reducing emission from greenhouse gases owing to agricultural activities (REAgg).

To get better understanding of what a REALU approach towards low-emission development strategies might entail (the foundation and the pillars), we embarked on a case study in Indonesia. The Tanjung Jabung Barat district (Kabupaten Tanjung Jabung Barat) in Jambi province, Sumatra , provided a high-stake REALU demonstration landscape. It includes active deforestation, conversion of peatlands, reforestation for the pulp and paper industry, oil palm plantations and an active smallholder agricultural segment, driven by active migration; all the big REALU challenges in a nutshell.

Tanjung Jabung Barat district, or also called Tanjabar, is located on the east coast of Jambi province, bordering Riau province in the north. The geographic location is 7.35S–102.64E and 1.45S–103.58E and the district area is approximately 500 000 ha or 5000 km^2. The district has been mapped as having vast peatland (approximately 40 % of the area), with varied thickness from very shallow to very deep. 50% of land tenure in Tanjabar is under the jurisdiction of MoF with production forest (HP) as the largest designation status. Large scale logging concessions were operating in Tanjabar in

1970s-1980s and the post-logging concession era was marked with the abandonment of logged-over areas in various parts of the district. These lands were considered as open access lands and 'encroachments' in various kinds took place resulting in further clearing followed by different planting practices. The population is around 280 000 people, dominated by migrants, including early migrants from other parts of Sumatera, Javanese transmigrants and spontaneous migrants from Kalimantan (Banjar ethnic) and Sulawesi (Bugis ethnic).

The overarching goal of the study in Tanjabar is the implementation of effective landscape-based strategies for REDD+/REALU in the context of sustainable rural development and respect of local people's rights.

The case study was built to meet several specific objectives:

- To understand livelihoods and responses to landscape dynamics related to CO_2 emissions, land rights and forestry policies.
- To develop scenarios for low-emission development based on consultation with local stakeholders.
- To assess the trade-off with, and impacts on, livelihoods implied through land-use changes both from historical changes as well as from the simulated changes as part of a low-emissions development scenario.
- To identify areas and find evidence that supports project intervention that is based on major drivers of land-use changes and emissions, which reflect REALU principles and are in line or additional to ongoing local efforts.

Diagnostic steps to achieve the understanding on the backgrounds of emissions applied RESFA framework (REDD/REALU Site Feasibility Appraisal). Sampling scheme was designed to ensure representativeness of the district typology by taking into account the two important properties for land use development in Tanjabar: major soil types (peatland and mineral soils) and types of community (local and migrants). Beyond the diagnostic appraisal, attempts were made to simulate the future land use dynamics including tradeoff assessment under different scenarios conducted in FALLOW modeling tool. Based on the simulation results, Reference Emission Level and emission reduction strategies were be established. The policy instruments and institutional settings for REDD/REALU were reviewed in order to obtain comprehensive ideas of the enabling conditions.

Preliminary findings and conclusions of the feasibility appraisal in Tanjabar are as follows:

- The remaining forest cover in in 2009 in Tanjabar is approximately 110 000 ha (24 % of district area), decreased from 330 000 ha in 1990.
- Oil palm plantations emerged in the 1990s and are extensive up to the present. Large plantations flourished, followed by extensive development of independent smallholder oil palm plantations. HTI or industrial plantation (mostly Acacia) appeared to be a new system emerging in the 2000s which appeared in a moderate size and is only owned by large scale operators.
- Traditional farming systems that are important for local livelihoods are rubber, coffee- and coconut-based systems. In peatland areas, coffee- and coconut-based systems seem to be more persistent, shown by the relatively constant area, despite slight dynamics. Rubber was relatively constant until 2005 and has experienced a decrease in the most recent four to five years.

- Welfare was assessed from income level and land holding. The finding shows that in average, income per year per household for villages in mineral soil area is higher than the figure in peat area. In addition, the difference of income between transmigration villagers and local villagers is high, with the income of transmigration villagers being about three times of the income of local villagers. In contrast, income of old migrants and recent migrants in peatland villages is similar.
- Most of the lands belonging to transmigration villagers are planted with oil palm. When categorized by land uses, the land holding of local villagers in mineral soil are dominated by rubber and oil palm. In peatland villages, agroforestry or mixed garden system that consists of mixed coconut with betel nut palm (*Areca catechu*) and coffee is an important land use system for early migrants.
- The equity of income is higher in peat area than in mineral-soil area. Income inequity is very high between transmigrants and local villagers in mineral soil areas. For transmigration villagers, surplus from oil palm income is often used to buy new lands from the local villagers and to invest in oil palm expansion, which further increases the income gaps.
- In-migration in mineral soil villages is relatively higher than in peatland villages. One of the reasons could be the availability of land in mineral soil which attracts people from other areas, who want to expand their farmlands. Trends of conversion are mainly into oil palm plots, and to smaller extent, into rubber monoculture plots. Currently, within peatland area, in-migration rate is relatively decreasing, due to the low land availability.
- In Tanjabar two types of KPH (*Kesatuan Pengelolaan Hutan*) or Forest Management Units have been formed: *Kesatuan Pengelolaan Hutan Lahan Gambut* (KPHLG, Forest Management Unit on Peatland) and *Kesatuan Pengelolaan Hutan Produksi* (KPHP, Forest Management Unit for Forest Production Purposes). KPHLG is established in peat forest area covering around 16 000 ha and KPHP is in Production Forest which allocates 80% of the area to timber plantation concessions while the remaining 20 % has not obtained formal management allocation.
- KPH scheme is expected to to address chronic forest governance issues and to bring better forest management systems for Indonesia's forest. For Tanjabar, the scheme was thought as a remedy to slowly remove the perception of 'open accesses' for the large parts of state forest land.
- Land tenure security was examined pertaining to the access gained by migrants and the changes in customary land tenure. The relational concepts of land rights between migrants and locals and customary land tenure changes by locals are often mediated by the expectation of benefits and costs, especially on claiming state forest land as customary land. Land transactions enable migrants to forge a social identity as part of customary people and to engage in the process of strengthening their access rights to land. On the other hand, the customary land tenure in Tanjabar is being modified and it adopts migrants' land tenure system that is being introduced not only to accommodate migrants' interest on land, but also to expand and strengthen customary land tenure over state forest land.
- Role of women in land and farming system management is minor compared to the role of men. Nevertheless, for particular aspects where activities are not physically demanding, women play major roles, e.g. in post harvesting activities.

- External drivers that play a big role in Tanjabar, as also in many other parts of Indonesia, are industrial demand for both food crops such as oil palm and pulp and paper such as acacia. Forestry and land-uses policies are the next link in the chain that supports the expansion of the two commodities. Other factors that go along with the process relate to the flow of in-migration in the area, which was driven both by the central government program of transmigration as well as the more organic spontaneous migration taking place since the mid-1900s up to the present.
- Ultimately, the local actors inevitably react to the dynamics and create their own loop in modifying their landscape responding to factors such as attraction of high profit commodities, labour considerations and land availability.
- From the biomass and carbon stock assessments of different land cover systems in Tanjabar, the findings confirm that total aboveground carbon stock of a particular land-cover system of is affected by factors such as age of the land-use system. There was as well indication of the difference growth rates of species planted in mineral soils and in peatland areas.
- Total belowground carbon stock in peat soil is affected by peat depth, bulk density and maturity of peat. Mature peat (sapric) has lower carbon content while it has higher bulk density.
- In Tanjabar, the trend of aboveground carbon loss, hence emissions, has the highest rate in the early 2000s, while towards recently, emissions decreased, which is very likely owing to the minimum stock available. There is indication of high emission in peat protection forest area in the recent years which is most likely due to increasing encroachment into the protection area for small-scale gardens and cultivation such as oil palm.
- Removal of CO_2, or carbon sequestration, shows a persistent increase, with a relatively high figure for the most recent years. Trajectories of sequestration came from an increase of vegetation densities in different tree-based systems, which most likely reflect agroforestation processes, additional intercropping in different tree-based systems or, to some extent, abandonment of the unproductive/low productivity farms.
- The district currently is undergoing a phase where highly commercial, low carbon-stock, land-use systems dominate the area. The increasing carbon stock in some land-use systems may indicate that Tanjabar is embarking on the later stage of the forest transition gradient where vegetation, and hence carbon, increases , although chances are that it will experience a prolonged medium stage in forest transition where low carbon-stock land-use systems persist.
- Profitability analysis of land uses in Tanjabar show that the land uses systems in both mineral soil and peatland are profitable and the most profitable system is large-scale oil palm.
- Among the smallholder systems, oil palm is the most profitable, both in mineral soils and in peatland areas. Rubber on mineral soils is less competitive than oil palm as the profitability of oil palm was almost three times that of rubber. Mixed gardens on peatland, e.g. coffee-based system, compete well with oil palm since their profitability is almost the same as that of oil palm. The threat of converting land to oil palm was higher on mineral soils than on peatland.
- Opportunity cost analyses show that the percentage of total emissions that could have been compensated by the price of carbon in the global market, which is assumed to be USD 5 in

this study, increased throughout the three periods of observation, from 42 % to 58% and to 64%.

- Projected land use changes based on the historical trends show a clear indication towards monoculture plantations of oil palm and acacia.

Four scenarios in FALLOW modeling were developed : 'BAU' by assuming conditions that are currently undergoing will persist until 2020, 'Peat Protection' in which the ongoing efforts of peat forest rehabilitation efforts will be better reinforced, 'REALU' which incorporates the local aspirations and initiated REALU/REDD relevant efforts and 'Green REALU' which added further conservation efforts to REALU scenario.

Summary of discussions towards the intervention of REALU in Tanjabar is presented below:

- In reality, establishing Reference emission level should take into account comprehensive and multi sectoral assessments including musltistakeholders' consultation. However, for this study attempt was made to establish REL based on BAU resulting from FALLOW simulation.
- Emission reduction strategy that reflects approaches and values proposed by REALU employs the simulated results of 'REALU' scenario, which reflects both reasonable emission reduction as well as low amount of forgone economic opportunity relative to BAU by 2020.
- By considering the contribution of reduced emissions through avoided emissions and carbon enhancement, enabling institutional and policy baselines as well as local efforts, two potential intervention sites were proposed each with strength and challenges to be addressed: KPHLG in the vicinity of peat forest remnants and KPHP Open Access areas in the western part of the district.
- Gaps and challenges for moving further with REALU approaches in Tanjabar have been identified which cover the topics/aspects of: leakage and leakage mitigation, improved estimation of emissions from peatland areas, interface with spatial planning for the more integrated and landscape-based low emission development and feasibility study for the promotion of locally appropriate carbon enhancement and agroforestation commodities.

1. Opportunities for integrated approach to land use based emissions in Indonesia

1.1 Introduction

Climate-change mitigation, as discussed in the UN Framework Convention on Climate Change (UNFCCC) includes efforts to reduce net anthropogenic emissions of greenhouse gasses by turning the net global source of CO_2 emissions in tropical land use into a sink, as has already happened in the temperate zones. Across the various greenhouse gasses and processes that lead to net emissions, 'agriculture, forestry and other land uses' (AFOLU) is responsible for about 30% of total emissions. Part of these emissions is caused by deforestation and decline in forest carbon stock ('forest degradation'). Earlier estimates of forest-related emissions as 20% of the total (Parker et al, 2008) have been adjusted downwards as fossil fuel use kept increasing (Friedlingstein et al, 2010). UNFCCC negotiations have linked efforts to reduce emissions from tropical land use to financial investment and coinvestment by industrialized countries. REDD (Reducing Emissions from Deforestation and (Forest) Degradation) or REDD+ (the same, plus efforts to restore or enhance forest carbon stocks), will require compensation for developing countries that are willing to reduce these emissions. What was initially defined as reducing emissions from deforestation (RED) has evolved into REDD and REDD+ with the inclusion of forest degradation and carbon restocking respectively. There are big challenges to reach the objectives and in developing the incentive mechanism, particularly in the definition of forest and also in the inclusion of other land uses with regards to emissions and the recognition of potential carbon sinks or CO_2 removal. For carbon and emission accounting, however, IPCC guidelines (IPCC 2006) decided that methods of accounting should include all sources of carbon pools (Agriculture, Forestry and Other Land Uses (AFOLU)) and emissions should be proportioned to the land-use sources from where they originate.

1.1.1 REALU or REDD-plus-plus, NAMA or LAAMA

Debates continue over basic concepts of scope of targeted actions to reduce land use based emissions related to the definition of forest. There is a clear need to account for all sources of emissions to fulfil the mitigation and emission reduction targets and emission displacement across land categories is a real concern, with substantial tree cover outside of conventional forest categories considered in REDD (Ekadinata et al, 2009). The $REDD^+$ debate has developed in parallel to the NAMA (nationally appropriate mitigation actions) approach to deal with emissions at national scale through a combination of policy instruments. Indonesia has been a leader and focus in the debates that now converge in nationally committed emission reduction targets across all sectors of the economy. In anticipation and response to such debates, the ASB partnership created an initiative (Figure 1) to address the issues of land-use definition or boundaries within REDD and introduced a more holistic landscape approach to land-based emission reduction efforts, formulated under the term Reducing Emissions from All Land Uses (REALU) (van Noordwijk et al, 2009, 2010). It tries to ensure that NAMA's are based on Locally Appropriate Adaptation and Mitigation Actions (LAAMA), that address real needs of the rural economy alongside environmental targets.

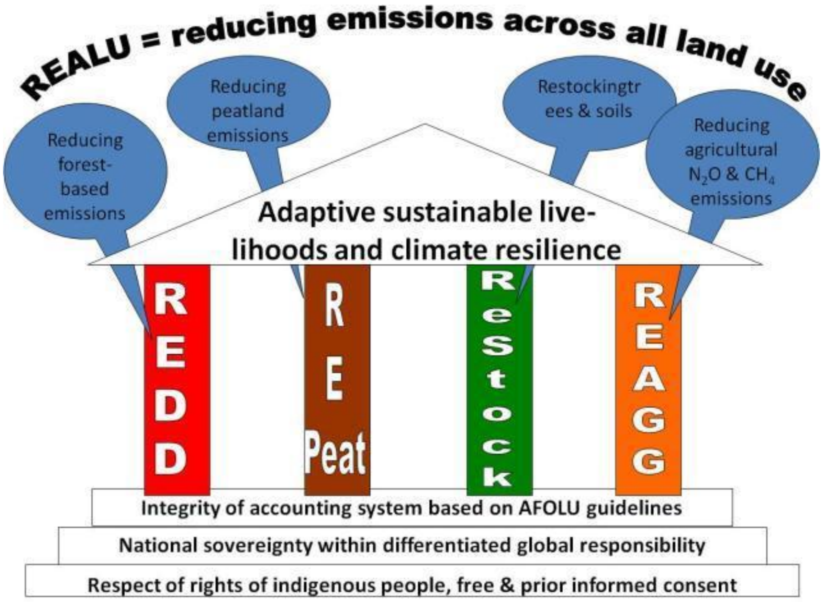


Figure 1. REALU foundation on three principles and architecture with four columns supporting the goal of adaptive sustainable livelihoods and climate resilience (van Noordwijk et al, 2009)

Van Noordwijk et al (2009) provided evidence of the emission reduction achievable by inclusion or exclusion of various land-use types in policy instruments. The authors suggested that moving ahead with REALU can be conducted through the promotion of high carbon-stock land uses, which support global climate goals as well as low-emission development goals at the local and subnational levels. There are three foundations to achieving REALU objectives: (1) Respect of the rights of indigenous people through free, prior and informed consent (FPIC); (2) Respect for national sovereignty within differentiated global responsibilities; and (3) Integrity of accounting systems based on AFOLU guidelines. To achieve these objectives, emission reduction and carbon enhancement in four different land use categories are laid out as the four pillars of REALU (van Noordwijk et al, 2009; see Figure 1):

1. Reducing emissions from deforestation and forest degradation (REDD).
2. Reducing emissions through improved peatland management (REPeat).
3. Reducing emissions by carbon-stock enhancement (REStock).
4. Reducing emission from greenhouse gases owing to agricultural activities (REAgg).

1.1.2 Emissions from peatland

Peat soils contain very high carbon stocks under natural conditions with natural vegetation cover, like peat forest or peat-swamp forest. However, the carbon stored is readily emitted when the vegetation is cleared and the soil is drained. In its natural condition and with good natural vegetation cover, peatlands serve as a sink for carbon that contributes to reducing greenhouse gases in the atmosphere, although the carbon accumulation process is very slow (Agus et al, 2009). Removing land cover and draining the peat soil will result in the oxidation of the carbon stored in peat to become CO_2, and the peat surface will easily subside as the result of emission and peat consolidation. Indonesia has vast peatland areas covering 20 million ha or approximately 10% of the land area. It has gained global attention owing to conversion of peatlands, which has been suspected of contributing a much larger share of CO_2 emissions than those from above ground. Part of the peat issues overlap with forest debates, but the efforts needed to reduce peatland emissions go substantially beyond internationally accepted forest definitions. Specific reference to peat next to forest is needed to provide institutional cover for what is needed on the ground.

Estimates of peat emissions owing to the opening and draining of the land bear high uncertainties and many estimates are still under debate about the level of confidence that can be assigned to them. Nevertheless, despite the uncertainties, forest conversions in peatlands undoubtedly bring about high emissions and should be seriously taken into account in emission calculations in the climate-change mitigation context. Proxies from various empirical studies have been applied to estimate the emissions owing to forest conversion to other land-uses (e.g. Hooijer et al, 2006). Ongoing analyses are also taking place in parts of Sumatra to try to find more reliable and cost-effective proxies for peat emission estimations (Maswar et al, in preparation).

From soil management perspectives, information on the variety of properties and characteristics of peat is very important in order to develop strategies for management of peatlands in order to reduce subsidence and potential CO_2 emissions and achieve a sustainable agricultural system and economic benefits from peatland. And ultimately, good and reliable information will also be crucial for emission reduction strategies.

1.1.3 REstock: forest and outside forest

The transition of forests to other land uses is normally a response to the drivers of the changes, which can be constituted into endogenous socio-ecological feedback as well as exogenous triggers (Rudel 2005, Lambin and Mayfroidt 2009). Within the forest transition gradient, land-cover changes serve as internal dynamics that lead to forest recovery.

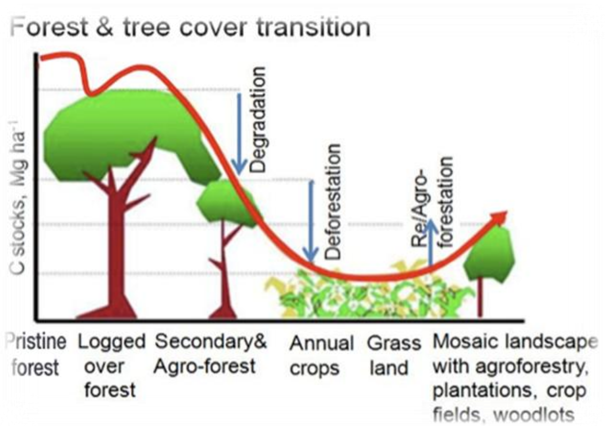


Figure 2. Gradients in forest and land-use transition

The inclusion of reforestation and afforestation in the Clean Development Mechanism (R/A-CDM) has not met the initial expectations. At least part of this (van Noordwijk et al, 2008a) has been due to issues of forest definition linked to the institutional control over reforested/afforested lands. The recognition of tenurial issues as central to any implementation of RED, REDD or REDD$^+$ (van Noordwijk et al, 2008b) has grown over time and this debate is now part of the NAMA/REDD$^+$ discourse in Indonesia.

1.1.4 REagg: agricultural greenhouse gas emissions

Intensification of agriculture can lead to higher yields per unit land and lower total land requirements to meet growing demand for food, feed, fibre and fuel, but it often increases emissions of nitrous oxide due to fertilizer use. Integrated 'footprint' calculations, as currently done for oil palm, include both costs and potential benefits (when expressed per unit product) of such intensification. However, the value and universal applicability of global default values of N_2O emissions per unit fertilizer use are uncertain.

1.2 REALU in Indonesia

Indonesia has committed to reduce carbon emissions by establishing its nationally appropriate mitigation action (NAMA) plans. Further, the country is taking voluntary action to reduce emissions by 26% below the 2020 'business as usual' scenario and by another 15% with international assistance. Economic growth, however, should also reach 7%. At subnational level, strategies to achieve both objectives is being formulated through low-carbon development planning.

Key challenges are in the integration across sectors and emission sources, and in the way local economies are nested in the national economy, including by demographic transitions that include migration into forest margins and away from degraded lands.

To get better understanding of what a REALU approach towards low-emission development strategies might entail (the foundation and the pillars), we embarked on a case study in Indonesia. The Tanjung Jabung Barat district (Kabupaten Tanjung Jabung Barat) in Jambi province, Sumatra , provided a high-stake REALU demonstration landscape. It includes active deforestation, conversion of peatlands, reforestation for the pulp and paper industry, oil palm plantations and an active smallholder agricultural segment, driven by active migration; all the big REALU challenges in a nutshell. For the rest of this document, 'Tanjabar', the shortened version of the district name, will be the lense through which we assess the feasibility of a REALU concept in the real world.

1.2.1 REALU-related issues at Tanjabar

Tanjabar district has issues that challenge the district government: land-use change needs to be in concordance with sustainable development, district revenue income as well as sustainable forest governance. These issues represent the degree of complexities faced by REDD+ implementation in Indonesia and thus have captured the interest of the REALU 2 project in Indonesia to choose Tanjabar as the demonstration landscape.

- Almost half of the area has peat soil (Wahyunto et al, 2003) and a large part of the peatland in Tanjabar has been drained and cultivated. Past peatland development was mainly smallholder farming of coconut- and coffee-based systems, while ongoing development involves large-scale plantations of oil palm and acacia. Issues of peatland management and cultivation and the implications on CO_2 emissions are relevant points for REALU.

- Forest governance in Tanjabar has been facing challenges related to land grabbing and encroachments on the ex-logging areas left by concession companies in the 1970s and 1980s.
- Tanjabar is largely a 'migrant land', since in-migration has been widely taking place since the mid-1900s to the present. The migration, together with the above-mentioned 'open access' phenomenon, escalates land grabbing and triggers uncontrolled land expansion.
- Recently, forestry authorities applied new approaches to rehabilitate forests that fall under the 'forest land' status. Understandably, such efforts faced resistance by local farmers and further approaches need to be developed to ensure that they are beneficial for local villagers.

1.2.2 Study area

Tanjabar district is located on the east coast of Jambi province, bordering Riau province in the north. The geographic location is 7.35S–102.64E and 1.45S–103.58E (Figure 3) and the district area is approximately 500 000 ha or 5000 km^2.

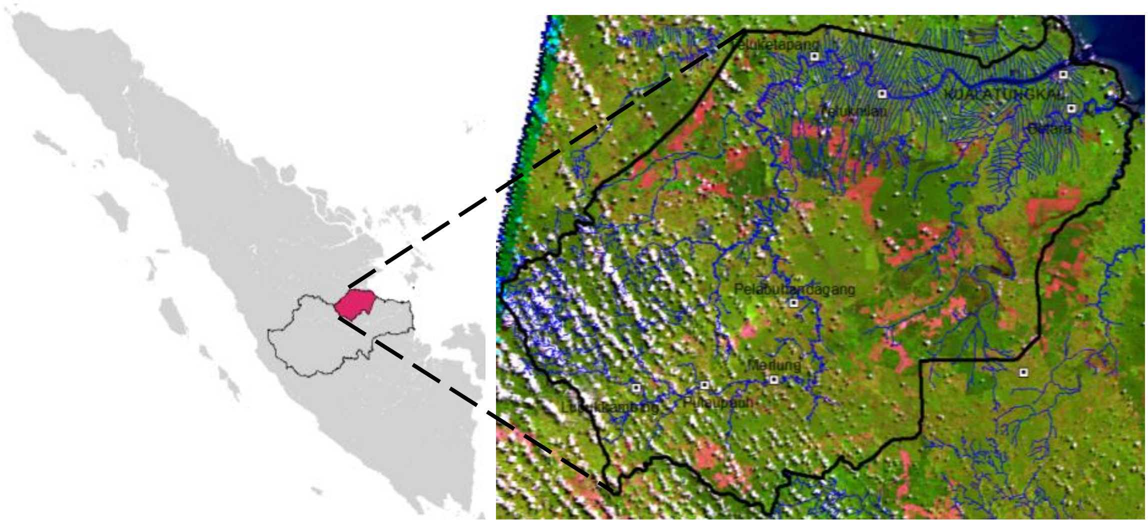


Figure 3. Location of Tanjabar district, Jambi province, Sumatra, Indonesia

Approximately 40% of the district is peatland , falling roughly into three subdistricts (locally called *kecamatan*): Pengabuan, Betara and Bram Itam. The remaining 60% of the area, in the southwestern part, is mineral soils, dominated by podsolik, alluvial, and grey hydro morfik. About 48% or 240 000 ha of the district is classified as 'forest area'. About 71% of this 'forest area' is classified as production forest, 6.65% is protected peat forest and 3.66% is national park. The proportion of 'non-forest area' in this district is very high, dominated by coconut agroforestry, rubber agroforestry, rubber monoculture and, most recently, oil palm.

