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ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT WORKING PAPER

ENVIRONMENT CLIMATE CHANGE [ENERGY] MONITORING AND ASSESSMENT

Pilot Testing of GBEP Sustainability Indicators for Bioenergy in Indonesia


Food and Agriculture Organization of the United Nations

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FAO - ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT WORKING PAPER

ENVIRONMENT – CLIMATE CHANGE – BIOENERGY – MONITORING AND ASSESSMENT

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ENVIRONMENT CLIMATE CHANGE [ENERGY] MONITORING AND ASSESSMENT

Pilot Testing of GBEP Sustainability Indicators for Bioenergy in Indonesia

This project represents a contribution to the GBEP programme of work

GBEP Global Bioenergy Partnership

Climate, Energy and Tenure Division (NRC)
September 2014

Food and Agriculture Organization of the United Nations

ENERGY

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FOREWORD

The Global Bioenergy Partnership (GBEP) has produced a set of twenty-four indicators for the assessment and monitoring of bioenergy sustainability at the national level. The GBEP indicators are intended to inform policymakers about the environmental, social and economic sustainability aspects of the bioenergy sector in their country and guide them towards policies that foster sustainable development. The indicators, which were agreed upon by GBEP Partners and Observers at the end of 2011, needed to be pilot tested in a diverse range of national contexts in order to assess and enhance their practicality as a tool for sustainable development and to strengthen the capacity of countries to measure bioenergy sustainability.

Given the data requirements and the broad range of necessary scientific expertise in what is a relatively new area, some countries may require technical and financial assistance in order to measure the indicators and use them to inform policymaking. In response, FAO, which is among the founding members of the Global Bioenergy Partnership, tested the indicators in Colombia and Indonesia, with generous support from the International Climate Initiative (ICI) of the Federal Ministry of the Environment, Natural Resource, and Nuclear Safety of Germany.

This report presents the results of the testing of the GBEP indicators in Indonesia. In order to test the indicators and study their practicality within the specific country context, whilst also contributing to national capacity development, the measurement of the indicators was entrusted to a team of researchers from the Bogor Agricultural University (IPB), supported by researchers from the Indonesian Soil Research Institute, Indonesian Geospatial Information Agency (BIG) and international experts. FAO stimulated the institutional coordination for the project by involving the relevant stakeholders, under the lead responsibility of the Ministry of Energy and Mines, Directorate General of Renewable Energy and Energy Conservation.

The testing provided Indonesia with an understanding of how to establish the means of a long-term, periodic monitoring of its domestic bioenergy sector based on the GBEP indicators. Such periodic monitoring would enhance the knowledge and understanding of this sector and more generally of the way in which the contribution of the agricultural and energy sectors to national sustainable development could be evaluated.

The testing in Indonesia also provided a series of lessons learnt about how to apply the indicators as a tool for sustainable development and how to enhance their practicality.

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Natural Resources Management Officer
Project Coordinator

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ACRONYMS

BAL – Basic Agrarian Law
BEFS – FAO's Bioenergy and Food Security
BOD – Biochemical oxygen demand
CBD – Convention on Biological Diversity
CITES – Convention on International Trade in Endangered Species
COD – Chemical oxygen demand
COPD – Chronic obstructive pulmonary diseases
CPO – Crude palm oil
CSD – Commission on Sustainable Development
DALY – Disability-adjusted life years
EIA – US Energy Information Administration
EFB – Empty fruit bunches
ESDM – Ministry of Energy, Republic of Indonesia
FAME – Fatty Acid Methyl Ester
FAO – Food and Agricultural Organization of the United Nations
FFB – Fresh fruit bunches
FSS – Farmer field school
GAPs – Good agricultural practices
GBEP – The Global Bioenergy Partnership
GHG – Greenhouse gas
GINI – Gini coefficient
GDP – Gross Domestic Product
GNI – Gross National Income
HCV – High Conservation Value area
IBD – Important Bird Area
ICALRRD – Indonesian Center for Agricultural Land Resources Research and Development
ICI – International Climate Initiative
IEA – International Energy Agency
IFEU – Institute for Energy and Environment
IHME – Institute for Health Metrics and Evaluations
ILO – International Labour Organization
ILUC – Indirect Land Use Change
IPCC – International Panel on Climate Change
IUCN – International Union for Conservation of Nature
KKPA – Koperasi Kredit Primer Anggota: Members Primary Credit Co-operative
LCA – Life Cycle Assessment
LHV – Low heating value
LUC – Land Use Change