Hutan Lindung Gambut (HLG) or peat protection forest is based on the decree of the Jambi governor on 'peta padu serasi TGHK and RTRW' No. 108/1997 and the decree of the Jambi Forest Agency No. 425.3/2350/Dinhutbun/2004 on 11 May 2004. The total peat protection area is approximately 16 065 ha. Some parts of HLG have been used by the local community as log transportation paths.

Data from the district forest agency shows that around 4624 ha has been occupied by local farmers for farming. Ditches and canals were built manually and semi-mechanically to regulate water and for transportation.

The district population is around 280 000 people, with a population density of 56 per km^2. Local people dominate the inland in the southwestern part of the district, while migrants dominate the peat areas and coastal villages (northeastern parts). Locals are defined as native people as well as inland migrants from western or northern Sumatra who came to the region around 100 years ago. In lowland areas, early spontaneous migration was from South Kalimantan (ethnic Banjar people), South Sulawesi (Bugis people) and Java (Javanese), who came between 1930 and 1950. In both inland and lowland areas, transmigration from Java began around 1980 and continued up until 2000.

1.2.3 Goal and objectives

The overarching goal of the study in Tanjabar is the implementation of effective landscape-based strategies for REDD+/REALU in the context of sustainable rural development and respect of local people's rights.

The case study was built to meet several specific objectives:

- To understand livelihoods and responses to landscape dynamics related to CO_2 emissions, land rights and forestry policies.
- To develop scenarios for low-emission development based on consultation with local stakeholders.
- To assess the trade-off with, and impacts on, livelihoods implied through land-use changes both from historical changes as well as from the simulated changes as part of a low-emissions development scenario.
- To identify areas and find evidence that supports project intervention that is based on major drivers of land-use changes and emissions, which reflect REALU principles and are in line or additional to ongoing local efforts.

1.3 Methodology

The diagnostic steps of REALU feasibility follow the REDD/REALU Site Feasibility Appraisal (RESFA) framework developed by the World Agroforestry Centre (ICRAF) Southeast Asia Program (van Noordwijk and Joshi, 2009). In principle, the framework tries to address the major question: 'Is it worthwhile to pursue a project to reduce emissions from land uses (including forest) or will it be too complex, too costly or low in co-benefit returns?' There are three hierarchies of assessment in RESFA that will be explained briefly in the following section (see Figure 4).

1.3.1 REDD/REALU Site Feasibility Appraisal

The first layer of RESFA contains basic assessments related to carbon stock, land-cover maps, land-use and land-cover changes, profitability of land uses, analyses of land tenure security, existing forest institutions and policies and livelihoods assessments. All of the assessment methods have been developed at the World Agroforestry Centre (ICRAF) Southeast Asia Program (http://www.worldagroforestrycentre.org/sea/projects/tulsea/) and have been standardised for cross-referencing and to ensure synchronised attributes and definitions.

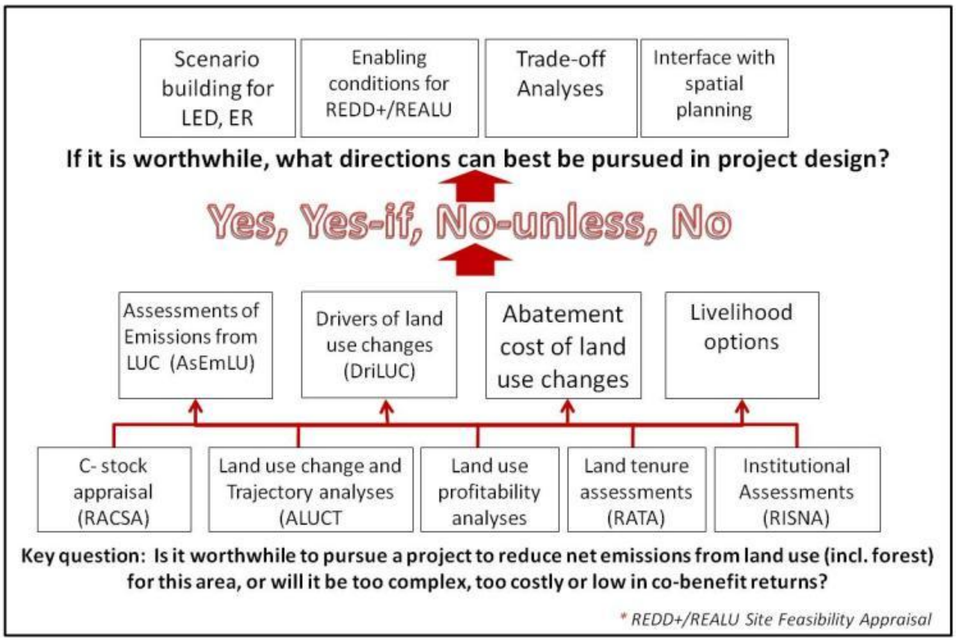


Figure 4. RESFA Framework (Legend: LED = low emissions development; ER = emissions reduction; LUC = land-use change; AsEmLU = Assessments of Emissions from Land Use change; DriLUC = drivers of land-use change; RACSA = rapid carbon stock appraisal; ALUCT = analysis of land-use and land-cover trajectories; RATA = rapid tenure appraisal; RISNA = rapid institutional appraisal)

The second hierarchy of assessments involves more integrated approaches, making use of the outputs from the first layer. Some examples of the assessments are below.

- Assessment of emissions from land-use changes, which takes into account the extrapolation of plot-level carbon stock to the landscape level, based on an area factor in land-cover maps.
- Opportunity cost of land-use changes, which incorporates emissions resulting from land-use changes and the changes of net present value derived from land-use profitability assessments.

Based on the assessments, an initial indication of the feasibility of the site can be achieved as either

1. 'Yes'
2. 'Yes, if'
3. 'No, unless'
4. 'No'

For the first three responses, further actions can be pursued, which are beyond the diagnostic steps of RESFA, providing direction to project design based on the feasibility findings. These cover several points:

- Building scenarios for emission reduction and risk analyses of not pursuing emission reduction strategies.
- Trade-off analyses, including impacts on people's livelihoods.
- Assessments of the enabling conditions, including existing institutions, needed for the implementation of low-emission development.

- Interface with the spatial planning.

Emission reduction scenarios, the trade-offs and impacts on livelihoods were operationalised using the modeling approach in the ‘Forest, agroforest, low-value landscape or wasteland’ (FALLOW) method (van Noordwijk 2002, Suyamto et al, 2009). The interface with spatial planning will be based on a framework called ‘Land-use planning for low-emission development strategies’ (LUWES).

1.3.2 Sampling for socio-economic and livelihoods characterisation

To capture the different socioeconomic and livelihoods properties of the population in Tanjabar, sampling strategies need to consider representativeness for the entire district, while taking into account the compromise between level of detail and the number of samples in relation to timeframe and cost. We decided the sampling level would be at the village level and the sampling scheme would follow the criteria discussed below.

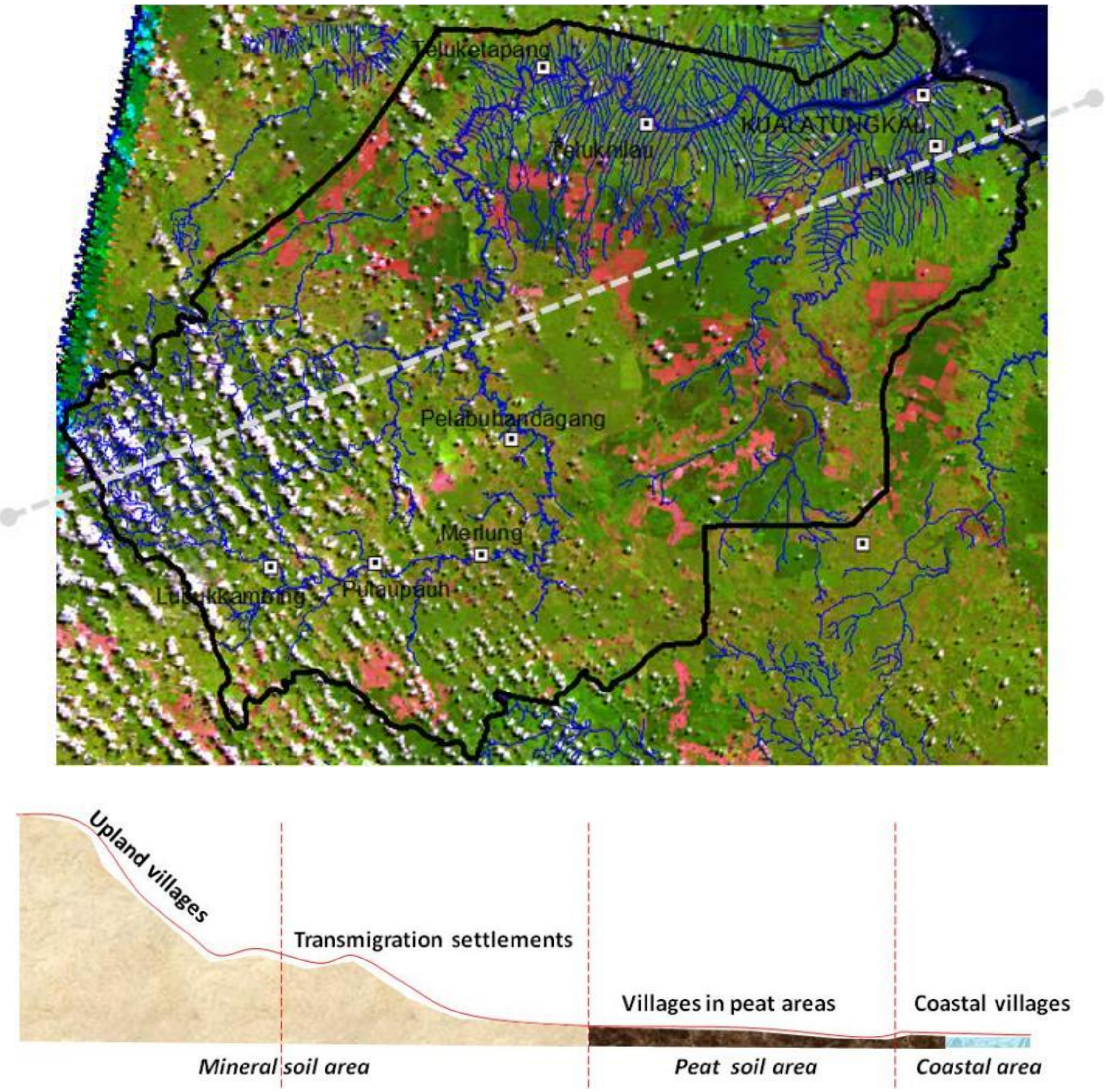


Figure 5. (top) West-to-east cross section of Tanjabar district; and (bottom) villages sampled based on topographical gradients of the cross-section (not to scale)

Owing to the strong difference in soil types that affects land-use development, the first category for the sampling scheme was by soil categories: peat soil and mineral soil. Further categorisation was based on the types of community, differentiated into migrant and local communities. Four strata as combinations of soil and community were then determined as the bases for a sampling scheme.

1. Lowland coastal villages. The community consists mostly of early migrants.
2. Peatland villages. These are in the vicinity of peat forests. The population consists of both early and more recent migrants.
3. Villages that were formerly transmigration settlements. These are located on mineral soils from the lowlands to hills.
4. Upland villages. These villages are located at the foothills of Bukit Tiga Puluh national park. The population is categorised as 'local'.

There are approximately 50 villages in Tanjabar. Based on the classification of the four strata weighted by the proportion of each strata from the entire number of villages, nine villages were sampled for further assessment (Table 1).

Table 1. Communities in Tanjabar based on the sampling typology

Group	Village	Remarks
Upland villages	Lubuk Bernai Lubuk Kambing Rantau Benar	Mineral, local community
Former transmigration settlements	Lampisi Adijaya	Mineral, migrant community
Peatland villages	Teluk Nilau Bram Itam Kanan Bram Itam Kiri	Peat, migrant community
Lowland coastal village	Tungkal 1	Coastal area, early migrant community

2. Backgrounds of current emissions from all land uses in Tanjabar

2.1 Livelihoods options and poverty[1]

Noviana Khususiyah, Janudianto, Yana Buana and Suyanto

2.1.1 Introduction

The livelihoods study collected data from community and household interviews. Focus group discussions gathered information on sources of livelihoods, land management practices, demography, poverty, gender roles, major development or commercial activities and migration patterns. Ten-to-15 people, representing formal and informal leaders, were invited to attend a one-day discussion. Following up on issues raised at the focus group discussion, more quantitative data were collected through a survey at household level. There was a total of 80 respondents for each area: 40 respondents in the mineral area (one transmigrant village and one local village); and 40 respondents in the peat area (one early migrant village and one recent migrant village) was randomly selected from the larger sample). As much as possible, both the husband and wife in each household were interviewed together when data was being sought on family characteristics, such as the number of family members; age, ethnicity and schooling of the household heads; modes and years of land acquisition; land use before acquisition and at present; plot size for all crops; costs, hired labour use and revenue of land-use types, such as oil palm, rubber and mixed gardens. Income and expenditure data for each household were used to assess the poverty level of respondents.

2.1.2 Farming system and livelihoods options

We analysed the changes of livelihoods in five periods.

1) Earlier years of the village's establishment.
2) 1970s (logging concession period).
3) 1990s (transmigrant and oil palm period).
4) 2000s (Reformation era).
5) 2010 (time of study).

Due to the emphasis on farming systems, Tungkal 1 village, which represents coastal villages, was excluded from these assessments. Tungkal 1 villagers, owing to the village location, mainly engage in coastal and marine livelihoods such as fishing.

[1] Based on Khususiyah N, Janudianto, Mulyoutami E, Buana Y and Suyanto. *Livelihood options, poverty and equity in the peat and mineral lands of Jambi: case study in Tanjung Jabung Barat*. in preparation.

2.1.2.1 Upland villages (mineral soils-local community)

The dominant ethnic group in these upland villages (or mineral soil–local community) is Malay, who have been living in the villages since the early 1900s. Most of them rely on the agricultural sector, especially tree-based land-use systems.

The history of agricultural systems in this area began more than a century ago and has undergone a long process of transformation from subsistence to market orientation. Currently, the livelihoods of most communities rely more on commercial agricultural crops such as rubber and oil palm and villagers mostly work as farm labourers.

Rubber cultivation

This mineral soil–local community has been familiar with rubber cultivation since their ancestors began to occupy the area. Rubber (*Hevea brasiliensis*) is currently the main source of livelihoods. Rubber has been planted form more than a century in Sumatra, from colonial times. Joshi et al, (2001) stated that at the beginning of the 20th century, *para* rubber (*Hevea brasiliensis* from the Amazon, Brazil) was brought from peninsular Malaysia to Sumatra by migrant workers in plantations, merchants and pilgrims. As reported by agricultural extension staff in 1918, the rubber agroforests in Jambi were first cultivated in 1904 using a slash-and-burn system.

In general, so-called 'smallholder rubber' is still traditionally managed, which means farmers still use low-quality seeds with minimum to zero fertiliser and weeding. Farmers in this upland area also use low-quality germplasm that comes from wild rubber seedlings that grow in old rubber plantations. These rubber seedlings have low rubber productivity (600 kg/ha/year). In this area, farmers do not apply fertilisers and pesticides in their rubber management. There are two rubber farming systems used by local people.

1) Simple rubber agroforests with up to one-third of non-rubber trees inside a rubber garden with 5–20 non-rubber species of > 2 m height and 5–20 non-rubber trees as tall as or taller than the rubber trees.
2) Rubber monoculture with almost no non-rubber trees (< 1%) and usually intensively managed (clean weeding).

Simple rubber agroforest

Most of the farmers in this area practise simple rubber agroforestry. When developing rubber gardens, farmers generally plant rubber together with fruit trees and valuable timbers, such as durian (*Durio zibethinus*), *duku* (*Lansium domesticum*), *petai* (*Parkia speciosa*), *jengkol* (*Archidendron pauciflorum*), jackfruit (*Artocarpus heterophyllus*) and rambutan (*Nephelium* sp). Practising this system, farmers will benefit not only from rubber but also from non-rubber products where fruit and timber also generate money for the family.

Monoculture rubber

In contrast, monoculture rubber seems to be much less favoured by many farmers in upland villages. Farmers usually practise monoculture rubber using traditional management where weeding and fertilising is still at a minimum level. Few or no non-rubber crops are grown in the garden, and if so, usually they are only planted on ditch banks as a barrier plant, such as betel nut palm (*Areca catechu*).

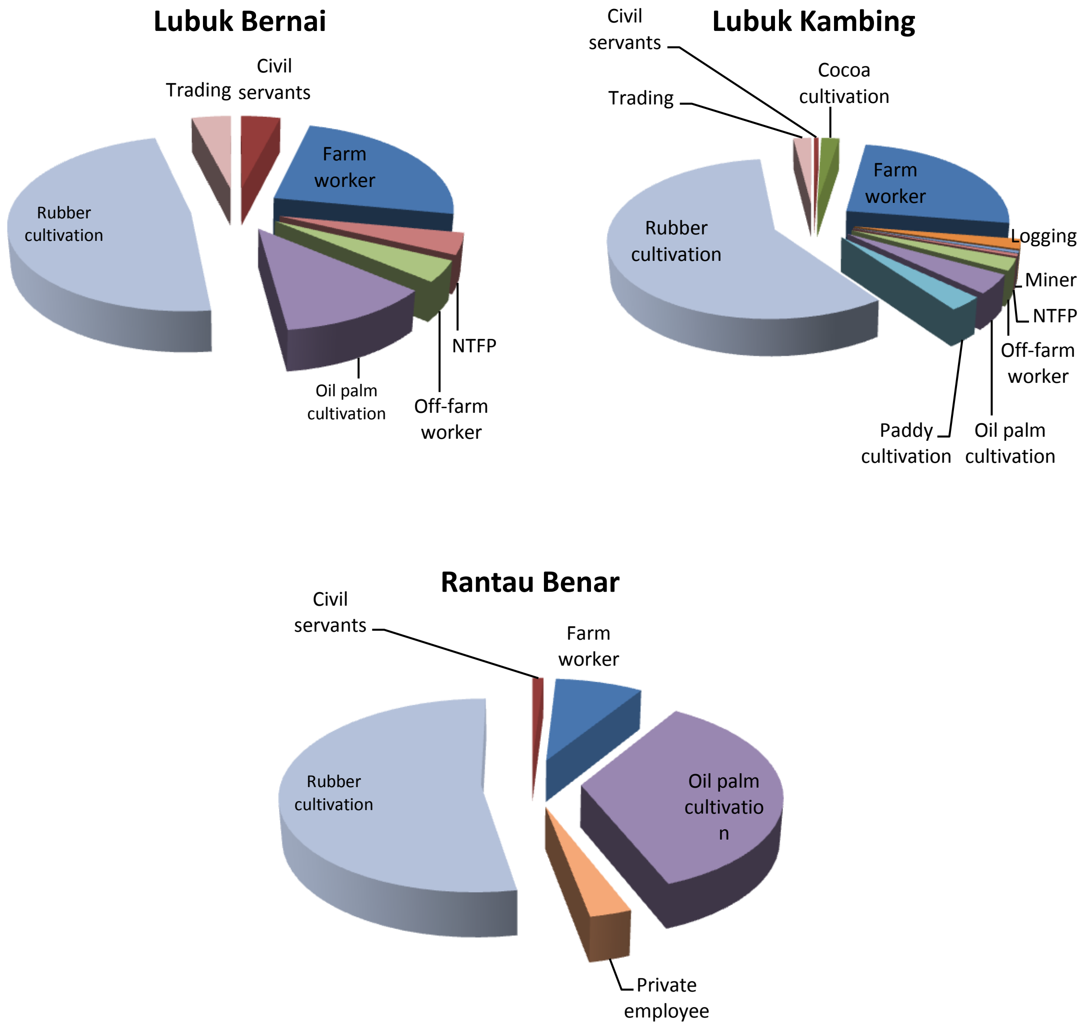


Figure 6. Components of main livelihoods strategies in mineral soil–local communities in 2010

Oil palm

The expansion of oil palm (*Elaeis guineensis*) in Indonesia has increased rapidly since 1970, especially in the 1980s, marked by the establishment of several government plantations followed by private plantations and 'people's plantations' that promote Nucleus Estate Smallholders or NES. The success of NES then encouraged the development of oil palm smallholdings. The NES scheme has been popular in Tanjabar.

The high demand for manpower on large-scale private oil palm plantations has led companies to cooperate with the Department of Transmigration in order to bring in labourers from outside the area (particularly from Java). Transmigrants are settled in areas adjacent to oil palm plantations.

The transmigrants are given 2 ha of oil palm plantation. Plantations previously established by a company are subsequently sold to transmigrants on credit. Participants pay the entire cost of plantation development, on credit, to the companies through the sale of oil palm bunches.

The high profitability and easy access to markets for oil palm drove the rapid expansion of the commodity and it soon became the most popular commercial crop in the area. Then, communities started to develop oil palm gardens independently. In general, the productivity of oil palm smallholdings was up to 13 ton/ha/year with medium levels of fertilisation.

The rapid development of smallholder oil palm in the mineral–local community area drove more conversion of secondary forest, shrubs or old rubber gardens. It is expected that the area of oil palm will increase even more, replacing the rubber gardens.

Logging

Currently, logging is not an important livelihood for people in the area. The nearby forested areas around the village are almost all gone; the only forest left is located far from the community in difficult terrain. The villagers have been extracting timber from the forest for centuries. Timber is mainly used for construction, such as building houses or fencing, or for sale. Currently, communities still use simple tools for relatively small-scale logging. However, during the 1970s logging was a very important source of livelihoods. Since the mid-1970s, large logging concession companies started to operate in the region. This was the first period of logging 'euphoria' in the region. The community reported that there were several villagers who participated in this activity.

In the 2000s, there was an increase in logging activities (illegal logging) in the villages around the forest by local communities. Increased activity was allegedly owing to weak supervision and law enforcement by the Government during the transition period from the New Order to the Reformasi or reform period. This was the second period of logging euphoria. Farmers left their rubber gardens to become logging workers because this activity gave higher returns in a short time.

Swidden-paddy cultivation

Currently, swidden-paddy cultivation is no longer an important livelihood for the community in this area. For most communities in Jambi, however, swidden is the main subsistence livelihood.

Cultivation of paddy in the past usually consisted of a group of 20 or 30 farmers managing 2–5 ha per household through slashing and burning a forested area. Farmers planted local varieties of paddy with a long harvest period of up to six months after planting. Besides paddy, farmers also planted other crops such as chilli, long beans, cassava, cucumber, corn, eggplant and squash. Farm management was traditional and extensive, using minimum or no amounts of fertiliser. After harvesting, the land was left fallow for several years to recover soil fertility. In the past, an average fallow period of 15 to 20 years was sufficient to restore soil fertility (Gouyon et al, 1993, van Noordwijk et al, 2008). However, the average fallow period in the study site was much shorter at three years.

Nowadays, swidden as the main livelihood option has been replaced by other sources of livelihoods that are more profitable. The biggest change occurred with the popularity of the market-oriented plantation commodities such as rubber and oil palm. Many people abandoned swidden practice and converted their land into rubber or oil palm gardens. This evidence was similar to that of Suyanto et al (2001), who reported that commercial tree plots had been actively developed in Sumatra following the change of land tenure from collective family ownership to individual ownership.

In the 1990s, when large-scale plantations started to operate within this area, a broad tenure claim was alleged to have influenced the way community views on tenure and land tenure systems that existed in villages at that time. The company's claim on tenure in the region caused decreasing areas of swidden and some areas of swidden practice were converted into plantations.

2.1.2.2 Former transmigration settlements (mineral soil–migrant community)

The term 'mineral soil–migrant community' was used to represent transmigrant and spontaneous migrants who mostly came from Java and live in mineral soil areas. Similar to local communities, people in mineral soil–migrant communities relied on agriculture activities, especially oil palm.

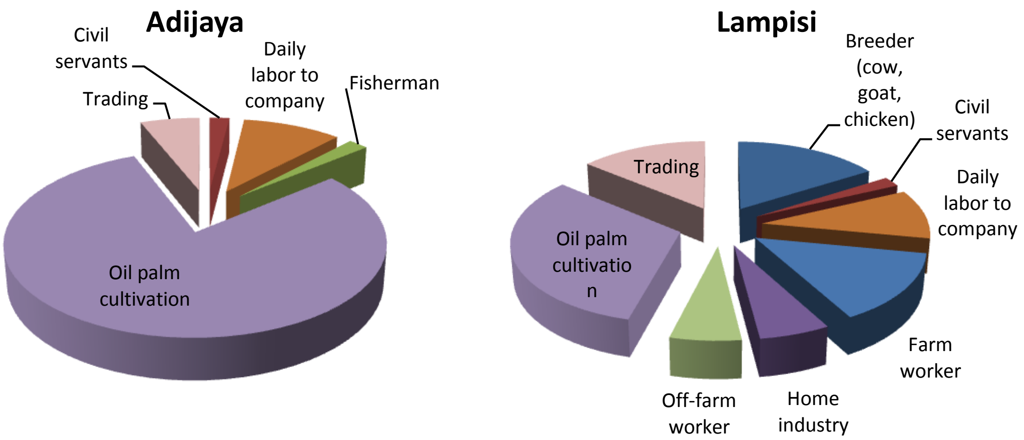


Figure 7. Components of main livelihoods strategies in mineral soil–migrant communities in 2010

Currently, the important livelihoods sources in the region are oil palm cultivation, daily labour for oil palm companies, farm work, livestock raising, and trading. Among the two villages located in mineral–migrant community area, we found that for the long-established transmigrant village, even though oil palm is still the main source of income, the village and community are more developed, off-farm work has developed as home industries and entrepreneurship and trading are fairly advanced. In contrast, for the newly established transmigrant village, dependency on oil palm was very high, reaching about 80% of total income. Labouring for oil palm companies constituted 10% of income (Figure).

The history of the transmigration program in Indonesia began in 1905 during the Dutch colonial era. Palembang, Bengkulu, Jambi, North Sumatra, Sulawesi and Kalimantan were new colonisation areas developed by the Dutch government (Setiawan 2004). Tebing Tinggi subdistrict was one of the transmigration sites in Tanjabar, opened in 1984 with hundreds of migrants from Central and East Java. At that time, transmigrants planted crops but results were less than satisfactory.

Ten years later, there was an offer from one oil palm plantation company to establish a partnership in the form of credit cooperatives and the NES-Transmigration (locally called PIR-Trans). This partnership provided an opportunity for farmers to obtain technical assistance with planting, fertilising and harvesting. The program succeeded in improving people's livelihoods in Purwodadi village, now one of the most prosperous villages in the subdistrict.

Oil palm

Currently, oil palm remains the only main livelihood option for the community. The mineral–migrant community is accustomed to, and comfortable with, the NES scheme. The average productivity of NES scheme oil palm was 13 ton/ha/year with high levels of fertilising as per company protocols.

Each participating family in the transmigration program received 2 ha of land for planting oil palm and 0.5 ha to build a dwelling. The 2 ha was cultivated together with the company through a partnership. The clearing of land for the gardens and their management up until the planting of oil palm was undertaken by the company. Farmers paid the entire cost of this through a credit scheme implemented by the companies after harvest. They pay the credit debt each time they sell their crops. Almost all farmers have paid the debt so that they now enjoy the entire benefit of their oil palm gardens.

The scheme was copied by other large plantation companies that started similar partnerships in other villages in the mineral area. It seemed that the transmigration program could be a mutually beneficial cooperation between oil palm plantations as a nucleus with transmigrants as plasma. The transmigration program provided valuable labour plantations in the area.

Labouring for an oil palm company

Labouring for an oil palm company is a more important livelihood for recent transmigrants (Adi Jaya village) than for others (Lampisi village). Most people work as daily labourers for oil palm plantation companies to meet their daily needs. This work includes various activities such as planting, weeding, fertilising and harvesting. It is generally done both by men and women. They use the income to buy new land to establish oil palm gardens.

Paddy and horticulture cultivation

In the early days of a transmigrant village, most people also managed their home gardens to provide food and vegetables for their family. About 0.5 ha around the house was planted with paddy, vegetables and other horticultural crops to support daily needs only.

Now, most of these home gardens have been converted to oil palm gardens. The farmers decided that food and vegetables could be easily bought from the market with the money they earned from oil palm.

Livestock

Cattle, goats and poultry are important sources of livelihood for mineral–migrant communities, supported by experience, skills and extensive knowledge in animal husbandry. Local government, through the Animal Husbandry Agency, also provides technical guidance and assistance to smallholders to grow cattle.

2.1.2.3 Peatland villages (peatland–migrant community)

The term 'peatland–migrant community' is used to represent migrants of Banjar, Bugis and Javanese ethnicity who have been arriving since the last century and who live in villages in peatland areas. Different to communities on mineral soil, these migrants mostly rely on coconut agroforestry, coffee agroforestry and oil palm cultivation. Agricultural management on peatland requires a drainage system (canal and ditch) to remove excess water in order to provide preferred conditions for trees.

The canal and ditch system is used to manage the water supply, avoid high level of peat acidity and to prevent flooding during tides. People spend considerable amounts of money to keep the system functioning well.

Coconut agroforests have been cultivated since the early period of the village. Oil palm has also been an important source of livelihood. Other sources of livelihoods were on-farm and off-farm work, swamp paddy cultivation and rubber.

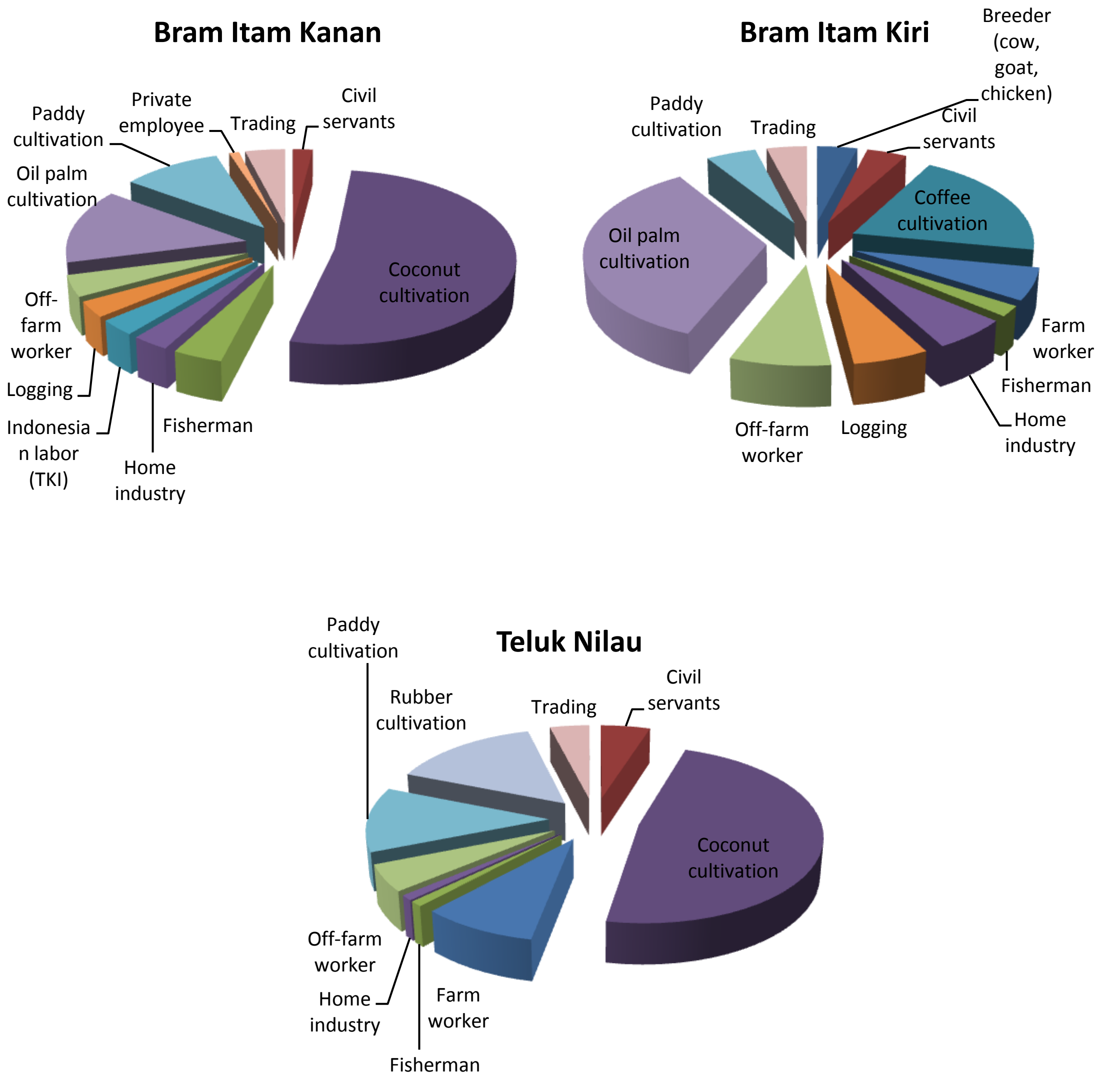


Figure 8. Components of main livelihoods strategies in peatland–migrant communities in 2010

Coconut agroforestry

Coconut agroforestry was established around 1980 and until the 1990s was a popular commercial crop, with copra as the main product. The productivity of copra from coconut agroforests was up to 1.4 ton/ha/year. In the beginning, farmers planted monoculture coconut as the main commodity with the highest economic value. However, since the 1990s, coconut productivity and prices have declined. Thus, farmers began to intercrop coconut with betel nut palm and coffee.

Betel nut palm is usually planted on the border as a live fence and mark of land tenure. Betel nut palm is also planted on ditch banks in order to strengthen the soil structure. At the end of 1998, when prices of betel nut palm reached IDR 15 000 (USD 1.49) per kg, it quickly became a major commodity, contributing significantly to community livelihoods. Because of this, many farmers started to plant betel nut palm to intercrop with coconuts, not only as a fencing tree.

Coffee agroforestry

Farmers also planted coffee to intercrop with coconut. Now, coffee is more important than coconut because of better prices and a more suitable soil in peatland. Coffee requires shade trees such as betel nut palm and coconut.

The most popular variety planted is *Coffea liberica var. dewevrei*. Also known as Excelsa, it is a unique coffee variety that can only found on peatland in Tanjabar. Excelsa coffee grows well in this area, especially in mature peat like in Bram Itam Kiri village. Excelsa beans are bigger than Robusta and the species does not require special climatic conditions. In areas where Robusta is not suitable, Excelsa coffee can grow well. In peatland, Excelsa starts to produce beans 3.5 years after planting. The productivity is 600–700 kg/ha/year of dry coffee grains. Currently, the coffee beans are exported to Malaysia and Singapore.

Oil palm

Migrant communities in peatland areas started to plant oil palm in the early 2000s and, as a result, oil palm gardens have increased rapidly during the past few years. Farmers in Bram Itam Kanan and Bram Itam Kiri villages planted oil palm in peat protection forest (Hutan Lindung Gambut). The productivity of oil palm in this area was up to 10 ton/ha/year. Farmers used local seedlings (uncertified) and low-to-medium levels of fertiliser application.

Rubber cultivation

Rubber was not common in the peatland–migrant area except in Teluk Nilau where there was a rubber program run by the Forestry and Plantation Agency in 2007. Farmers in Teluk Nilau planted rubber in shallow-to-medium peat soil (0.8–1.5 m deep) and applied minimum-to-zero amounts of fertiliser. However, rubber in this area has lower productivity compared to rubber in the mineral area, which is around 300 kg/ha/year.

Swamp paddy cultivation

Swamp paddy has been cultivated since the early years of village establishment and was generally converted from secondary forest. Most of the fields are located on river banks, especially in Teluk Nilau, while in Bram Itam Kiri small areas of paddy are located in coconut gardens. Farmer used the *Ciherang* variety with an average productivity 2 ton/ha/year and applied complete fertilizer (NPK) at a medium level.

BOX 1 : *Jelutung (Dyera sp)*

Dyera lowrii, locally called *Jelutung*, is a highly commercial tree species. The main product is the latex, which is used by industries for chewing gum, cable coating and cellophone. *Jelutung* timber is also commercially sold for plywood, as material for pencils and other wood products.

Jelutung latex is exported to Singapore, Japan and Hong Kong. During 1993 to 1998, export figures for *Jelutung* latex showed a range of 302–2142 t. Starting from 2001, owing to demand from Japan, latex production rose again. Currently, demand remains high and in *Sumatra* the main market line is established in Jambi through PT Dyera Hutan Lestari, with plantations located in Muara Jambi and Tanjung Jabung Timur.

In Tanjung Jabung Barat, wild *Jelutung* in peat forest has vanished owing to logging operating until 1990, which extracted the timber to fulfill the needs of the frame and pencil industries. In the past few years, *Jelutung* has been widely discussed again owing to promotion by the Forestry Agency as a forest restoration species as well as for commercial purposes. The current recommendation for intensive planting is approximately 300 trees/ha and the Forestry Agency estimates that *Jelutung* productivity is 3–4 kg latex/tree/month. With the current price of approximately IDR 6500/kg, each tree can command IDR 20 000–25 000/month.

Farmers in Tanjabar peat areas have relatively good perceptions of *Jelutung* to be planted within their own plots (private land), since *Jelutung* latex normally has a higher price than that from the more commonly grown rubber (*Hevea brasiliensis*). Bastoni and Lukman (2004) in Rahmat and Bastoni (2007) showed that tapping can start at 10 years after planting and continue until 30 years with latex productivity of 0.36 kg/tree with a 7-day tapping interval. A female rubber tapper from Mekar Jaya village in Betara subdistrict, who used to gather *Jelutung* latex from the nearby forest, expressed a more optimistic estimation of *Jelutung* and testified to gathering approximately 50 kg of harvest from around 50 *Jelutung* trees in one day. That was 10–15 years ago, however. Presently, the nearby forest is almost devoid of mother trees and nurseries have to import seeds from Kalimantan. The high transportation cost, low seed viability and long nursery time (6–7 months) results in a high price for seedlings. Valued at about IDR 10 000 to 12 000 per seedling, an ordinary farmer can hardly afford it.

Jelutung productivity as a non-timber forest product on peat in Lamandau River Wildlife Reserve, Central Kalimantan, counted as 1 ton/ha/year, with an estimation of 78 trees/ha. *Jelutung* profitability as presented by Rahmat and Bastoni in 2007, at 15% discount rate, was IDR 11 650 000/ha/year.

The rising demand for *Jelutung* latex and timber offers more opportunities to ensure income sustainability for smallholder farmers living on peatland because *Jelutung* productivity can span up to 20 years and the timber can provide good cash when rejuvenation takes place.

2.1.3 Landholdings

Based on our survey of 80 households, we found that the average landholding of transmigrant villages on mineral soil was the highest (8.12 ha), following by recent migrants on peat (6.19 ha), local villagers on mineral soil (4.91 ha) and the lowest was old migrant villagers on peat (4.37 ha) (See Figure 9).

The composition of landholdings by land-use types was different across the sites. Transmigration villagers owned 99.6% oil palm and only 0.4% of bush fallow. The dependence of transmigration villagers on oil palm was very high. The composition of landholding by land-use type for local villagers on mineral soil was more diverse. They owned 35% oil palm, 35% rubber and 30% bush fallow.

On peatland, the agroforestry or mixed garden system that consists of coconut with betel nut palm (*Areca catechu*) and or coffee was very important for old migrant villages. The average mixed garden plantation (agroforest) land was 3.56 ha or 81% of the total landholding while the average oil palm area was 6% and bush fallow was 11%. The swidden-rice area was very small.

All land that belongs to transmigrants, locals and old migrant villagers is private land. However, for recent migrants on peat around 71% of total landholdings was state land. They planted mostly oil palm (82%) and a small area was mixed garden and bush fallow. Private land belonging to recent migrants was located far away from the village or in the original place of arrival and it was mostly planted with mixed trees (agroforest).

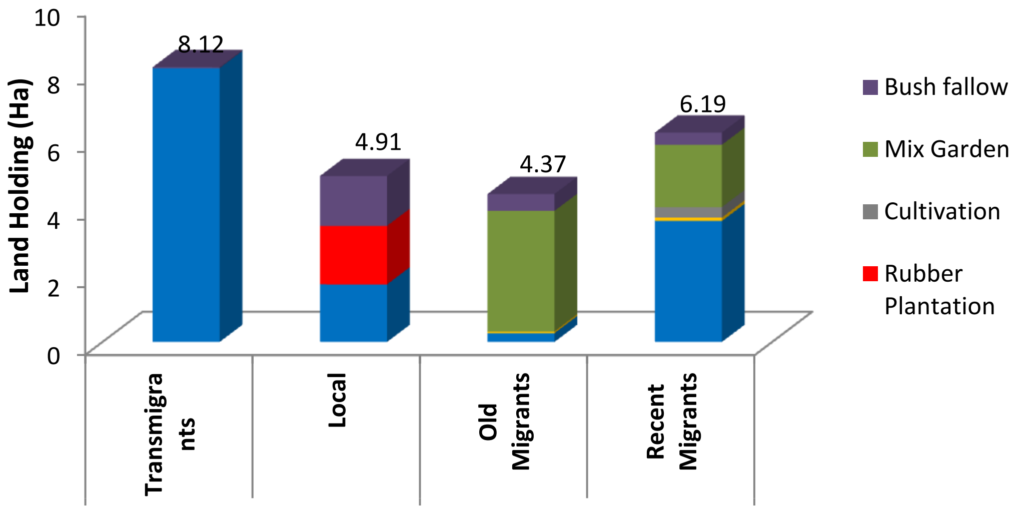


Figure 9. Landholding per household

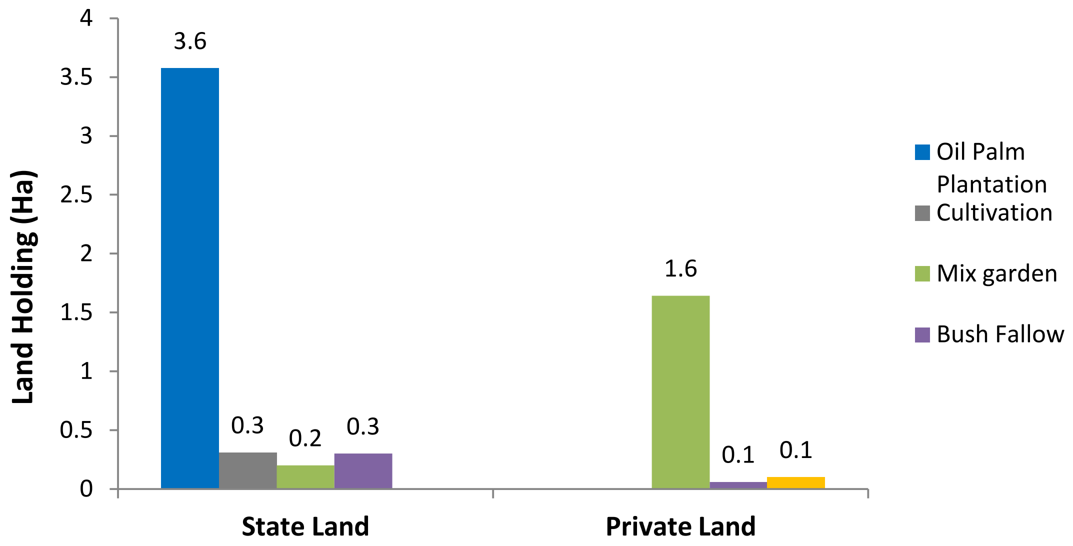


Figure 10. Average landholding size and type owned by recent migrants in peatland villages

2.1.4 Poverty and equity

2.1.4.1 Qualitative indicators

Using the participatory approach, communities were asked to define poverty indicators based on their perceptions. The poverty definition was then used to assess the condition of the communities over several periods. Poverty indicators that were identified are listed as below (Table 2).

Table 2. Qualitative indicators of poverty as defined by communities

No	Indicator category	Indicator
1	**Lack of access to social services**	Unable to buy proper clothes
		Unable to access medical services
2	**Lack of valuable assets**	No electricity
		No vehicle
3	**No proper house**	House made from bamboo, logs etc
		No house
4	**Lack of proper land for farming**	Land size less than 0.5 ha per household
		No land
5	**No permanent job**	
6	**Income**	

The poverty indicators discussed by the communities were varied: income, permanent job, land as farm assets and house were the four most important. Vehicles, electricity, education, health and clothing also became indicators. The income that was categorised as poor varied between communities. In the transmigration areas, Lampisi and Adijaya, people with incomes less than IDR 1 500 000 per month were categorised as poor, while in local communities people with incomes of IDR 1 000 000 a month could be categorised as on the poverty line. These indicators are similar to the components of the human development index (HDI).

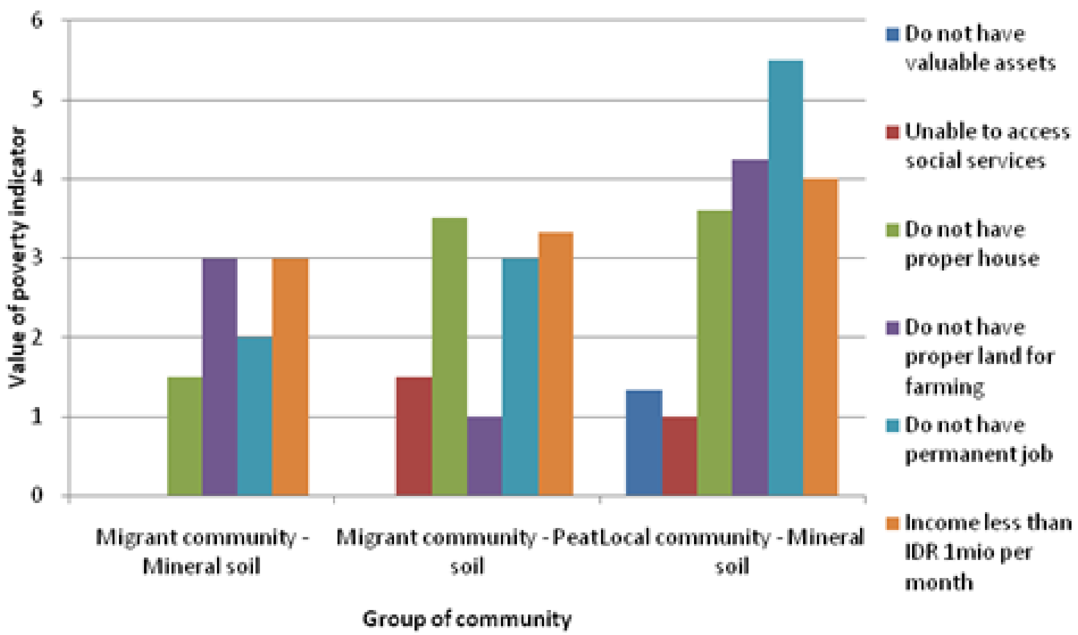


Figure 11. Values of poverty indicators in three different communities

Based on local definitions of what is poverty, communities were asked to assess their own poverty level from previously to the current time. The welfare pattern from past to present in each group of communities on mineral soils was almost similar, which shows positive progress. However, for the peat migrant community in the period 1970–1980, income was high because of logging activities (Figure 12).

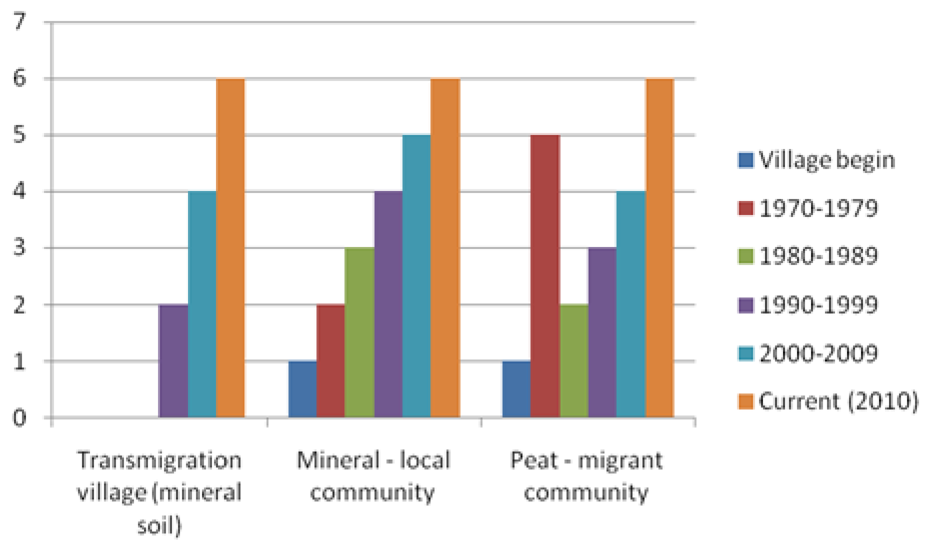


Figure 12. Level of community welfare from past to present based on local perceptions

2.1.4.2 Quantitative analysis

We used income as a quantitative indicator to assess poverty. The calculation of income included the value of commodities consumed. However, most income came from cash crops.

The average total income per year per household in the mineral soils area was higher than in the peatlands. However, the difference in income between transmigration villagers and local villagers was high. The income of transmigration villagers was about three times that of local villagers. In contrast, income of old migrants and recent migrants on peatland was almost the same. The daily income per capita of transmigrant villagers in the mineral soils area was IDR 71 455 (USD 7.9)[2] and for local villagers it was IDR 25 046 (USD 2.8) (Figure 13). In peatlands, the daily income of old transmigrant village members was IDR 32 484 (USD 3.6) and recent migrant villagers was IDR 27 816 (USD 3.1).

The average family size ranged from 3.1 to 3.8 members at both sites. Using the international poverty standard of USD 1.00 a day (World Bank), the percentage of respondents living below this in the mineral soils area and in peatlands was none (0%).

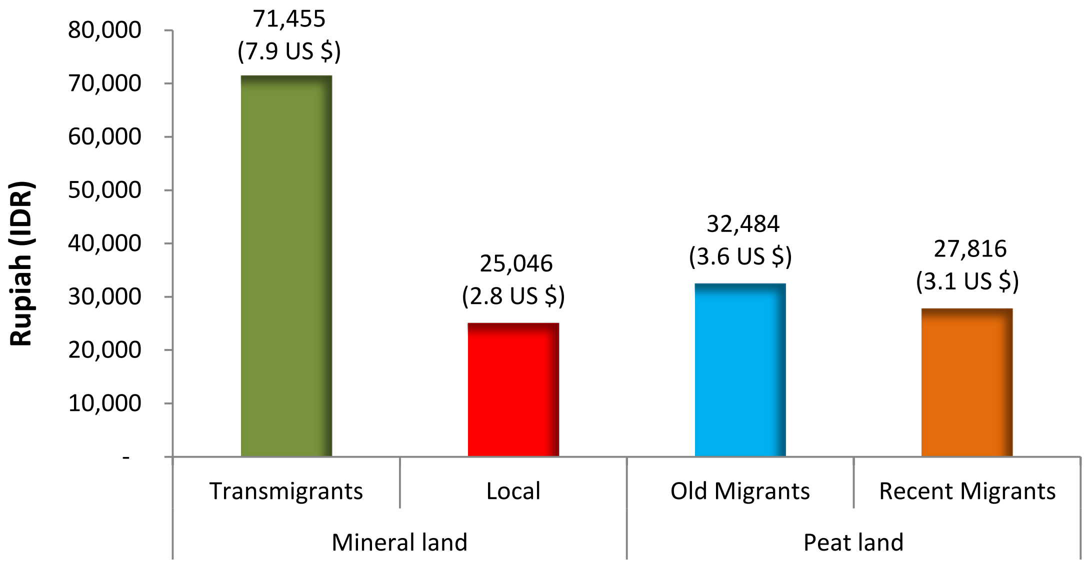


Figure 13. Income per capita per day

Agriculture was the major source of income both in mineral and peat areas, but the type of agricultural income was different (Figure 14). In transmigration villages in the mineral area, the highest source of income was from oil palm plantations (75.24%), while rubber plantations (60.68%) was the major sources of income for local villages in the mineral area. The share of income from oil palm plantations in local villages in the mineral area was low (8.90%). We expect that the share of income from oil palm will increase in the near future since about 35% of landholdings were now immature oil palm.

In the peatland area, the major source of income was different for old and recent migrant areas. The highest income in old migrant areas came from mixed gardens (62%), while oil palm (54%) was the major income source in recent migrant areas.

[2] Exchange rate in 2010 averaged at USD 1 = IDR 9000.

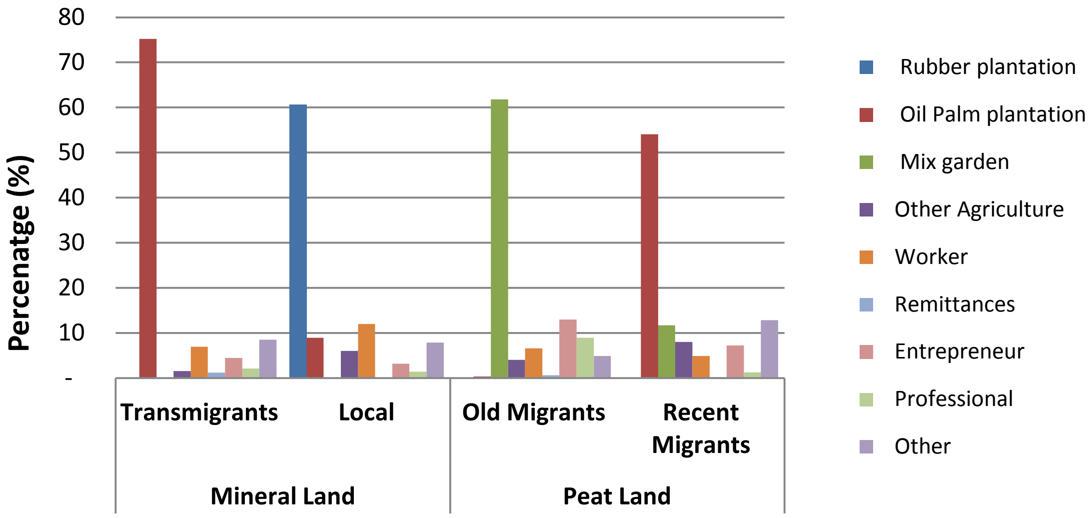


Figure 14. Household income by activity type (%)

2.1.4.3 Equity analysis

In order to analyse the equity of incomes, a decomposition analysis was applied using the Gini coefficient that ranges from 0 (equal distribution of income) to 1 (total concentration of income). Gini decomposition is commonly applied in economic analysis, using the formula that was developed by Fei et al (1978) and Pyatt et al (1980). The computation results of the decomposed Gini ratios for income are shown in in Annex 6 . The equity of income was higher in the peat area than in the mineral area, as indicated by a lower Gini ratio (see Annex 6).

The assessment of income inequity used the concentration coefficient. A source of income is influential in improving income equity if it has a concentration coefficient of less than 1. On the contrary, if the concentration coefficient is higher than 1, the source of income is influential in causing income inequity.

Income from rubber plantations reduced the overall inequity of income distribution in the mineral soils area. This suggests that income from rubber plantation is relatively equally distributed, making this income important in reducing poverty and increasing income equity. On the other hand, income from oil palm plantations on private land lead to unequal income distribution in the mineral area. Wealthy farmers often extended their private land through purchasing, which seems to have concentrated income in the hands of fewer people. In contrast, in the peatland area, income from oil palm plantations on state land reduced the inequity of income, since forest areas (HLG) were more available.

The coefficient concentration for mixed garden (1.89) indicated an increase in inequity of income in the peat area and the share of income was high (37.52%). This implies that the value of mixed gardens on peatland is high (Figure 15).

Working (wages) in agriculture, especially for oil palm plantations, made up an important share of total income (5.76%–8.28%) and the concentration coefficient was lower than unity for both sites, which implied a distribution that was equal. It is important to note that for poor farmers, selling their labour is a very important income source.

Other agriculture (agriculture from home garden and livestock) also reduced income inequity at both sites. About 2.85%-5.89% of total income was from other agriculture categories. Non-farm income (entrepreneurship and professional work) was more unequally distributed in both areas. Income from entrepreneurship accounted for 4.10% of total income in the mineral soils area and 10.18% in the peatland area; income from professional work was 1.88% of total income in the mineral area and 5.20% in the peat area. Most non-farm income came from professional work requiring higher skills, higher education and large amounts of capital, such as teaching, government positions,small shops and trading. Therefore, non-farm income widened income disparities between individuals and households in the community.

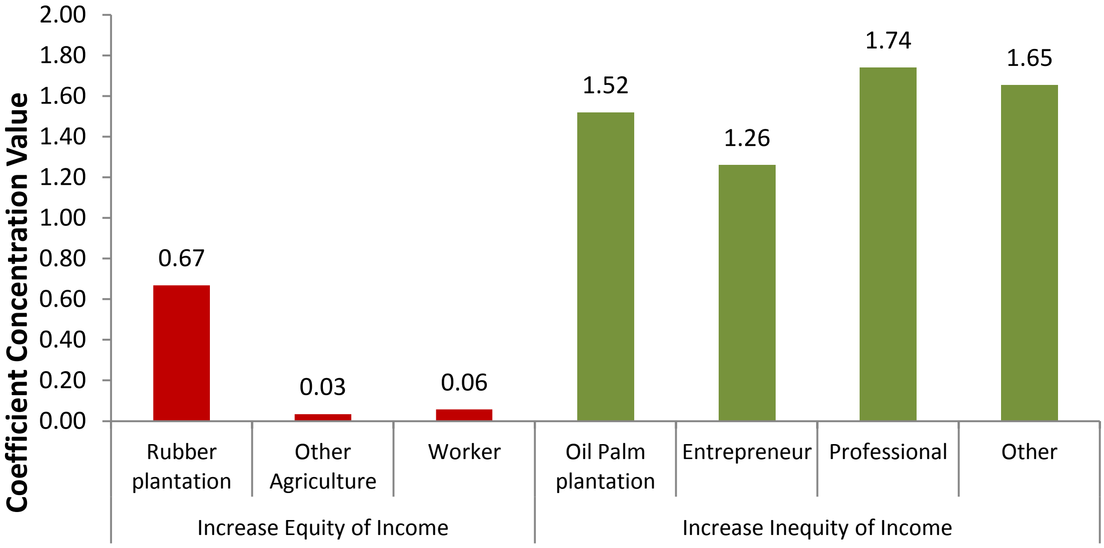


Figure 15. Coefficient concentration in the mineral soils area

Figure 16. Coefficient concentration in the peatland area

2.1.5 Conclusions and recommendation

This study concluded that the welfare level among different community types, as indicated by income and land holding, are different. The average of total income per year per household in mineral soil area is higher than the figure in peat area. In addition, the difference of income between transmigration villagers and local villagers is high, indicated by the income of transmigration villagers being about three times of the income of local villagers. In contrast, income of old migrants and recent migrants in peatland is similar. The compositions of land holding by land use types are different across the sites. Most of the lands belonging to transmigration villagers are planted with oil palm. When categorized by land uses, the land holding of local villagers in mineral soil show differences, dominated by rubber and oil palm. In peatland, the agroforestry or mixed garden system that consists of mixed coconut with betel nut palm (*Areca catechu*) and coffee is an important land use system for early migrants.

The equity of income is higher in peat area than in mineral-soil area as indicated by lower gini ratio. Income inequity is very high between transmigrants and local villagers in mineral soil areas. For transmigration villagers, surplus from oil palm income is often used to buy new lands from the local villagers and to invest in oil palm expansion, which further increases the income gaps.

Designing intervention for emission reduction without the understanding of local people's livelihood strategies can often lead to misleading recommendations. From this study, implications for both the national and provincial level are outlined, as follows:

- A complete restriction of development of oil palm will raise a negative impact on smallholder livelihood. The development of oil palm can still continue but it should be established in the lands that have lower carbon stock. Khasanah et al (in preparation) reported that the average carbon stock of oil palm plantation is 40 ton C per ha that can be used as the basis for land use policies pertaining to new oil palm establishments.
- Policy development in favour of local villagers should be prioritised in order to reduce income inequity between transmigrants and local villagers.
- Rehabilitation of degraded peatland areas with agroforest systems such as coffee, coconut, betel nut, and jelutung should be more seriously explored.
- Restriction of large scale development programs in peatland should be considered in order to avoid the environmental and socio-economic impacts of large-scale demographic shifts.

2.2 Forest governance and land tenure security

Putra Agung, Gamma Galudra and Suyanto

2.2.1 Forest governance and its legality

The state forest land (*kawasan hutan*) in Tanjabar covers 246 601.70 ha or 45% of the district and the major part of it is classified as production forest (See Table 3). Approximately 16 000 ha is classified as peat protection forest (*hutan lindung gambut*), although parts of the areas have been affected by human use in recent decades.

Table 8. Areas of state forest land (designated forest zone) in Tanjabar

No	Forest Functions	Ha
1	Nature reserve	85
2	National park	9,900
3	Peat protection forest	16,056
4	Limited forest production	41,995
5	Production forest	178,605
	Total	**246,601**

Source: District Forest Agency of Tanjabar (2009)

The long history of state forest governance began in the 1970s when forest areas were being logged by forestry companies. Customary forest governance run by local communities was not recognised by the state at that time because of its unclear characteristics and elite domination over customary rules to forest access and use. Nevertheless, logging operations during that period did not have a strong legal basis as the companies only received permits from the Ministry of Agriculture to log the forest (forest concession permit). Along with the operation of logging companies, communities who previously had customary claims to the area joined in and opened natural forest searching for commercial timbers such as *ramin* (*Gonystylus bacanus kurst*).

In Tanjabar, there were more than seven logging concessions issued in from the 1970s until the 1990s that operated in production forest and limited production forest areas. These logging concessions came to an end at the beginning of the decentralization era in the early 2000s when some of the logging concession permits were revoked by the Ministry of Forestry.

The end of the logging concession era created vulnerable conditions for the status of state forest zones and forest cover. Ex-logging concession areas were abandoned and suffered from encroachment that caused more deforestation and degradation. Abandoned areas became 'open access' and the government at the time did not really have any ability to control the situation. The 'open access' situation continues until now and the government has to deal with various problems such as land tenure, forest governance and deforestation.

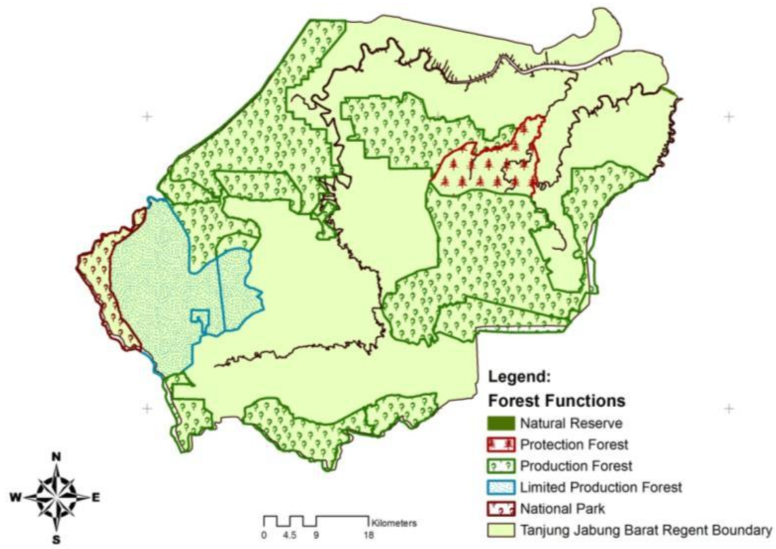


Figure 17. Tanjabar and the distribution of forest land

In 1985, the government enacted the Forest Allotment Consensus (Tata Guna Hutan Kesepakatan) that classified around 238 000 ha of forest in Tanjabar as state forest land under the administration of the Ministry of Forestry (MoF). The enforcement of this forest classification remains disputed even today. Several notes issued by different ministries[3] instructed the governor and the local land administration to support this new so-called 'consensus'. These policies, consequently, laid a stronger basis for logging operations in Tanjabar.

From 1984 until 2000, the transmigration programs placed 7 396 households within areas designated as state forest land. Many of these forest areas were cleared for the transmigration program that aimed to provide labour for crop-estate plantations, mostly oil palm (See Table 4), and industrial timber plantations. This itself created great pressure on remaining forest since these migrants searched for more land in order to accumulate their capital in addition to the land they received for planting oil palm.

Table 4. State forest land converted to oil palm plantations, until 2002

No	Oil Palm Plantation	Permit Issued	Area (ha)
1	PT. Dasa Anugrah Sejati	266/Kpts-II/1990	10 200
2	PT. Agrowiyana I	111/Kpts-II/1991	13 694
3	PT. Agrowiyana II	681/Kpts-II/1995	1050
4	PT. Bukit Kausar	175/Kpts-II/1993	1000
5	PT. Trimitra Lestari	396/Kpts-II/1995	5403
6	PT. Rudi Agung Laksana	769/Kpts-II1996	4240
7	PT. Kumala Jaya Perkasa	226/Kpts-II/1997	500

Source: Ministry of Forestry (2002)

After the end of Soeharto's reign in 1997, the central government devolved management responsibilities to provincial and district governments. This heralded the commencement of a period of 'decentralization'. Central government handed down certain power and authority over forestry affairs to district heads (*bupati*). Law 22/1999, on regional administration, and Law 25/1999, on fiscal balancing between the central government and the regions, were issued to support greater autonomy of district governments to formulate policies and obtain a larger share of forest revenues. When these policies came into effect in January 2001, the Tanjabar district government was quick to issue as many small-scale concession permits as possible, and started to impose charges on existing companies.

During this period, the *bupati* and the governor were allowed to grant annual timber harvesting permits of 100 ha and small forest concessions of 10 000 ha to private landowners, communities and customary forest owners. The forest area in Tanjabar was then subjected to further loss of cover and degradation of forest quality, in other words, the unintended ill-effect of decentralising forest management was to accelerate deforestation.

[3] Ministry of Home Affairs No. 26/1982, 13 May 1982, and Ministry of Agrarian Affairs No. 586/1982, 17 July 1982

Based on its history, the Tanjabar case study provides an example of how central government policy indirectly creates perceptions of open access to forests. To respond to this situation, the central government launched the Kesatuan Pengelolaan Hutan (KPH, Forest Management Unit) scheme, which portions state forest land into management areas in accordance with the basic functions and purposes of the forests. KPH itself is believed to be the solution to the lack of governance of Indonesia's forests. KPH is expected to address the fundamental problems in forest management systems over the years and to conduct forest management at the site.

Three KPHs were launched in Tanjabar by Ministry of Forestry decrees SK.787/Menhut-II/2009 and SK.77/Menhut-II/2010 (Figure 18). Two KPHs were established for production forest and one for peat protection forest. Problems still exist in the KPH areas, despite the legislation. For example, the KPH in the peat forest area, called Kesatuan Pengelolaan Hutan Lahan Gambut (KPHLG, Forest Management Unit on Peatland), with around 16 000 ha for the whole KPHLG area, faced problem of land occupation by local people who convert the lands into to oil palm farm, which in total cover around 4000 ha. This situation triggered the creation of forest replanting programme by district forest agency by promoting *Jelutung* (Dyera sp) to be planted amongst the oil palm.

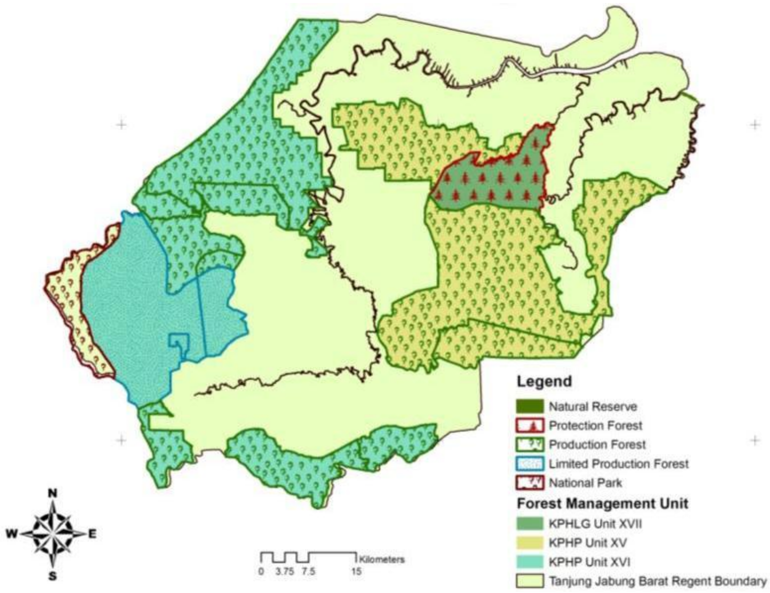


Figure 18. The distribution of Forest Management Unit in Tanjabar district

For the KPH in Production Forest, 80% of the KPH area is already given to timber plantation concessions and they are established as *Kesatuan Pengelolaan Hutan Produksi* (Forest Management Unit for Forest Production Purposes). One of the biggest timber plantation concessions is PT. Wira Karya Sakti which owns concession over around 141.594 ha in Tanjabar district.

Despite central government efforts to protect and rehabilitate the remaining state forest, the forest legality and legitimacy itself remains a conflicting issue. The central government has strengthened the forest legality issue through finalizing the forest gazettement process, but it still being challenged by the local governments and local communities

2.2.2 Land tenure security[4]

2.2.2.1 Land tenure related issues

This section is concerned on social relationship between migration and deforestation, and its impact to local tenure arrangement and state forest tenure insecurity in Tanjung Jabung Barat district, Jambi Province, Indonesia. The objectives of this assessment are to addresses three questions that are under-explored in the research on conflicts and rural migration in the region:

- How do migrants obtain access to customary land use to establish new livelihoods and secure these rights in their home?
- How are customary land tenure arrangements being modified in response to the growing demand for land by 'outsiders' for agricultural development?
- How these new tenure arrangements are being harnessed to claim state forest land, causing conflict with 'legal' right-holders given from the state?

Migrants carry with them notions about property rights arrangement that are familiar, and seek or are compelled to pursue new constructs in new locations. Thus, migration brings distinct tenure ideas and constructs into contact with those established in-place communities and state. Such a process comes about due to pluralism, where no single authority (including the state) is seen as legitimate and able to implement rules regarding evidence of claim (Unruh, 2008). This paper analyzes the land tenure dimension of migrations in rural areas, especially accommodation and integration mechanisms, as well as emerging strategies to claim or reclaim the state forest land. It highlights the local changes of which both local and migrants are the main stakeholders on land tenure dynamics, deforestation and forest tenure insecurity.

The study is conducted in West Tanjung Jabung Region, Jambi Province, which contains a high proportion of peatland. The site is regarded as hot spot that contribute to high carbon emission in the province, while still contain a high proportion of carbon stock. On the other hand, the region faces migrants and local people who deforest for cash crop plantation. This high emission put the region for the next REDD project site, but fail to recognize the importance of tenure insecurity that will cause the complexity of benefit sharing. The site provides an example of relational concepts of land rights between migrants and local people and how it plays their role to claim forested area for cash crop development.

Methods

Data collection was undertaken in early 2011. Key informant interviews were conducted in Jakarta, Jambi (Jambi Province) and Kuala Tungkal (West Tanjung Jabung District. For convenience, the study design was patterned after the study on migrants by Unruh *et al* (2005), Curry and Koczberski (2009) and Koczberski *et al* (2009). These were supplemented with a range of other sources, including newspaper stories, government reports, and reports from conservation agencies, NGOs and individual consultants, as well as the Dutch Colonial texts on the area. By using policy content analysis, formal and informal land tenure was better understood from the collection of policies and laws. Direct observation also helped to deepen the understanding of local land tenure.

[4] Based on Galudra, G., Agung, P., Sardi, I., Suyanto, van Noordwijk, M. and Pradhan, U. *Migrants, Land Market and Forest Tenure Insecurity: an Example of Deforestation in Tanjung Jabung Barat Region, Jambi Province, Indonesia*. in preparation

2.2.2.2 *Migrants, land market and forest tenure insecurity*

Migration is defined as an individual's moving from his/her usual place of residence for the minimum conventional duration of six months, as estimated by demographers. Here, we categorized migrants as actors that are motivated by commercial interests and therefore in search for large areas of land. Several scholars in Indonesia have documented the sale of land to spontaneous migrants seeking land for cash-crop production (Barkmann *et al*, 2010; Bayuni, 2006; Elmhirst, 2001; Li, 2002; Potter and Badcock, 2004). Several previous studies in different parts of Indonesia show that customary land owners sold their lands to the newly arrived migrants because of the uncertain legal status of the lands (Galudra et al, in preparation). Concern over this customary land selling was raised by Elmhirst (2001) as people from transmigration settlement bought customary land, causing new farming systems and creating active land market. Another case by Bayuni (2006) shows that village and district elites change the customary tenure arrangement as an attempt to maintain their position and political support from the migrants.

Migrants, here, are regarded as an intermediate factor. According to Colin and Ayouz (2006), the combined factors of demographic growth, the development of cash crops, and changes in cropping systems (development of perennial crops, disappearance of shifting cultivation, shortening of fallow periods) increase land value and spontaneously lead to the individualization of land rights and the introduction of the right of alienation in the bundle of rights.

There are many factors that can lead to land conflicts and deforestation. In his article, de Oliveira (2008) described that forest conflict and deforestation in Eastern Amazon were related to several factors such as existence of vast but unproductive land properties outside the forest, a large number of landless combined with distorted distribution, and political factors as well as the existence of unclear and insecure property rights over land and timber, driven by conflicts between government agencies, by unclear laws or regulation, or lack of enforcement. Based on these factors, several scholars mostly related current land conflicts and deforestation in Indonesia to political factors when forest decentralization policies was introduced in 1999 but being revoked in 2002, and insecure property rights over land (Curran et al, 2004; Galudra et al, 2011; McCarthy, 2000 and 2004). A case study in West Kalimantan by van Klinken (2008) described how local ethnic elites seized an opportunity to control timber presented by a weakening central authority due to sudden resignation of President Soeharto in 1998 and 1999 decentralization policies that devolved greater decision making and budgetary power to the district than before. These local ethnic elites' interest transformed them from victims to actors of deforestation. The lack of legitimacy of state forest land is argued by several scholars (Galudra and Sirait, 2009; McCarthy, 2005; McWilliam, 2006; Peluso, 2005; Peluso and Vandergeest, 2001) related to the failure to recognize and codify customary rights and territory within state law, causing uncertain and insecure forest property rights. However, all these scholars neglected the role of migrants on developing a new tenure arrangement that indirectly contribute to state forest tenure insecurity.

2.2.2.3 *Changes on land tenure arrangements: the expansion of customary territories, bundle of rights and land commoditizations*

Population increase and the modernization of production means (which enables the development of larger areas) accelerate the expansion of croplands and the tightening of competition for land access, which contribute to the evolution of land transactions. Basically, customary land tenure systems in the district share four basic characteristics:

- Land belongs to a community (village), rather than to an individual;
- Differentiated tree tenure rights and ownership from land tenure system;
- It had sacred dimension that is part of the production and reproduction of that social group;
- Theoretically, land is inalienable, i.e. it cannot be sold.

In early 1900s land was abundant and obtaining a piece of land by opening forestland was as easy as requiring the permit from village headmen. This pattern of land acquisition was still valid for the migrants from 1970s and 1980s, when the third and fourth wave of migrations from Bugis and Javanese (mostly arrived as part of transmigration program) reached its peak. Similar system also operated in the lowland peat areas where Banjar migrants dominate and had better experience and technology in peat management for farm development. Interestingly, despite their claims to the opened forest land, and unlike their origin land tenure system, Banjar migrants tend not to lay claim the drain construction, leaving it as an open access. The reason behind this is because they wanted to build better social relationship with other ethnic groups, by allowing them access for different livelihood strategies, e.g. fishing for Malay people.

In 1980s, land obtained as a gift from the chief was not generally valid anymore as problem of land scarcity had become apparent and no more land can be distributed to the newcomers. Land transfer institutions were relatively new phenomenon for West Tanjung Jabung people in general and were forbidden by the village headmen and customary land tenure systems. However, the introduction of rubber planting in 1960s in their villages gradually changed communal land to private land, causing a possibility for the local people to sell or lease their land to the arriving migrants. The long term cultivation of perennial cash crops, replacing gradually local communities' traditional shifting cultivation, has induced de facto changes in land tenure regimes. Usufruct rights are increasingly being vested in the same family or individuals for extended periods, leading some villagers to claim exclusive rights of access to, and inheritance of, these resources. In effect, land rights are being 'individualized' as land is excised from the communal pool of land that is governed by communal tenure. The customary land tenure system, which regulates any intensive cultivation to the land more than 3 years can regarded as 'individual' rights, provides this basis of claim. In this context of customary land law, land rights can be claimed in two principles. The first one emphasizes the rights derived from first clearance of land. The second refers to the principle of 'land to the tiller', whereby rights are obtained from putting land into use for a certain period of time.

Finding it as an open opportunity, the Bugis and Javanese then introduced and practiced land transaction called 'bagi tanah'/land share tenancy to be the ways for getting access to land resources. This practice was adopted and commonly applied also by these migrants' people in Central Sulawesi when they introduced cacao and mandarin orange fruits to local people who previously cultivating coffee (Barkmann *et al*, 2010). Depending on a consensus or contract, the land-share tenancy mostly cultivates annual crops (cash crops) such as oil palm over the land. Cost of production including labour wage is solely covered by the migrants until harvested yield, which is around 8 years for oil palm. Most importantly, the contract/consensus contains a description of that share of the land that tenant can keep after the initial plot is divided in two parts. This transaction not only helps the migrants, who mostly use it came from Java, to access and accumulate land resources as well as surplus of oil-palm production, but gives the local people a simple way to gain access of technology and capital for oil palm plantation. It also provides a certain level of tenure security for the migrants, especially when the land is regarded by the forestry officials as state forest land.

Nevertheless, the migrants still find land that they cultivate under these mechanisms insecure since they do not have alienable rights to these lands. Many migrants view these mechanisms as conferring ownership in perpetuity which allows their children to inherit the land. This is not the case as the land remains customary land with the potential for the block to be reclaimed by the customary landowners on the death of the people who own previous 'land-share tenancy'. Despite there is still uncertain among the local people whether the land through this system can be inherited or sold/lease, the migrants still interpret this transaction as individual ownership similar to freehold title. On the other hand, some local people view it as an inalienable resource held by the previous owner.

Purchasing customary land through 'sale' is another method used by the migrants. Purchase transaction has become increasingly important means to secure land access. To secure their purchase process, the migrants seek a "letter of land utilization" from the village headmen. From then, land holders can apply to the regional Land Affairs Office (BPN) for official land titles. Indeed, there have been numerous cases of migrants being harassed by members of the landowning group, especially by younger local members, and instances where the land 'purchased' by migrants has been reclaimed by the customary landowners, especially where the land were previously used for shifting cultivation. Due to these reasons, the migrants prefer to buy a land that covered by rubbers monoculture as this land could be claimed customarily as private land ownership rather than shrub area which commonly used for shifting cultivation.

2.2.2.4 Forest tenure insecurity: how constructed of new tenure arrangements were used for land grabs and claims

Many migrants in this area do not receive a formal title, but land sales through their relationship with local people have been the ways of these migrants to gain access and control over the state forest land. Land sales through several local tenure arrangements have become the legal basis for the migrants to make a strong claim to convince that the land could not simply be seized. Four reasons on why local tenure arrangements had been changed to accommodate the migrants' interest over the land. A first issue in this area is the extent to which village officials have the power to determine land allocation, especially the ability to issue documents legitimizing possession by migrants. The village administration is not really run by an organizational apparatus but solely by the village headmen. The existing pattern is likely power polarization with the whole political power held solely by village headmen. This case study shows how local officials, as the 'official arbiters on land matters', interpreting the law according to their own interests and understandings.

A second important element of the way in which migrants gain control over land involves the interest of the local people to gain access of knowledge and capital on cultivating oil palm. The land-shared tenancy provides an example on how this tenure arrangement was introduce as a way to provide a win-win solution for both actors' interests. Another factor is the fear of confiscation by others' interest groups, especially where the area is located in state forest land. Locals often fear confiscation of their land by private companies or government projects, and thus often move to sell to the migrants. As privatization based intensity of agriculture production occurs, land sale can easily happened. It also helps the local people to strengthen their customary claims together with the migrants.

The last aspect that contributes to the land transfer is to extend the customary claims and territories over the state forest land. Using such claims, the area can be regarded as customary land but this certainly requires the changes on land tenure arrangements. In forest peatland, some migrants have also the technology and knowledge to open and drain the forest, which local people have limited knowledge about it. By inviting the migrants, this was used to open and claim forest peatland by the local people.

2.2.3 Conclusions

The study has examined the processes by which migrants gain access and change customary land tenure, as illustrated not only by the 'selling' of land, but also by the expansion and strengthening of customary territories within the designated state forest land. On closer scrutiny, the relational concepts of land rights between migrants and locals and customary land tenure changes by locals are often mediated by the expectation of benefits and costs, especially on claiming state forest land as customary land. The above land transactions enable migrants to forge a social identity as part of customary people and to engage in the process of strengthening their access rights to land. On the other hand, the customary land tenure is being modified and it adopts migrants' land tenure system that is being introduced not only to accommodate migrants' interest on land, but also to expand and strengthen customary land tenure over state forest land.

2.3 Forest loss and land use changes[5]

Atiek Widayati and Muhammad Thoha Zulkarnain

2.3.1 Introduction

Analyses of land use and land cover changes are crucial for further identification of drivers of forest loss and other land use conversions and also to analyse further the consequences on land use based emissions. The quantified land use changes and the trajectories of changes serve as the evidence for the magnitude and the direction or trends of changes. In combination with the cabon data set, such information will also determine the consequences of land-based human activities on the CO_2 emissions or removal. Relating them with different other data sources on the factors that are assumed to cause the changes of emission sources will provide strong assessments as the basis for the design of intervention towards reduced emission efforts in the area.

The major objectives of this section are two-fold:

1. To quantify land use changes in Tanjabar and observe the trajectories of changes
2. To relate the information with different biophysical and policy-relevant distribution in the study area, e.g. peat areas, forest land status

Methods

[5] Based on Widayati, A., Ekadinata, A., Johana, F. and Zulkarnain, M.T. *Understanding drivers of forest and land use conversions as the basis for locally-appropriate emission reduction interventions*. in preparation

Analyses of land-cover changes and the trajectories in this study are presented as a standardised framework developed at ICRAF called 'Analysis of Land-Use/-Cover Trajectories' (ALUCT) and is based on interpreted and classified satellite images. The entire procedures applied in ALUCT are presented in Annex 1.

Four time series data based on Landsat TM imageries were used in this study: 1990, 2000, 2005 and 2009. Discussions of land use changes and drivers utilized decade as time frame (1990-2000 and 2000-2009) to be relevant with decadal patterns from different secondary sources.

Definitions of land cover types are presented in Annex 2, and elaborate descriptions of different land uses as systems can be obtained in Sections 2.1 and 2.6

2.3.2 Land use changes and the trajectories

2.3.2.1 Land use/cover changes from 1990-2009 at district level

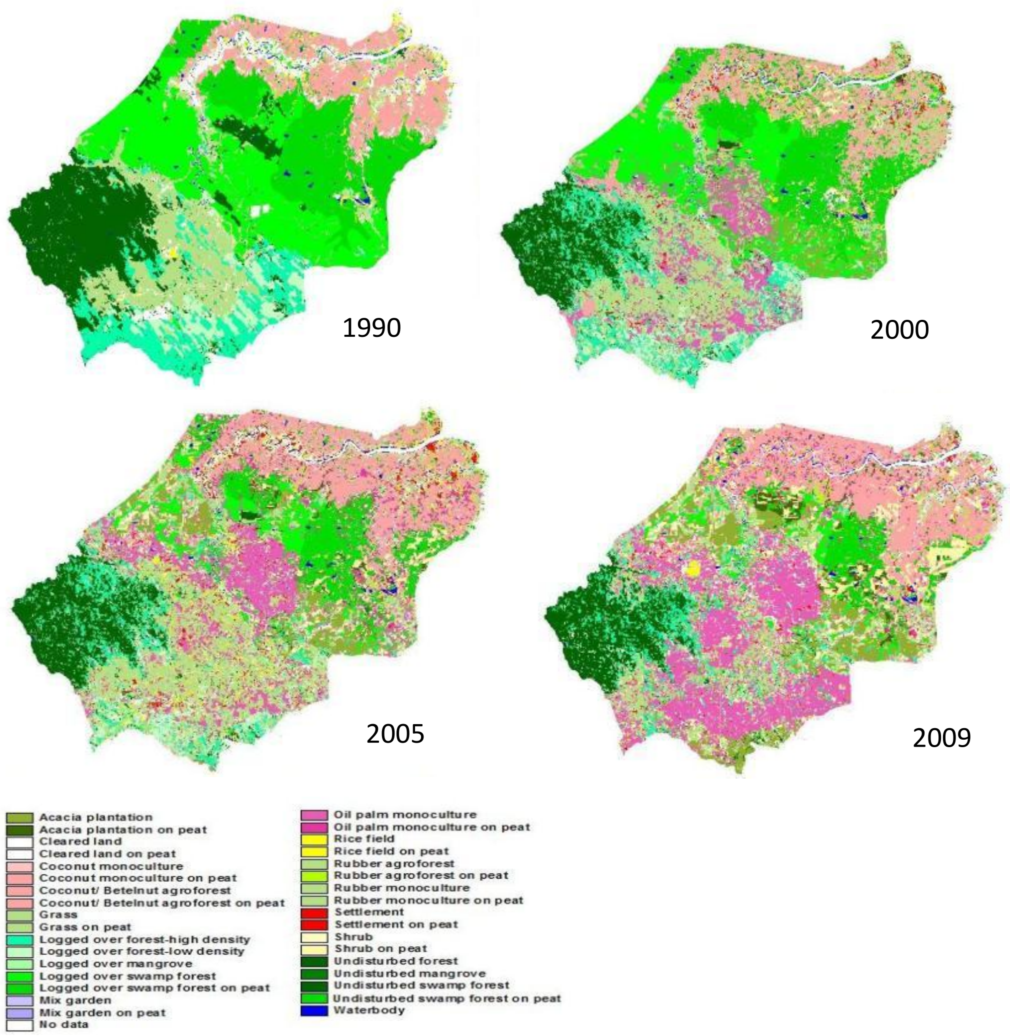


Figure 19. Time series land cover maps of Tanjabar district

Figure 19 shows the time series land cover maps of Tanjabar district for 1990, 2000,2005 and 2009. The indication of accuracy of the most recent land cover map (2009) is 73 %.

2.3.2.2 Forest loss and land use changes throughout the entire district

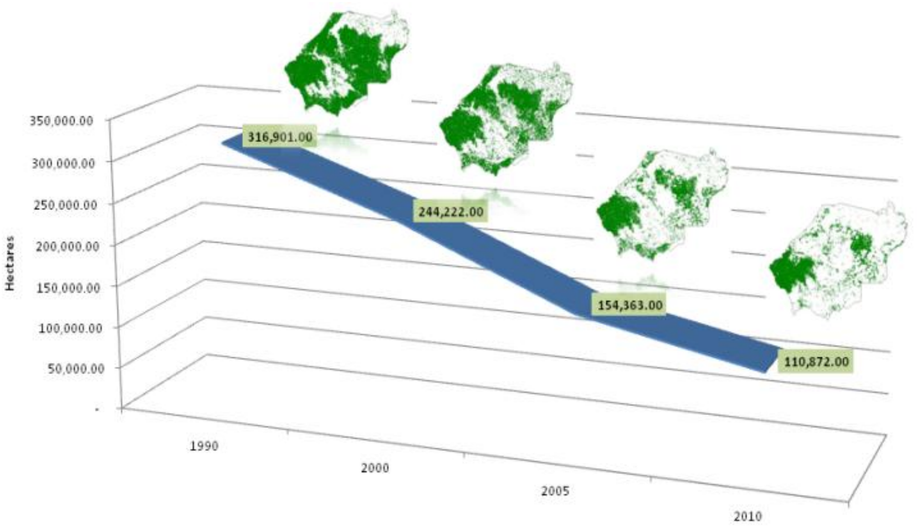


Figure 20. Forest loss in Tanjabar 1990-2009

In 2009, Forest areas in Tanjabar covered 24% (110 000 ha) of the district area. Forest is dominated by lowland to submontane forest (66%) located in the western part of the district towards Bukit Tiga Puluh National Park, followed by peat forest (22%), including peatswamp forest, located in the northeastern lowland part of the district. The latter is mostly part of peat forest protection (*Hutan Lindung Gambut*).

Forest cover dynamics in Tanjabar shows decreasing trend, from 310 000 ha in 1990 (68% of district area) to 244 000 ha in 2000 (52% of district area) and 110 000 in 2009 (24% of district area). Decrease of undisturbed forest area indicates both forest loss and forest degradation and for Tanjabar the loss of undisturbed forest was 47% in 1990-2000 and 25% in 2000-2009. Forest degradation in 1990-2000 was as large as 37%, while in 2000-2009 was 10%. Average annual rates of forest loss in the two decades are 2.6% yr^{-1} for 1990-2000 and 8.4% yr^{-1} for 2000-2009. Land cover changes are shown in Figure 21 and the areas of changes are presented in Annex 3.

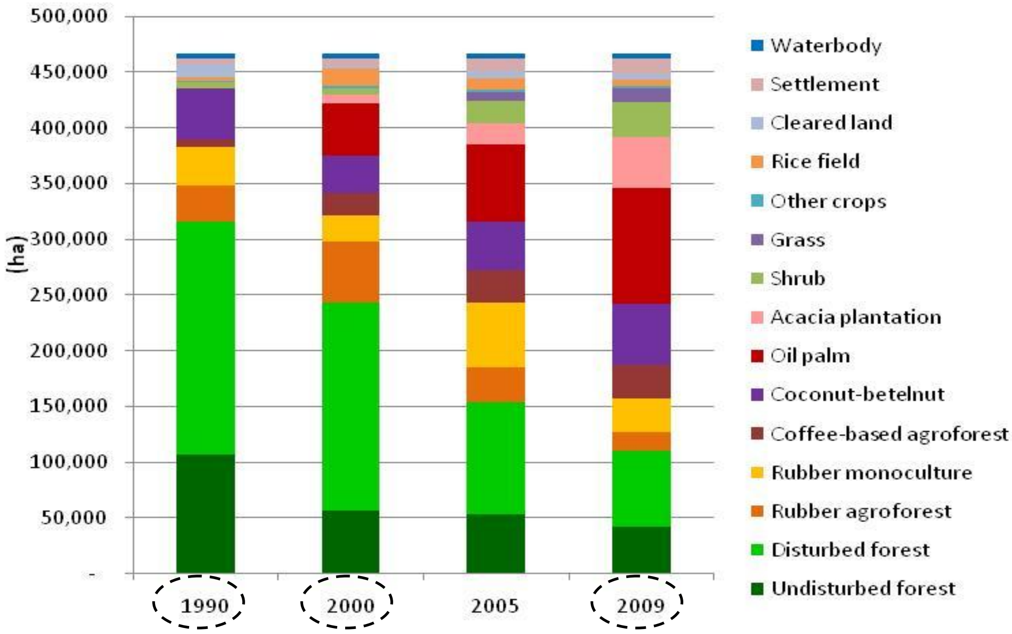


Figure 21. Land cover changes and the area of changes in Tanjabar 1990, 2000, 2005 and 2009

The other land uses also experience dynamics, characterized by the increases of monoculture plantations and the decreases of traditional agroforest system of rubber. The annual rates of changes in two decades of observation for those major land uses can be seen in the Table 5 below:

Table 5. Annual rates of major land use development

Land use type	Rate 1990-2000 (%/year)	Rate 2000-2009 (%/year)
Disturbed forest	**-12%**	-9%
Rubber agroforest	**-11%**	-14%
Coffee-based agroforest	7%	1%
Acacia plantation	**18%**	**24%**
Rubber monoculture	**20%**	**-15%**
Oil palm	8%	11%
Coconut-betel nut	5%	7%

Negative sign (-) refers to decreasing area.

2.3.2.3 Trajectories of forest conversion and other land use changes

Major trajectories in 1990-2000

Major land use conversion from forest in the first decade (1990-2000) was oil palm plantations and rubber, mostly from disturbed forest, 30 000 ha (15%) and 21 000 ha (10%) of forest loss respectively (Annexes 7 and 8).

In 1990-2000, at least 10 000 ha of rubber areas, both rubber AF and rubber plantations, were converted into oil palm plantations. Changes taking place in the other farming systems represent internal dynamics or modifications within the systems. These happened for monoculture rubber plantation developing into rubber gardens with higher plant densities and in coconut-betel nut gardens intercropped with coffee or tidal swamp paddy. 8 800 ha (26% of 1990 area) of monoculture rubber developed to rubber gardens and 7000 ha (16% of 1990 area) was shown to change into ricefields, which likely shows the post production period for coconut, while the tidal swamp ricefields are still maintained.

Major trajectories in 2000-2009

Six types of dominant land cover changes took place in 2000-2009 as shown in Table 6. Land cover type that 'suffered' most from changes to other uses is disturbed forest through the conversions to different cash crops and industrial plantations (Annexes 9 and 10). Major conversion from disturbed forest was into oil palm plantation (30 000 ha, 16% of forest in 2000, 3,350 ha/year) and into forest plantation of Acacia mangium (29 000 ha or 15% of forest in 2000, 3,213 ha/year). Increasing shrubby vegetation from disturbed forest is also high (18 000 ha, 2000 ha/year) demonstrating further clearing presumably form logged areas or other secondary growth, which is likely as preparation for planting. Outside forest cover, extensive land use conversions were mostly into oil palm plantations, where as large as 34 000 ha of rubber, both rubber AF and rubber plantations were converted into oil palm in 2000-2009. To smaller extent, change into rubber plantations also occurred. The increase area of rubber plantations was mostly due to the rejuvenation of the old rubber system (rubber agroforest), while expansion to new areas is less likely. Acacia plantation areas that largely emerged in late 2000s were shown as conversion from non-forest cover such as rubber and oil palm (approximately 7 000 ha).

Table 6. Major trajectories of land use change, 2000-2009

No	Trajectories of changes	Avg. change area/year (ha)
1.	Disturbed forest to oil palm	3,350
2.	Disturbed forest to acacia plantation	3,213
3.	Rubber AF to oil palm	2,809
4.	Disturbed forest to shrub	2,019
5.	Disturbed forest to coconut-betel nut	1,445
6.	Disturbed forest to rubber monoculture	1,243

**extracted for the highest figures of above 1000 ha/year*

By observing the past 4 years of changes (2005-2009), there are no substantial differences on dominant trajectories compared to those in the entire decade (2000-2009). However, there are two types of change that emerged rather differently from the decadal observations (Table 7).

Table 7. Two typical trajectories of land use changes in 2005-2009

No	Trajectories of changes	Change area/year (ha)
1.	Undisturbed forest to disturbed forest	1,381
2.	Rubber monoculture to disturbed forest	1,379

Forest degradation apparently increased in 2005-2009, shown by the 'change' from undisturbed forest to disturbed forest (1,381 ha/year). Another change emerging substantially in 2005-2009 was from rubber monoculture to disturbed forest (1,379 ha/year) which is an interesting phenomenon. It is very likely that this change denotes growth of non-rubber vegetation in the gardens, so that the resultant land use in 2009 was captured as disturbed forest. This type of change is important for the discussions of carbon sequestration in the area.

2.3.2.4 Land use changes in peat area and in mineral soils area

Peat Area

As large as 133 000 ha of the 49 000 ha Tanjabar district has been mapped to be ***peat soils*** (Wahyunto et al, 2003) with varied depth from 0-50 cm to 400 m. Peat swamp forest decreased from 70 000 ha in 1990 into 62 000 ha in 2000 and 40 000 ha in 2009, decreasing by approximately 10% and 30% in the two decades (1990-2000 and 2000-2009). Coffee-based farming system expanded from around 4 000 ha in 1990, into 22 000 ha in 2009. This farming system is the largest farming system in peat areas and is well developed through the two decades of observation. Oil palm only emerged in late 2000s, which covers approximately 7 000 ha in 2009 (Figure 22).

Another large farming system is coconut-betel nut which is normally intercropped with paddy or as monoculture near the coastal area. This farming system covered approximately 35 000 ha to 40 000 ha, and is relatively stable throughout the two decades.

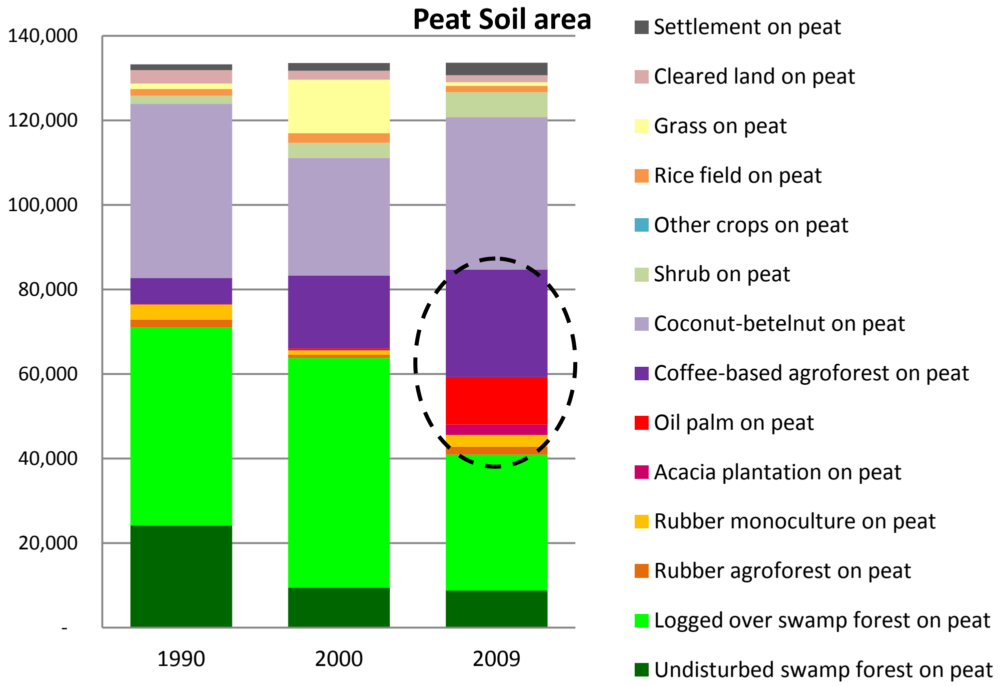


Figure 22. Land cover change and areas of changes in peat soil

Mineral soils area

From the three forest types in mineral soils of Tanjabar, lowland-montane, swamp and mangrove, forest cover was as large as 240 000 ha in 1990, but was reduced into 180 000 ha in 2000 and into 120 000 ha in 2009. Oil palm emerged largely in 2000 observation (46 000 ha), indicating that plantation establishments widely started in 1990s, and slightly increased into in 2009 (into 58 000 ha) (Figure 23).

Rubber area, both rubber agroforest and rubber plantations, increased slightly in the two decades of observation, between 70 000 ha to 80 000 ha.

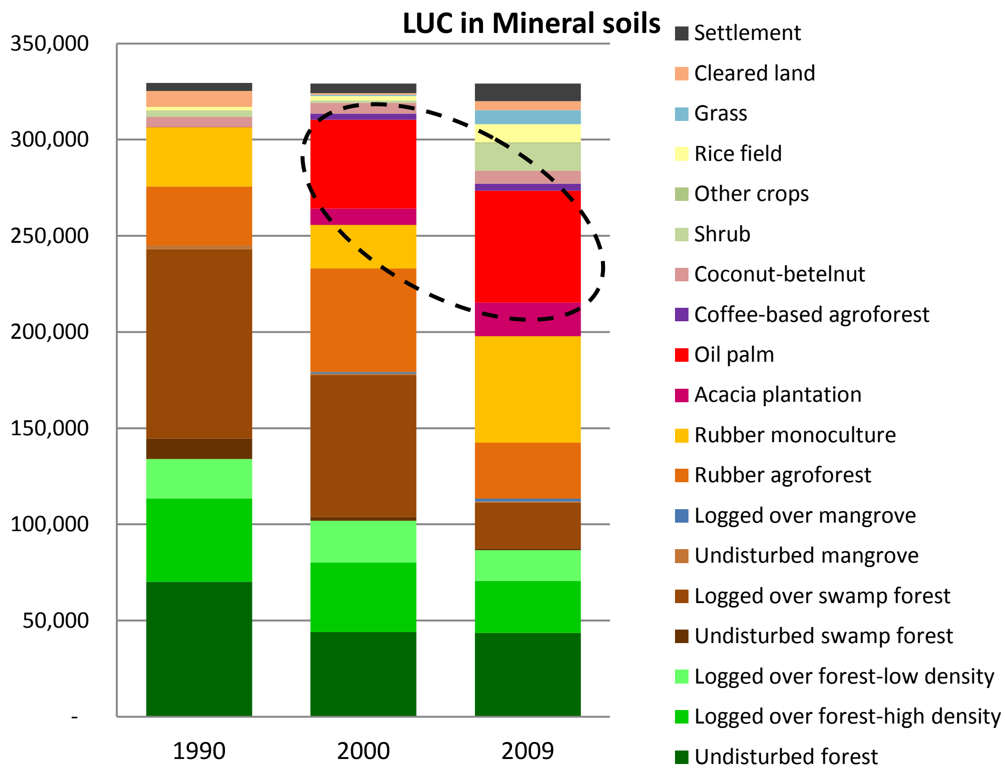


Figure 23. Land cover change and areas of changes in mineral soil

2.3.2.5. Land use/cover change in based on state forest land status

Based on state forest land status (*kawasan hutan*) or designated forest zone, three forest zones and one non-state forest zone are identified in Tanjabar district (see also Section 2.2.1):

- Production Forest (HP – Hutan Produksi, approx. 210 000 ha) consisting of Production Forest and Limited Production Forest,
- Peat Protection Forest (HLG – Hutan Lindung Gambut, approx. 16 000 ha), and
- Bukit Tigapuluh National Park (approx. 13 000 ha).
- The remaining area of the district belongs to non-state forest zone (APL) covering approx. 250 000 ha.

The figures above show that Tanjabar district has similar areas between those under the jurisdiction of Ministry of Forestry and those which are not.

Areas under ***Production Forest*** experience the decrease of undisturbed forest cover from 35% to 18% and to 14% in 1990, 2000 and 2009 respectively, of which the reduction can be due to both degradation and conversions. Conversion to non forest clearly took place occupying 22% of the area in 2000 and 66% in 2009 (See Figure 24)

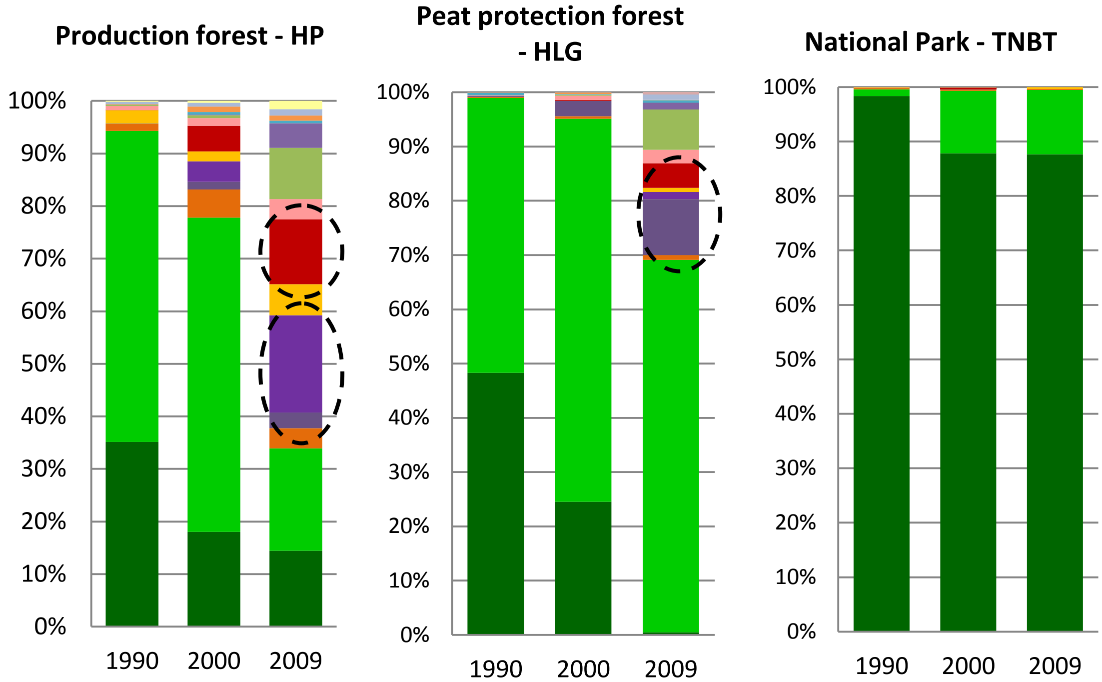


Figure 24. Land cover change and areas of changes based on designated peat zones (legend in Figure 25)

Peat Protection Forest status in Tanjabar was reinforced in 1999 along with the national policy of *Padu Serasi* with Presidential decree of 421/Kpts-II/1999, and it was determined as a model of peat forest management (*KPHL Model*) in 2007. Despite the reinforcement of such protection status, it is clear that forest degradation and conversion still took place in 2000s, shown by the total loss of undisturbed forest and conversion to other land uses (30%). Coffee-coconut agroforest has existed since 1990s and it keeps growing towards 2009, while smallholder oil palm in this area emerged more recently occupying 7% of the area. Shrub class in HLG mostly represents further clearing of logged forest which is mostly as the preparatory stage of oil palm by local farmers, covering another 8% of HLG area (See Figure 24)

Bukit Tigapuluh National Park is located in the western end of the district. 13 000 ha of TNBT in Tanjabar show relatively stable area of forest cover, mostly undisturbed forest cover. There was 10% degradation taking place in 1990-2000, which is likely due to (illegal) logging/timber extraction activity (see Figure 26), but it does not show increase in the last decade (2000-2009).

In 1990, approximately 40% of ***Non-forest zone*** (APL) (Figure 25) was still covered with disturbed forest or secondary growth due to various logging and timber extraction in the past, 20% was coconut areas and around 15% was rubber agroforest. In 1980s there was a government program of introducing coconut planting as commercial cashcrops for the lowland peat coastal area of Tanjabar which resulted in vast area of coconut plantations in the northern and eastern part of the district. These coconut areas are mostly intercropped with different understorey plants, e.g. rice and coffee. Several large-scale conversions took place in the course of 1990-2010 mainly oil palm By 2000, 25% of non forest zone was still covered with secondary forested land which was reduced into 9% in 2009. In 2000-2009 major land use dynamics is toward cash crops by smallholder farmers, the largest of which is oil palm followed by coffee agroforest and coconut/betel nut farms.

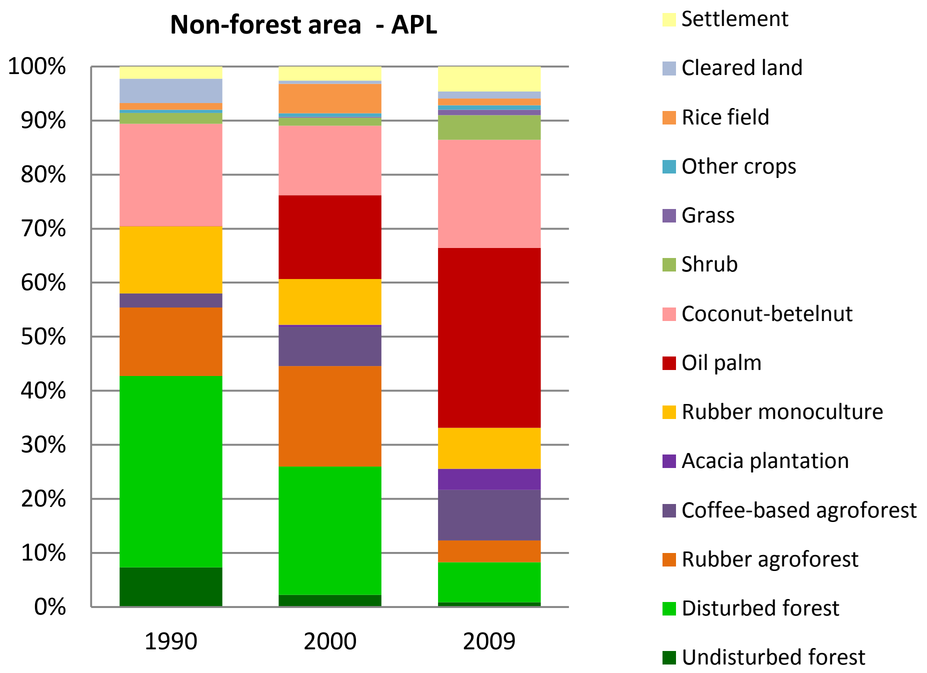


Figure 25. Land cover change and areas of changes in non-forest zone

2.3.3 Discussions and conclusions

For the entire district, land-use and land-cover changes show a general pattern of persistent forest loss from 1990 to 2009.

Oil palm plantations emerged in the 1990s and are extensive up to the present. Oil palm was booming in the 1990s, supported by the Government's transmigration program. Large plantations flourished, followed by extensive development of independent smallholder oil palm plantations lured by high profit, with easy market infrastruture. HTI or industrial plantation (mostly Acacia) appeared to be a new system emerging in the 2000s but, unlike oil palm, HTI appeared in a moderate size and the area increase was not as sharp as oil palm. Traditional farming systems that are quite important for local livelihoods are rubber, coffee and coconut systems. Coffee- and coconut-based systems seem to be more persistent, shown by the relatively constant area, despite slight dynamics. Rubber was relatively constant until 2005 and has experienced a decrease only in the past four to five years.

When dissecting the areas based on typical soil characteristics, that is, peat and mineral soils, the patterns of land-use and land-cover changes are different between the two. New monoculture systems, both oil palm and HTI, appeared earlier on mineral soil areas, that is, in the 1990s, than on peat soils (late 2000s). Areas for oil palm are always larger, on both peat and mineral soils, compared to HTI. Rubber appears to be the largest traditional land-use system on mineral soils and the area is relatively constant throughout the two decades. Area changes in the two rubber systems (rubber plantations and rubber agroforests) are internal system dynamics that reflect increases in plant densities and replanting/pruning. For the peat soil area, the largest traditional land-use system is coffee- and coconut-based systems, and these areas have also been relatively constant throughout the two decades.

State forest land status tends to serve as the basis for land-use policies, partly because forest land status marks large parts within administrative boundaries such as a district. HTI concessions are only issued for the production forest zone, hence the emergence of this land-use type in this forest zone. The concessions started to appear a little in the 1990s, with a substantial increase in the 2000s. In some areas, oil palm was also established in production forest in the 2000s. This is very likely smallholder oil palm as, by law, large-scale oil palm concessions are issued only on private land (APL) and not in any forest zones. The establishment of oil palm in production forest zones is likely related to the ‘encroachments’ on the leftover logged areas considered as open access.

In peat protection forests, cultivation and farming systems are not allowed, however, it was shown that both oil palm and coffee systems were established in these areas starting in the 2000s. As with the case above, prior to the formal issuance of peat protection forest status, the logged peat forest had been considered as open access by local people. And through a long history of cultivation, including land trading , the establishment of a forest reserve did not halt conversion owing to lack of awareness or negligence regarding the new law.

2.4 Migration pattern and the role of women[6]

Elok Mulyoutami, Noviana Khususiyah, Jasnari and Suyanto

2.4.1 Background

The notion that migration has a negative effect on land-use allocation, land dynamics, deforestation and climate change has been hotly discussed (McLeman and Smit 2006, Kartiki 2011). The consequences of human population distribution for land-use allocation and livelihoods strategies (Lambin et al, 2001) also have entered the debate. Our study in Tanjabar is a first step in analysing the consequences of human migration in relation to land-use allocation and gender issues. The study is part of a larger examination of livelihoods in the REALU project, with the main focus being on population distribution, migration and gender. The results will provide more information for formulating interventions for emission reductions and provide input to local governments while they are developing their regional and district spatial plans.

We used participatory approaches that employed discussions and household surveys. Two-day group discussions were conducted in seven villages in Tanjabar. Household surveys were conducted with a total of 80 respondents in three villages.

[6] Based on Mulyoutami, E, Khususiyah, N, Jasnari, Suyanto. *Migration and and gendered land-use perspectives in the peatlands of Jambi*. in preparation

Table 8. Demographic information of villagers in each of the surveyed villages

Grouping of communities	Village	District	Household	Population	Male	Female	Area (km^2)	Population density (people/km^2)	Population growth rate
Local–mineral soil	Lubuk Kambing	Renah mendalu	1037	3905	2073	1832	336.4	12	2.34
	Rantau Benar	Renah mendalu	485	1680	846	816	140.6	12	2.34
	Lubuk Bernai	Batang Asam	1112	4234	2224	2010	173.5	25	n/a
			878	**3273**	**1714**	**1553**	**217**	**16**	
Transmigrant–mineral soil	Lampisi	Renah mendalu	597	2470	1287	1183	12	206	2.34
	Adi Jaya	Tebing tinggi	328	1251	656	595	13.1	96	n/a
			462.5	**1861**	**972**	**889**	**12.55**	**151**	
Migrant–peatland	Bram Itam Kanan	Bram Itam	1435	5502	2902	2600	17.46	50	n/a
	Bram Itam Kiri	Bram Itam	1679	6545	3457	3088	8.73	50	n/a
	Teluk Nilau	Pengabuan	2475	9773	5048	4725	252.462	39	-0.031
			1863	**7273**	**3802**	**3471**	**92.884**	**47**	

Source: Subdistrict Statistic - 2009, and for Lubuk Bernai data was taken from Monograph and village profiles of 2008

2.4.2 Population and migration patterns

The population of the study area was about 266 952 people in 2009, with a density of about 51 people/km^2. The population density in the mineral soil area (35 people/km^2) was lower than in the peatland area (46.8 people/km^2). Villages in the mineral areas were established before the 1900s by inland people from western and northern Sumatra, while villages in the peatland area were established by ethnic Banjar people from Kalimantan in the 1930s, followed by ethnic Bugis and Javanese migrants in the 1940s. Most of the Bugis are now second generation and have already settled in other parts of Sumatra. In the mineral soil area, the significant migration occurred in the 1980s and 1990s with the transmigration program that was associated with developing large-scale oil palm plantations and industrial forestry estates. However, owing to the peatland area being strategically located near the main river that acts as a transportation route and also being on the coast, which is the core trading area in Tanjabar, the population is more dynamic than in upstream mineral soil areas.

Table 9. Population distribution by ethnic identity in the study area

Village	Ethnicity (%)				
	Malay	Banjar	Bugis	Javanese	Others
MINERAL–LOCAL	**62**		**5**	**19**	**18**
Lubuk Kambing	75	-	-	8	17
Rantau Benar	40	-	5	28	27
Lubuk Bernai	70	-	-	20	10
MINERAL SOIL–MIGRANT	**23**		**2**	**76**	**1**
Lampisi	25	-	2	73	-
Adijaya	20	-	-	79	1
PEATLAND–MIGRANT	**6**	**36**	**16**	**42**	**1**
Bram Itam Kanan	1.3	32.9	21.5	44	0.3
Bram Itam Kiri					
Teluk Nilau	10	39	9.5	40	1.5

Source: Group discussion, village leaders' estimation, and village monograph

The migration pattern as discussed with villagers at each study village shows that in-migration is relatively higher than out-migration. In the mineral soil-transmigrant villages, the in-migration rate increased during the second period of transmigration but has decreased at present. Transmigration is often followed by spontaneous migration from Java or other areas in Sumatra. Spontaneous migration from 2000 to 2009 was relatively high, but decreased in 2010 owing to high competition for jobs and land.

Within the mineral soil – local communities, the migration rate has increased. Discussion with villagers indicated land expansion rates were relatively high from migrant communities surrounding the local village. The migrant villagers came to the local village to increase their land area. Discussion with Lubuk Kambing villagers indicated that the amount of landless households was increasingly high in the last five years. Owing to economic problems, villagers would sell their land to outsiders, leading to land conversion, but at the same time the in-migration rate within this village was also higher than other villages.

Within the peatland–migrant communities the in-migration rate is decreasing. From 2000 to 2009, in- migration was relatively high, with Bugis migrants from Riau (Pulau Kijang, Guntung and Kuala Enok). Although in their original villages they cultivated coconut, in Tanjung Javung Barat the migrants preferred to cultivate oil palm.

Drivers of both in-migration and out-migration have been identified and can be used to predict future migration that might occur. People move in and out of an area for different reasons. Migration is seen as an adaptive strategy to adverse environmental conditions (McLeman and Smith 2006, Raleigh et al, 2001), to find better economic or agricultural options and as a cultural value for certain ethnic groups (Weber 2007). These differences affect the overall migration process that also affects population within the areas. Discussion with villagers showed some factors influencing in-migration and out-migration.

Table 5 lists all the factors that influence decision-making by households who migrated into the current villages. In-migration to peatland areas was normally driven by land expansion because people wanted to increase their farming area to improve income. Coconut was common around

1990, marking a boom period for copra production, with high market demand from Singapore. During that time, there was a high amount of migration from Java, with the inention of opening new land for agricultural production. This was also an impact of a successful transmigration program that attracted more people from Java as spontaneous migrants (Leinbach and Watkins 1998).

In the mineral soils area, landless people migrated to find off-farm livelihoods, as well as to find alternative land to establish their own farms. Within this area, in-migrants were mainly from nearby villages, in particular, transmigrants or their relatives searching for off-farm sources of income, such as waged work on neighbouring plantations (Holden et al, 1994, Leinbach et al, 1992).

Table 10. In-migration, originating area and reasons

Reason of inmigration	Actor	Livelihood source at destination		Remarks
		Peatland areas	Mineral soils areas	
Land expansion	Javanese transmigration	Coconut production	Rubber production	
	Malays or locals from other villages, districts or provinces	Oil palm production	Oil palm production	
	Bugis from other districts and provinces			
Better income	Spontaneous migrants from Java	Wage labour	Farm labour Company labour	Dominated by landless people
	Other villages and districts		Rubber tapper Wage labour Company labour	
Local transmigration program	Malays or locals from other villages or subdistricts	Coconut production Oilpalm production	Rubber production Oil palm production	
Conflict refugee (government relocation program)	Aceh	-	Rubber production Oil palm production	

Out-migration can be seasonal, temporary or permanent. Seasonal migration usually only involves individuals: one or two household members migrating to nearby villages or interregional area. They usually work in the construction sector, agriculture or wood company for a season and then return to their village. Seasonal out-migration was found in some local–mineral villages, while some males worked in Kalimantan in the agricultural industry (oil palm).

Temporarily out-migration was mainly driven by natural causes such as crop failure, flood and abrasion. Migration is perceived as one type of coping strategy pursued by the household in response to a natural hazard (Raleigh et al, 2001, McGregor 1994). When conditions are better, the forced migrants return to their villages and continue their lifes.

The local transmigration program operated by local government lead to a high rate of out-migration in local communities on mineral soils, such as in Rantau Benar and Lubuk Kambing, and also in the peatland–migrant community in Teluk Nilau. The villagers, mostly newly married couples who did not inherited land from their parents, moved to the nearby transmigration areas and cultivated commercial commodities such as oil palm.

There are also fluxes of migration among the transmigration settlements, mostly owing to problems in adaptation to their new environment or to find better land. Some of these migrants ultimately return to their original settlements, some end up in neighboring villages within or out of the district and some move to areas outside Jambi province, such as to Riau province. Some Javanese transmigrants from peatland areas migrated to Riau as coconut farmers. Their objective was to improve their income from farming.

Discussions with villagers regarding their perceptions of the impacts of in-migration revealed positive and negative opinions. The positive side of in-migration, according to villagers, is that it could accelerate village development and also increase farm labour availability. Many abandoned lands within the village could be managed and cultivated owing to the high migrant work force. The negative side of in-migration, according to the villagers, is that ultimately there is competition with the newly migrated people over land.

2.4.3 Education

From the household survey, we found that most of the respondents in the mineral areas, which included both husband and wife, had low education levels. About 70% of husbands and 77% of wives in transmigrant village had less than or equal to six years of primary schooling. The education level in local villages was lower than in transmigrant villages.

In the peatland area, we found that most of the respondent, which included both husband and wife, had a low education level. About 55% of husbands and 50% of wives in older migration villages had less than or equal to six years of primary schooling. The education level in recent migrantion villages, was lower than in old migration villages.

The mean length of schooling ranged from 4.4 to 7.0 years, which was lower than the average mean of 7.25 years at the district level in 2009. Nevertheless, the 6–10% illiteracy rate for transmigrants and local farmers (5–15%) was higher than the district level (2.1%) in 2009 (BPS Tanjabar 2010). The illiteracy rate in the peatland area for recent migrants was 5–6% but in older migration communities it was 0%. There was no significant difference in education level between men and women.

Table 11. Percentage of households by years of schooling of husbands and wives in Tanjabbar

Village	n	Year of Education (%)					Mean years of schooling	*t* test
		Illiteracy	Primary school	Junior high school	Senior high school	D3		
Transmigrants								
Male	20	10	60	20	10	0	5.6	*t* stat= -0.65
Female	17	6	71	12	6	6	6.3	(P>ItI= 0.69)
Local								
Male	20	5	75	15	5	0	4.4	*t* stat= 1.07
Female	20	15	80	0	5	0	3.4	(P>ItI= 0.63)
Early migrants								
Male	20	0	55	20	25	0	7.0	*t* stat= -0.05
Female	20	0	50	35	15	0	7.1	(P>ItI= 0.17)
Later migrants								
Male	20	5	50	30	15	0	6.9	*t* stat= 0.48
Female	18	6	61	22	11	0	6.3	(P>ItI=0.64)

2.4.4 Role of women in natural resource management

For land-based livelihoods, women's participation in coconut, oil palm and rubber cultivation was less than men. The role of women was more pronounced in vegetable production and cocoa cultivation. Interestingly, in farm labour, women's involvement in migrant communities, both in mineral and peatland areas, was less than men, while in local communities in the mineral soil area it was more than men. Discussions with the communities indicated that migrant communities preferred to cultivate their own land by themselves or invite external labour to work their land. There were more landless people in local communities than in migrant communities, meaning that these people usually sought work on other's farms. The role of women in paddy, betel nut and coffee cultivation was equal to men, but mainly in post-harvesting processing.

Table 12. Role of women in different livelihoods

No.	Livelihood option	Mineral		Peat
		Migrant	Local	Migrant
1	Oil palm cultivation	*	*	*
2	Rubber cultivation	-	*	*
3	Coconut cultivation	-	-	*
4	Company labour	**	**	-
5	Paddy cultivation	-	**	**
6	Betel nut cultivation	-	-	**
7	Coffee cultivation	-	-	**
8	Cocoa cultivation	-	***	-
9	Farm labour	*	***	*
10	Vegetable production	**	**	***

*Note: * less than men, ** equal to men, *** more than men*

The important role of women in marketing was mainly for paddy, fruit and vegetable production. Women may be able to obtain a better price and were perceived to have a better bargaining position in transactions than men. This mainly happened within local mineral soils communities, while in migrant communities, both on mineral and peat soils, the role of women in products marketing was the same as with men. In rubber, coconut and oil palm products marketing, the role of women was less than men, and had no impact on price. This was still relevant with the previous premise that indicated women's roles in coconut, rubber and oil palm were low.

2.4.5 Conclusions

In-migration in mineral soil community is relatively higher than in peat soil community. One of the reasons could be the availability of land in mineral soil which attracts people from other areas, who want to expand their farmlands. Trends of conversion are mainly into oil palm plots, and to smaller extent, into rubber monoculture plots. Currently, within peat soil area, in-migration rate is relatively decreasing, due to the low land availability. Role of women in land and farming system management is minor compared to role of men. Nevertheless, for particular aspects where activities are not physically demanding, women play major roles, e.g. in post harvesting activities.

2.5 Drivers of forest loss and land use changes[7]

Feri Johana and Atiek Widayati

2.5.1 Introduction

Transitions occurring in land uses including forest are normally as responses on the drivers of the changes which can be constituted into endogenous socio-ecological feedback as well as exogenous triggers (Rudel, 2005; Lambin and Mayfroidt, 2009). Instead of functioning as linear process, the modification of land uses triggered by particular drivers, perform feedback mechanisms which lead towards looping processes (e.g. van Noordwijk et al, 2011a).

This section serves as further assessments on the driving factors of the dynamics of land uses in Tanjabar by taking into account discussions and findings from Section 2.3 (on forest loss and land use changes) and Section 2.4 (on migration pattern).

Figure 20 describes the overall flow of driving factors that cause the various changes in land-based activities. In principle this framewok shows the flow from two major factors affecting land use decisions. The following framework was applied to guide the assessments of driver of land use changes in Tanjabar (Figure 26).

[7] Based on Widayati, A., Ekadinata, A., Johana, F. and Zulkarnain, M.T. *Understanding drivers of forest and land use conversions as the basis for locally-appropriate emission reduction interventions*. in preparation

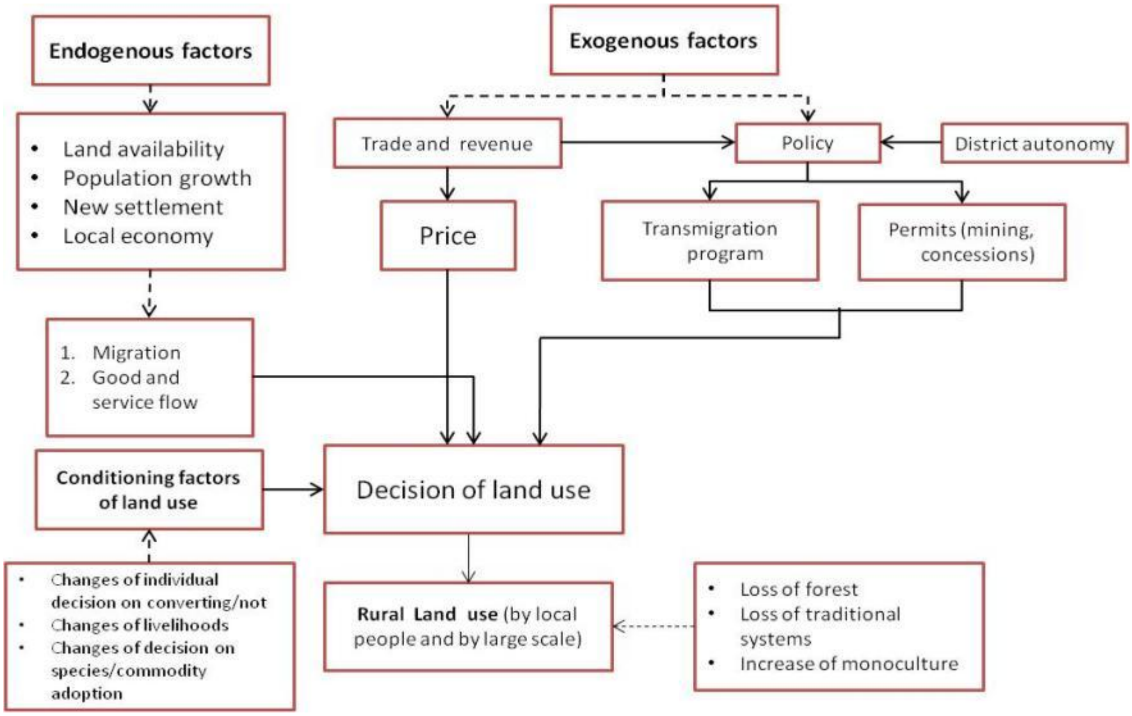


Figure 26. Framework of the drivers of land use changes in Tanjabar

Upon the quantification of changes and trajectories of land uses in Tanjabar (Section 2.3), assessments on the drivers of land use changes were conducted by:

1. reviewing the factors that shape the population and livelihood dynamics in the area
2. observing figures from secondary statistics data to connect among different patterns
3. and by consulting local stakeholders and tapping their perceptions on what have caused the dynamics of land uses in their areas

Qualitative analyses were conducted to assist in determining the types of luc drivers in TJB. Information was triangulated between the actual changes from land use change analyses, secondary data and stakeholders' perceptions.

2.5.2 Major drivers and the chain of factors

2.5.2.1 External drivers at central government

As mentioned in the earlier section, almost 50% of the district area is under state forest land status where forestry policies play major roles for the allocation and /or re-allocation of the land uses including extraction of the produce. Policies are evolving at the central government giving effects at the district level, e.g. issuance of small scale timber extraction and other concession permits.

Both land use policies leading to issuance of concessions and releases of forestland status to large-scale plantations are clearly the realization of different exogenous factors of palm oil production/market and pulp and paper industries.

McCarthy, 2010, discussed the major shifts of the driving factors of oil palm development in Indonesia. During New Order period of 1970s and 1980s the development was very much state-driven at the central government through Nucleus Estate Scheme (NES) or locally called PIR-Trans policies. During early 1990s, development of oil palm was shifted towards the Cooperative-assisted programme (KPPA) and direct partnership with smallholders. During reform era in late 1990s to 2000s, oil palm development was based on market demand, both national and export market. Despite the different policy trends, the direction remains similar marking the continuous victory of oil palm for the rural land use development in outer islands. For Tanjabar, one of the clear signal on the ground was the releases of parts of forest land status to oil palm plantation concessions rights (see Table 4 in Section 2.3.1)

Another major land use development, in this case within forestry sector, is driven by the ever-increasing demands for pulp and paper industries which have been determined as one of the top ten industries in Indonesia since the Soeharto era in 1980s (Thompson et al, 1996 : http://www1.aucegypt.edu/faculty/thompson/herbtea/articles/jab.html). For Tanjabar, the trend was also clear by the large allocation of forest plantation as the forest management strategies having. As large as 80% of the forest management units in Production Forest is allocated for large-scale acacia plantations.

Aside from forestry and land use policies, development programmes from the central government may also indirectly affect land use changes in the districts such as Tanjabar. One of such programme is transmigration resettlement largely implemented in major outer islands since 1970s. Part of this programme, as also having been indicated earlier, is closely related to the PIR-Trans program within the oil palm development. The flux of migrants to districts like Tanjabar along with the other policies supporting land use development altogether created major factors affecting forest loss and also the loss of traditional systems into more profitable land uses.

2.5.2.2 Factors at local level

At the more local level, aside from top-down effects from national policies and programmes, various development factors and local development dynamics brought consequences to forest conversions and other land use changes. Following is some evidence brought up from land use and land cover change assessments and the factors which serve as the local drivers.

Land use change and population density at district level

Based on time series observation of 1990 – 2009, decrease of forest cover and increase of areas of tree-based land use system show a linear relationship with the increase of population density (Figure 28). This pattern is typically demonstrated by areas dominated by rural livelihoods where dependence on lands for livelihood sources is high.

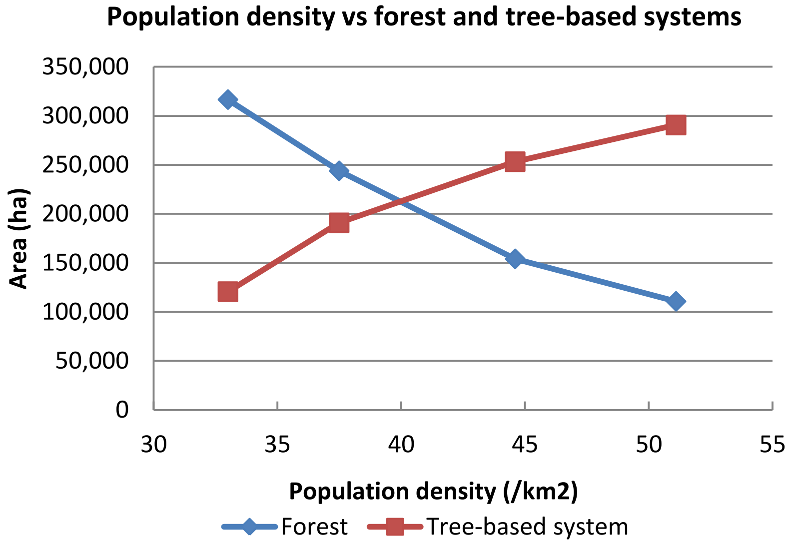


Figure 27. forest loss and agroforest increase vs population density

As discussed in Section 2.4.2, the increasing population is strongly correlated with the in-migration flux in Tanjabar. One central government policy that contributes to the migration influx started in 1980s with the government's transmigration programme. Due to the agrarian characters of the people, mostly on cashcrop farming, the increasing population inevitably means land expansion for their farms. With the unresolved land tenure issues resulting in open access perception over forest land, the increasing cash crop areas is at the expense of forest land (Figure 27). This is supported by the fact that in the peat areas the largest 'landholding' for oil palm is at the state forest land (see Section 2.1.3).

Land use change and regional income

Land-based activities are not only important for local livelihoods, but also important for district revenue. Although not as linear as the relationship with population, there is a relationship between decrease of forest cover and increase of tree-based land use systems and the annual district revenue (GDP) (Figure 28). Despite the varied scales, most of tree-based systems in Tanjabar are cash crops with local, national even export markets and industries, e.g. rubber, oil palm, coffee, coconut, betel nut, acacia.

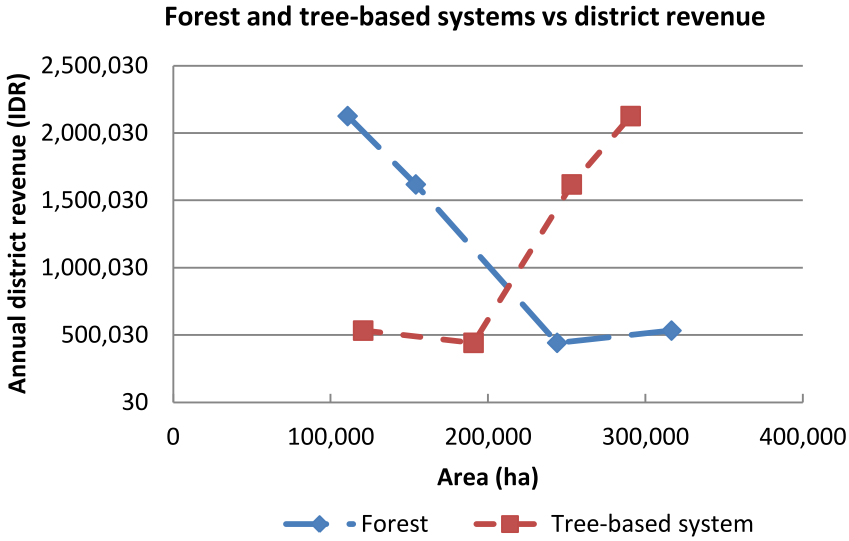


Figure 28. Forest loss and agroforest increase vs district regional revenue

With regards to income of the local population, as discussed in Section 2.1.4, income is perceived to be improved through time, and that fits the increasing uses of lands into more profitable land uses and the increasing loss of forest area.

2.5.2.3 Stakeholders' perspective on drivers of Land Use Change

Identification of drivers of land use changes from the local perspectives was connected to the typology of the area from biophysical perspectives as well as community one (see Section 1.3.2) For Tanjabar, the correlation between the two is quite distinct shown by the spatial and temporal patterns of land use and farming systems in the four strata. From the perspectives of local people, the changes and the drivers can be summarized as follows (see Figure 5 for the locations of these villages within the typology).

Downstream-coastal villages

Villages in the downstream lowland area are to various extents with peat soils or peaty-clay soils. The dominant land cover has been coconut plantations emerging in 1970s for *"kopra"* production. The dynamics within this farming system exist within the planting of coffee, replacement of betel nut for coconut and rejuvenating the coconut. However, since 1970s, the land use dynamics in this area is quite low, whereas this farming system has persisted as the main livelihood source.

Villages in peat areas

As perceived by local stakeholders, forest in peat area was pressurized by logging concessions in early 1970s. Post-logging period, the lands were occupied by local people by establishing coconut plantations for "*kopra*" mixed with coffee. The highest production of coconut was in 1980s, but due to big floods in that period, productivity decreased. Later until recently coconut has been replaced by betel-nut although in some areas rejuvenation of coconut take place. In some villages, still in relatively small patches, small-holder/independent oil palm plantations have also been developed in recent years (late 2000s) due to the alluring profit of oil palm. The major influence comes from oil palm which has been extensively planted in the mineral soils area, esp. transmigration settlements.

Transmigration settlements

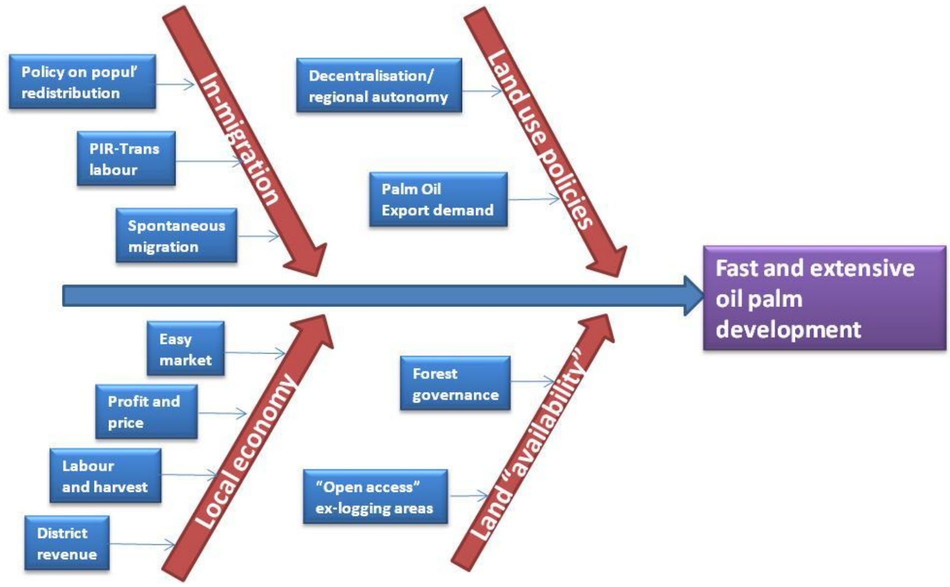
Back in the 1980s, transmigration programme was initiated by the central government and re-allocation of people form Java took place in some areas in Tanjabar. In 1990s, the programme continued aiming to provide labours for newly-established large-scale oil palm plantations (locally called PIR-Trans). These settlements have developed into villages characterised by the widely expanded independent oil palm plantations in the surrounding areas. As perceived by local stakeholders, the development of oil palm plantations was favoured and was mostly from secondary growth dominated by shrubby vegetation.

Upland villages

Most of these villages are located in the western part of the district and are within 20 km of Bukit Tiga Puluh national park. Local stakeholders perceive that during earlier years (1970s–1980s), large-scale logging concessions were the major factors of forest loss or degradation. Later conversion, starting from the 1980s, was driven by oil palm plantation, which continues until now. Old rubber plantations have existed since the 1940s. Despite the expansion of oil palm plantations, rubber areas are relatively well maintained in some areas and are the second of the commercial tree-based commodities. To some extent, *Acacia mangium* forest plantations for pulp-and-paper industries have been established and utilization rights (HGU) continue to be given to companies.

BOX 2: Fast and extensive oil palm development in Tanjabar: 'Fishbone' diagram

Oil palm plantations are one major rural land use in Tanjabar. Different factors determine the fast and extensive development of the plantations which can be categorized into: land-use policies, land availability, in-migration and local economy. Fishbone diagram (*) is adapted to observe the driving factors and the effect in the graph below.



(*) *A fishbone diagram or Ishikawa diagram is often used to show a cause and effect relationship with the causal factors grouped into categories and all leading to one overall effect. The diagram can be very useful as it graphically displays the relationships between the causes and the effect.*

2.5.3 Conclusions

Drivers of the dynamics of forest and land uses can represent both external drivers that create the effects on the ground, such as in Tanjabar, through chain processes and also through dynamics which develop their own loop resulting in modification of land uses by local actors. External drivers that play a big role in Tanjabar, as also in many other parts of Indonesia, are industrial demand for both food crops such as oil palm and pulp and paper such as acacia. Forestry and land-uses policies are the next link in the chain that supports the expansion of the two commodities. Other factors that go along with the process relate to the flow of in-migration in the area, which was driven both by the central government program of transmigration as well as the more organic spontaneous migration taking place since the mid-1900s up to the present. Ultimately, the local actors inevitably react to the dynamics and create their own loop in modifying their landscape responding to factors such as attraction of high profit commodities, labour considerations and land availability.

Careful identification of drivers of changes or transitions, including better understanding of the relationships, is key in moving forward beyond the diagnostic approach or feasibility appraisal of REDD+ or REALU. The need is accentuated in a place like Tanjabar owing to its advanced stage in the transition gradient and where the magnet of commercial commodities has been powerful in affecting the local actors to react.

2.6 Above and belowground carbon stock

Subekti Rahayu, Ni'matul Khasanah and Tonni Asmawan

2.6.1 Introduction

As previously indicated, the distinct biophysical characteristics of Tanjabar lie in the vast peat areas covering major parts of coastal and lowland areas. From anecdotal information in the field, peat forest was opened in 1950s for pineapple cultivation and continued with coconut. Aside from coconut-based farming, another major land-cover types in peat areas in Tanjabar is rubber, which was first planted about 40 years ago. Besides rubber plantations, simple agroforestry systems of coffee mixed with coconut or betel nut (*Areca catechu*) are widespread as smallholder farming systems in the area. Large-scale monoculture timber plantations (*Acacia* sp.) have also been established by private companies like PT WKS. Peat forests are left as remnants in ex-logging areas and have been given status as Hutan Lindung Gambut (HLG, peat protected forest).

Aboveground carbon stocks of different land-use systems in peat areas are still unknown. Assuming that the primary productivity of trees is different between similar systems on peat and mineral soils, it was necessary to measure these systems to better understand aboveground carbon stock. At the same time, peat soil measurements were also conducted to observe the depth and carbon stock content of peat soils in this area.

Objectives

There were several objectives for the carbon measurements in Tanjabar.

- To estimate carbon stock at plot level.

- To estimate the growth rate of acacia in peat and non-peat soils, as well as for coffee in peat.
- To estimate time-averaged carbon stock for each land-use
- To estimate the carbon emissions from peatland owing to land-cover change

Methods

Sampling for plot measurements was based on the identified gaps in aboveground carbon stock data in the World Agroforestry Centre's data set. There were 49 plots established for the measurement of aboveground carbon stock, which covered several categories.

1. Coffee mixed systems on peat soil: 1, 3, 6, 9 and 15 years
2. Acacia plantations on peat and mineral soils: 1, 3 and 5 years
3. Rubber agroforests on peat soil: 25 and 45 years
4. Coconut mixed systems on peat soil: 20 and 40 years
5. Mangrove forest
6. Disturbed forest on peat soil

The plot measurements in principle applied the Rapid Carbon Stock Appraisal (RaCSA) methodology (Hairiah et al, 2011) Nested plots of 6 x 50 x 50 cm inside 40 m x 5 m and 100 m x 20 m plots were set up in each land-cover system. Destructive sampling for understorey and litter was done in the 50 cm x 50 cm plots; trees and necromass at 5–30 cm diameter were measured in the 40 m x 5 m plots; and trees and necromass more than 30 cm diameter were measured in the 100 m x 20 m plots. Tree species (local name and scientific name) were recorded to identify wood density value. Drying process at 85°C for 2 x 24 hours or up to constant dry weight was carried out to estimate dry weight biomass of understorey and litter. An allometric equation (Hairiah et al, 2011, Ketterings et al, 2001, Arifin 1999, Brown 1997) was used to estimate tree biomass (Table 13). Carbon stock of each component was then estimated by multiplying the biomass to an average value of carbon content 46% (Hairiah et al, 2011).

Table 13. Allometric equation developed by several researchers for estimating tree biomass

Measured species	Allometric equations	References
General tree species	$W = 0.11\rho D^{2+c}$	Kettering *et al,* (2001)
Coconut	Y = exp{-2.134 + 2.530 * ln(D)}	Brown (1997)
Coffee	$Y = Y = 0.0303\ X^{2.1345}$	Arifin (1999)

where W or Y is dry weight biomass (kg/tree), ρ is the wood density (g/cm^3), c is coefficient based on the allometric relation between tree height (H, m) and tree diameter (D, cm); $H = aD^c$ (default value for c = 0.62); D = tree diameter on the basis of stem diameter at 1.3 m above ground (dbh)

Samples of belowground carbon stock were taken in peatland under rubber, coconut mixed systems and disturbed forest using a peat auger. Ash content and bulk density analysis was done in the laboratory of the Indonesian Soil Research Institute, Ministry of Agriculture. In coconut mixed systems, the height of the coconut stump from the current surface was also recorded to assist with estimating peat subsidence.

2.6.2 Vegetation of various land uses

Disturbed mangrove

Two types of mangrove were identified in this area, naturally grown mangrove located at the waterfront and planted mangrove from a forest rehabilitation program run by the district forestry agency located close to the settlement. Natural mangrove consists of various species such as *Rhizopora stylosa, Aviccenia alba, Mezzetia parviflora, Bruguiera cylindrica and Sonneratia alba.* Planted mangrove is dominated by *Rhizopora stylosa* 5-to-10 years-old. Population density of mangrove both natural and planted is about 1100 trees/ha at various growth stages (Figure 29).

Figure 29. Planted mangrove of *Rhizophora stylosa* (left) and natural growth mangrove (right)

Rubber Agroforest

Rubber (*Hevea brasiliensis*) is one important commodity in Tanjabar which has been cultivated since the 1950s in agroforestry systems both on mineral soil and peatland, but mostly on the latter. Rubber agroforests on peatland were established using slash-and-burn methods and drainage systems. Three years after burning, pineapples and vegetables were planted, followed by rubber or coconut. A low management system without intensive weeding was applied. Besides rubber, other secondary succession trees such as *pulai* (*Alstonia sp.*) and *tutup* (*Macaranga hypoleuca*), fruit trees like durian (*Durio zibethinus*) and rambutan (*Nephelium lappaceum*), coffee (*Coffea excelsa*), betel (*Areca sp.*) and *cempedak* (*Artocarpus integer*) were also found in the rubber agroforests.

There are two types of rubber agroforest based on age of establishment: old rubber agroforest, which was established after forest clearing; and young agroforest of about 25 years age, which was established from coconut plantations (Figure 30). On average, the population density of rubber with 30 cm diameter or higher is about 100 trees/ha, less than 30 cm diameter is about 400 tree/ha and is about 150 trees/ha for non-rubber. Various size of rubber trees were found in one plot, since some of them grow naturally from seedlings.

Figure 30. Rubber agroforest 25 years (left); rubber agroforest 45 years (right)

Coconut-betel nut agroforest

Betel nut is an important commodity exported to India and in Tanjabar it is mostly planted intercropped with coconut. Establishing a coconut-betel nut agroforest is similar to a rubber agroforest. Betel nut is cultivated at 5 x 5 m distances and coconut at 8 x 8 m (Figure 31). Sometimes in this system there are also other crops such as coffee, orange and oil palm. On average, population density of coconut is about 156 trees/ha and betel nut is about 400 trees/ha.

Figure 31. Mixed coconut and betel nut at 20 years (left) and 40 years (right)

Disturbed forest on peat

Before assignment as protected forest in 1999, the area's status was production forest. Most of the forest is located at Bram Itam Kanan and Bram Itam Kiri villages and also within the concession areas of PT WKS. Logging activity is still carried out in the protected forest, while for the non-forested area nearby, oil palm plantations have been established, aged 5–10 years old, with maize plantations found along the road to the forest in the recently opened area and pandanus along the river.

There were 22 tree species found in 2000 m^2, dominated by *Lansium domesticum*, *Diospyros sp*. and *Syzigium* sp., with a population density of 58 trees/ha, 48 trees/ha and 45 trees/ha respectively. Tree diameter ranges were 5–55 cm, with 81% less than 30 cm diameter, and the rest more than 30 cm diameter. The condition of the protected forest in HLG areas is shown in Figure 32.

A B

C D

Figure 32. Recently opened forest (A); *Pandanus* sp. along the river (B); logging in HLG (C); vegetation stand inside HLG (D)

Oil Palm

Oil palm has been in Tanjabar since the 2000s. Large areas of oil palm plantations were found on the peatland of Bram Itam and within the boundaries of the HLG. The conversion process of oil palm from forest is the same as for rubber agroforest, which starts with slash and burn, with others converted from rubber and coconut plantations. The district forestry agency has a program to convert oil palm into *Jelutung* (*Dyera* sp.). The program was initiated by planting *Jelutung* in oil palm plantations (Figure 33).

Figure 33. Oil palm mixed with *Jelutung* (*Dyera* sp.)

Coffee-betel nut agroforest on peat

There are two types of coffee-betel nut agroforest in Tanjabar:

1. betel nut mixed with coffee; and
2. betel nut grown as a fence of coffee plantations (Figure 34).

This type of agroforest was established from about 1960 through slash-and-burn practices with 8 years fallow with every two years of slash and burn process. During the fallow period, drainage ditches were built around the plot, with two different sizes and depths:

1. main ditch 3 m wide and as deep as the peat; and
2. smaller ditch 30 cm wide, 150 cm deep.

During the first period, *Coffea robusta* was grown in this area, but since 1980 farmers have changed to *Coffea excelsa* owing its good adaptation ability to peat and its status as an export commodity to Malaysia. Density of coffee is about 2240 trees/ha and betel nut is 60 trees/ha.

Figure 34. Coffee and betel nut on peat

Acacia plantation

There are two acacia species grown in the plantations of PT WKS: *Acacia mangium* on mineral soils and *Acacia crassicarpa* on peat (Figure 35). The planting density is about 2500 trees/ha for the first planting, with a thinning process conducted three years after planting leaving about 1100 trees/ha.

Figure 35. *Acacia mangium* plantation

2.6.3 Aboveground carbon stock

Total aboveground carbon stock measured included the four carbon pools of tree, litter, necromass and understorey. High variations in total carbon stock occurred in the acacia plantations owing to different soil conditions (peatland and mineral soil) as well as the age of the plantation (Figure 36). Age of acacia ranged 1–5 years-old and rubber ranged 25–45 years-old. Variations in disturbed peat forest occurred owing to the different levels of disturbance. Land-cover conditions in mangrove forests in Tanjabar were relatively homogenous, even though the species compositions were different, as is shown by the narrow range of data in the box plot.

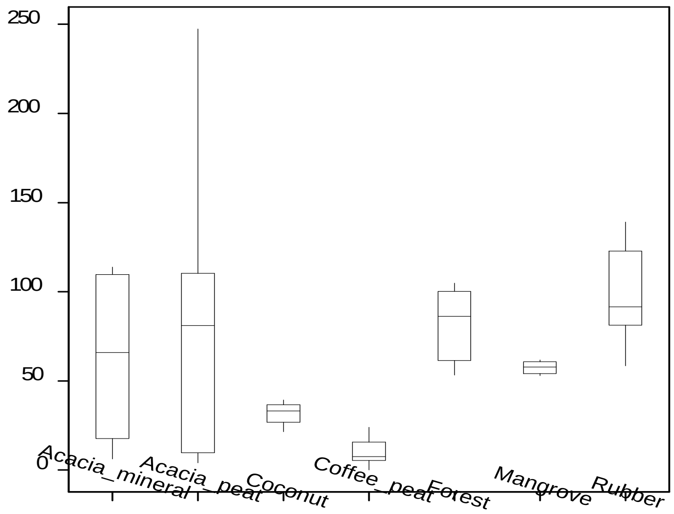


Figure 36. Box plot of aboveground carbon stock in various land-use systems

Generally, variability of aboveground carbon stock in each land cover class was influenced by the age of the plantation (Table 14), except for forest and mangrove, where age of land cover could not be specified.

Table 14. Total carbon stock in each land-cover system

Land use	Age (years)	Total carbon (ton/ha)	
		Non-peat	Peat
Acacia	1	6.88	13.07
Acacia	3	98.20	70.77
Acacia	5	141.93	106.26
Coconut mixed with betel nut	20		26.87
Coconut mixed with betel nut	40		36.67
Coffee mixed with betel nut	1		2.51
Coffee mixed with betel nut	3		5.90
Coffee mixed with betel nut	6		12.44
Coffee mixed with betel nut	9		14.40
Coffee mixed with betel nut	15		17.36
Disturbed forest			81.43
Disturbed mangrove		57.50	
Rubber agroforest	20		73.26
Rubber agroforest	45		105.05

Acacia

Total carbon stock of acacia plantations on non-peat was slightly higher than those on peat, but statistically they were not significantly different at 95% confidence value (F_{prob} = 0.541). The significant difference occurred when we compared each carbon pool. The carbon pool of tree biomass on non-peat soil was significantly higher than on peat soil (at 95% confidence value, F_{prop} = 0.016) (Figure 37).

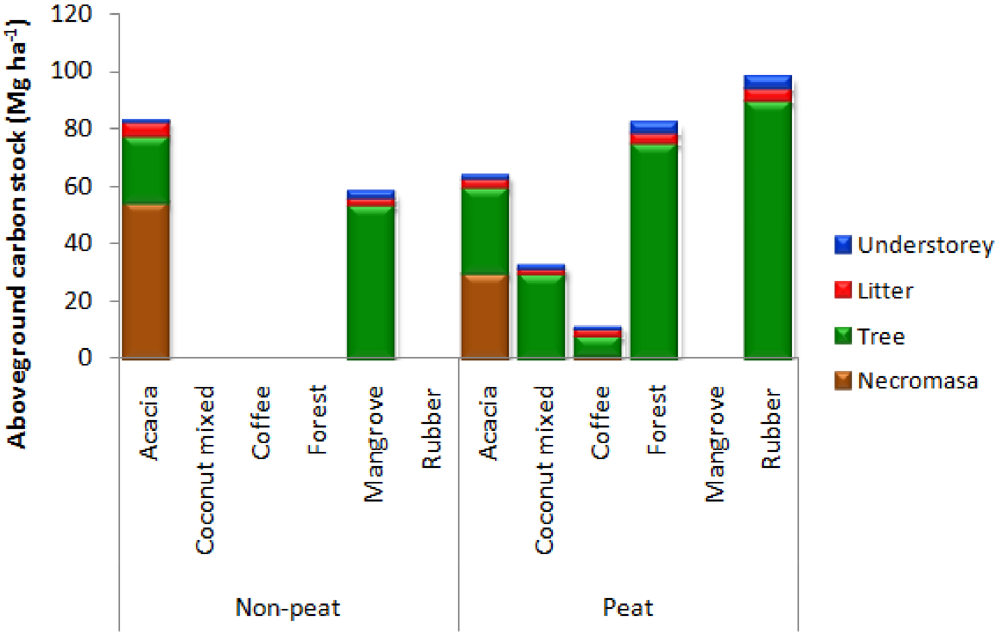


Figure 37. Aboveground carbon stock based on carbon pools of various land uses on mineral soil and peatland

This difference corresponds to the different growth rates. *Acacia mangium* on mineral soil (power value is 1.9017) indicates faster growth than *A. crassicarpa* on peat (power value is 1.3901), particularly after three years, and are significantly different based on the Kruskal-Wallis analysis of variance at value of probability (H) = 0.01754 (Figure 38)

Initial carbon stock of *A. mangium* (7.1 Mg ha^{-1}) is different compared to *A. crassicarpa* (12.3 Mg ha^{-1}). Higher initial carbon stock of *A. crassicarpa* is owing to higher initial diameter when it was planted, on average 3.97 cm for *A. mangium* and 6.11 cm for *A. crassicarpa,* but *A. mangium* grows faster than *A. crassicarpa* (Figure 39). Diameter increment of *A. mangium* is 7 cm per year, compared to 5.3 cm per year for *A. crassicarpa.* In addition, *A. crassicarpa* has a higher wood density (0.62) compared to *A. mangium* (0.53). In line with carbon stock increment of the two acacia species, species with a higher wood density indicates slower growth.

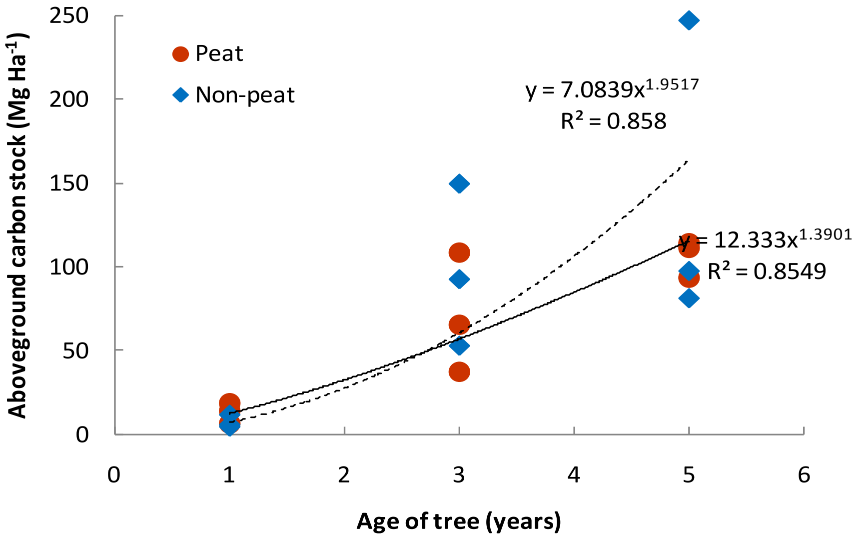


Figure 38. Regression and correlation between age of Acacia sp. and aboveground carbon stock on peat and mineral soil

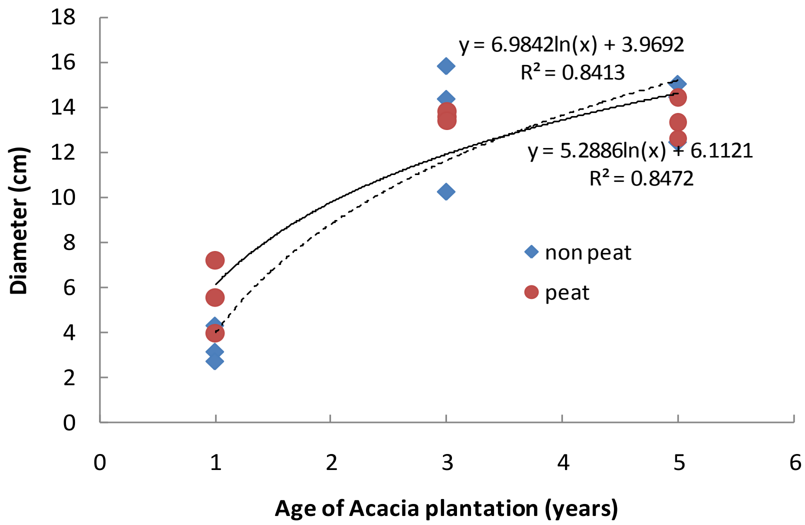


Figure 39. Diameter increment of *A. mangium* (non-peat) *and A. crassicarpa* (peat)

Through the extrapolation from logarithmic to linear regression in 0 intercept, growth rate of carbon stock of Acacia can be estimated to 16.5 Mg ha^{-1} year^{-1} for *A. mangium* (Y = 16.542X; R^2 = 0.9566) and 14.7 Mg ha^{-1} year^{-1} for *A. crassicarpa* (Y = 14.759X; R^2 = 0.9902) (Figure 40).

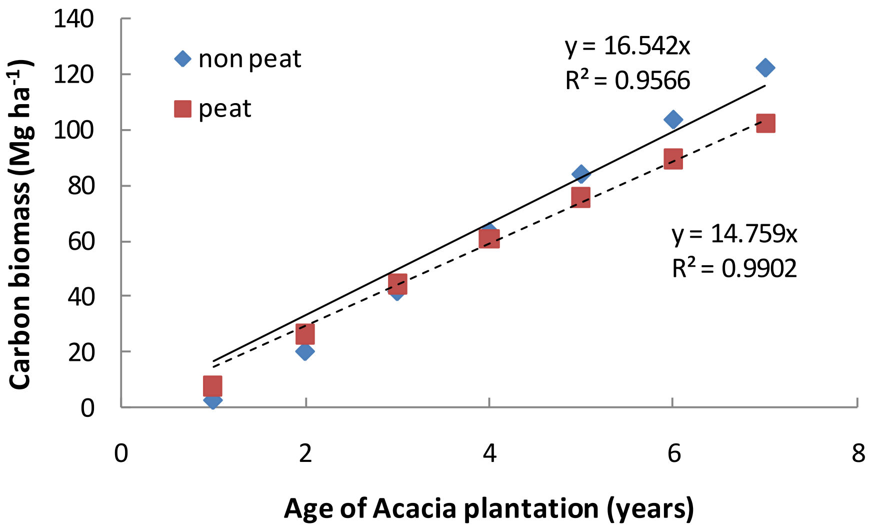


Figure 40. Linear regression carbon stock growth rate of *A. mangium* (non-peat) and *A. crassicarpa* (peat)

If the life cycle of acacia is seven years, the time-averaged carbon stock of *A. mangium* can be estimated to be 57.9 Mg ha^{-1} and *A. crassicarpa* 51.6 Mg ha^{-1} for.

Coffee

Coffee on the peatland of Tanjabar commonly grows in mixed garden systems with betel nut and coconut. Diameter measurement at 1–15 years of age can predict the growth rate of carbon stock for coffee in the peatland (Figure 41).

Extrapolation to linear model with 0 intercept resulted in growth rate of carbon stock amounting to 1.7 Mg ha^{-1} year^{-1} (Y = 1.7182X; R^2 = 0.9183) (Figure 42). This value is slightly lower than for coffee-based agroforestry systems on the mineral soil of Sumberjaya, Lampung: 1.86 Mg ha^{-1} year^{-1} (van Noordwijk et al, 2002). If one cycle period of coffee plantation is 30 years, time-averaged carbon stock can be estimated at 26 Mg ha^{-1}.

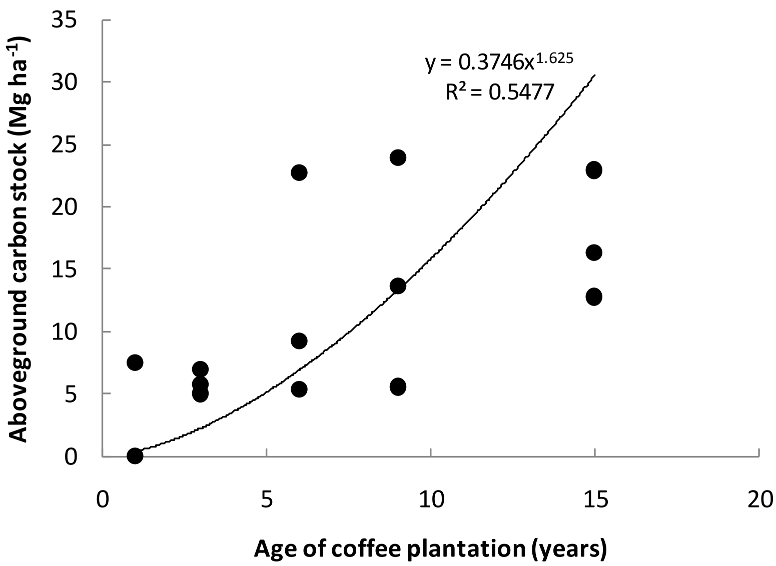


Figure 41. Relationship between age of coffee plantation and aboveground carbon stock

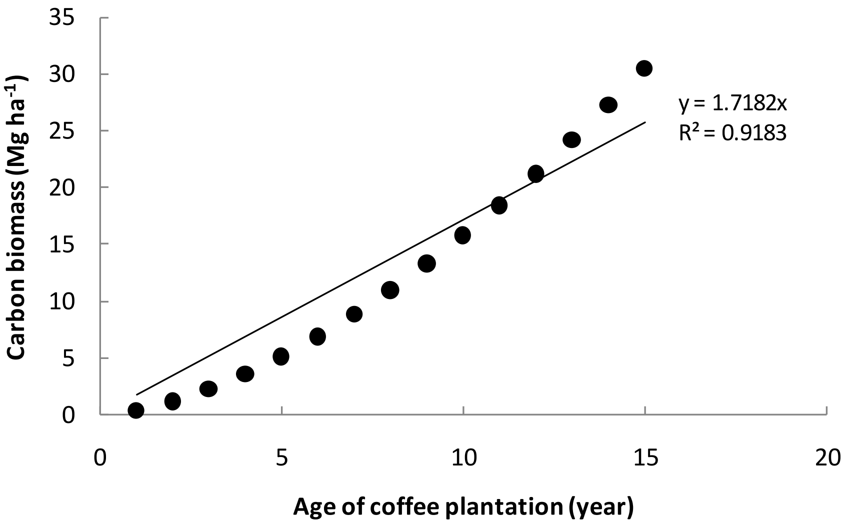


Figure 42. Linear regression carbon stock growth rate of coffee plantation on peat

Rubber

Most rubber agroforests in Tanjabar are old gardens of more than 20 years with the carbon stock ranging from 58.4 to 139.2 Mg ha^{-1} (Figure 43). Growth rate of carbon stock in rubber agroforests on peatland is 2.9 Mg ha^{-1} year^{-1} (Y = 2.8738X; R^2 = 0.9726) (Figure 44), higher than on the mineral soil of Bungo: 2.3 Mg ha^{-1} year^{-1} (unpublished data). Carbon stock growth rate, using 40 years period for rubber cycle, is time-averaged at 58 Mg ha^{-1}.

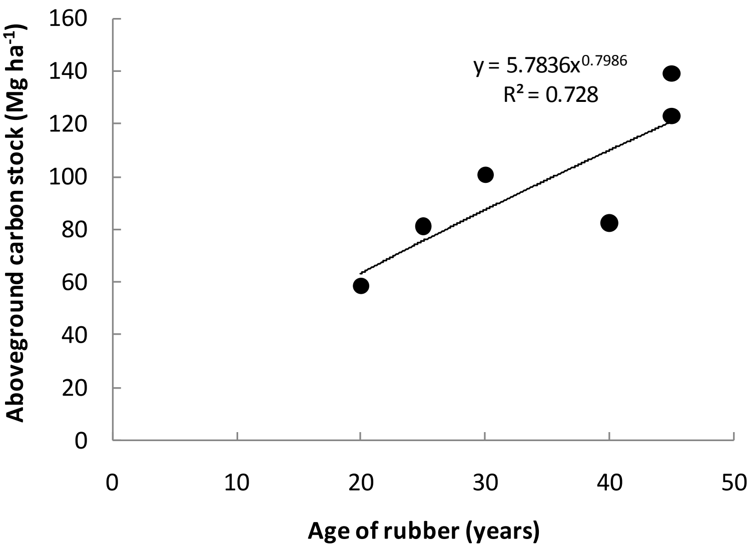


Figure 43. Relationship between age of rubber and aboveground carbon stock

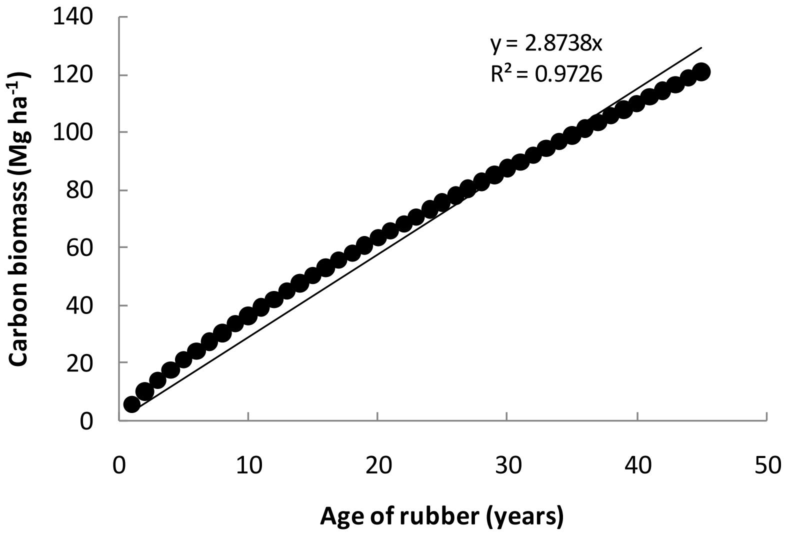


Figure 44. Linear regression carbon stock growth rate of rubber on peat

Coconut

Similar to rubber, coconut mixed with betel nut in Tanjabar has been mostly planted for more than 20 years with carbon stock of 21.4 to 39.4 Mg ha^{-1}. Establishing regression was not possible to generate time-average carbon stock since there was a lack of information on plantation age. To simplify, time-averaged carbon stock was estimated with average value of all observation plot, that is, 31.8 Mg ha^{-1}.

The summary of time-averaged carbon stock in Tanjabar is affected by the type of land-cover system: rubber agroforests, disturbed peat forests and acacia plantations tend to accumulate higher carbon stock compared to coconut, coffee and disturbed mangrove. The complete list is shown in Table 15.

Table 15. Time-averaged aboveground carbon stock based on measurements in Tanjabar

Land use	Time-averaged carbon stock (Mg ha^{-1})	N (Plot number)	Life cycle (years)
***Acacia mangium* on mineral soil**	57.9	9	7
***Acacia crassicarpa* on peat**	51.6	9	7
Coffee mixed with betel nut on peat	26.0	15	30
Rubber agroforest on peat	58.0	6	40
Coconut mixed with betel nut on peat	31.8	4	
Disturbed mangrove	57.5	3	
Disturbed forest on peat	81.4	3	

2.6.4 Belowground carbon stock

As mentioned earlier, peatland in Tanjabar was cleared by migrant communities since 1970 to grow pineapple, coconut and rubber. As part of the land management, they built ditch systems to drain the peatland (Figure 45).

Figure 45. Drainage stream built by migrant in Tanjabar

Coconut trees survive for up to about 15 years before collapsing owing to peat subsidence. From some old coconut trees, there was an indication of about 1 m peat subsidence occurring in this area over the past 40 years (Figure 46).

Figure 46. Uprooted coconut (left) and *Ficus* sp. trees (right), showing distance from soil surface

Most of the roots of old rubber in carbon plots were uprooted from the soil surface and the trees collapsed (Figure 47). The depth of the uprooted rubber stem was affected by the age of the plantation. In younger rubber (20–25 years), uprooted stems ranged 15–35 cm, but in the older trees (45 years) they ranged 50–75 cm.