MDG – Millennium Development Goals
NASA – National Aeronautics and Space Administration
NER – Net Energy Ratio
NES – Nucleus Estate Smallholder
NEV – Net Energy Value
OECD – Organisation for Economic Co-operation and Development
PAN – Pesticides Action Network
PFAD – Palm Fatty Acid Distillate
PIR – Perkebunan Inti Rakyat
POME – Palm Oil Mill Effluent
PTPN – Perusahaan Terbatas Perkebunan Nasional
RPO – Refined Palm Oil
RPBDS – Sterain
RPBDOI – Olein
RSPO – Roundtable on Sustainable Palm Oil
SBZ – Special Biofuel Zones
SOC – Soil Organic Carbon
TARWR – Total Actual Renewable Resources
TAWW – Total Annual Water Withdrawals
TPES – Total primary energy supply
UNDP – UN Development Programme
UNEP – UN Environmental Programme
UNESCO – United Nations Educational, Scientific and Cultural Organization
UNFCCC – UN Framework Convention on Climate Change
UNIDO – UN Industrial Development Organization
URI – Upper respiratory tract infections
USDA – United States Department of Agriculture
WHO – World Health Organization
YLL – Years of life lost

UNITS

USD – United States $
IDR – Indonesia Rupee
ha – Hectare
g/MJ – Gram per mega joule
GJ – Giga joule
m^3/ha – Cubic meter per hectare
m^3/kWh – Cubic meter per kilowatt hour
m^3/MJ – Cubic meter per mega joule
m^3/tonne – Cubic meter per tonne
Mg – Megagram (=1 tonne)
mg – Milligram
mg/ha – Milligram per hectare
mg/l – Milligram per liter
mg/MJ – Milligram per mega joule
MJ – Mega joule
MW – Megawatt
pH – Acidity level
ppm – Parts per million
t – Metric ton (or tonne)
µS/m – Electrical conductivity
bbl/d – Barrels of oil per day
cmol/kg – Centimol per kilogram

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CHAPTER 1

PILOT-TESTING OF GBEP SUSTAINABILITY INDICATORS FOR BIOENERGY IN INDONESIA: OVERVIEW

1.1 INTRODUCTION

The Global Bioenergy Partnership (GBEP)[1] is an international initiative that has produced a set of twenty-four indicators for the assessment and monitoring of bioenergy sustainability at the national level (see section 1.4). The GBEP indicators are intended to inform policymakers about the sustainability aspects of the bioenergy sector in their country and guide them towards policies that foster sustainable development.

The indicators, which were agreed at the end of 2011 by over 70 among GBEP Partners and Observers, needed to be pilot tested in a diverse range of national contexts in order to assess and enhance their practicality as a tool for sustainable development and to strengthen the capacity of countries to measure bioenergy sustainability. At the same time, the countries where the tool is tested will obtain valuable information regarding the performance of their bioenergy sector. More importantly, the testing of the indicators should provide countries with an understanding of how to establish the means of a long-term, periodic monitoring of their bioenergy sector based on the GBEP indicators, which should result in an important enhancement in knowledge and understanding of this sector and indeed more generally of the way in which the contribution of their agricultural and energy sectors to national sustainable development could be evaluated. It was also understood that, given the data requirements and the broad range of necessary scientific expertise in what is a relatively new area, some countries may require technical and financial assistance in order to measure the indicators and use them to inform policymaking.

In response, FAO, which is among the founding members of the Global Bioenergy Partnership, began to explore possible ways to test the indicators in those developing countries that had expressed an interest in such a project. This led to a proposal for a project in Colombia and Indonesia, which was accepted for funding by the International Climate Initiative (ICI)[2] of the Federal Ministry of the Environment, Natural Resource, and Nuclear Safety of Germany. The project started in October 2011 and ended in September 2014.

Over the course of this project, the indicators have also been piloted or implemented to varying extents in Argentina, Brazil, Germany, Ghana, Japan (Kyoto Province), the

1 Global Bioenergy Partnership website: www.globalbioenergy.org
2 http://www.bmu-klimaschutzinitiative.de/en/news

Netherlands, the United States of America, whereas Italy will begin the pilot testing in the upcoming future. New activities on this front continue to emerge and practitioners are able to share experiences through the GBEP Working Group on Capacity Building for Sustainable Bioenergy.

1.2 PROJECT GOALS AND ACTIVITIES

The main goals of the project were to:

1. assess and enhance the capacity of Colombia and Indonesia to measure the GBEP indicators and use them to inform bioenergy policymaking; and
2. learn lessons about how to apply the indicators as a tool for sustainable development and how to enhance the practicality of the tool.

To achieve these goals, the project developed the following main activities:

- Institutional and stakeholder mapping;
- Identification of national consultants;
- Establishment of multi-stakeholder task force (and roles of members);
- Project kick-off meeting to familiarise task force with indicators and project objectives and receive initial feedback on the indicators and project plan;
- Assessment of data availability, followed by workshop to validate findings and receive additional sources of information;
- Initial assessment of institutional and human capacity and gaps;
- Formulation of overall data collection methodology and methodologies for each indicator suited to national context;
- Capacity development on indicator concepts and methodologies;
- Data collection and indicator evaluation: meetings with stakeholders to validate provisional results, fill data gaps and discuss indicator methodologies along the way;
- Provisional results reviewed by FAO and technical experts;
- Technical workshop to present provisional results and seek feedback;
- Workshop to present and receive task force feedback on provisional indicator results and recommendations for:
  - improvements to the GBEP tool (including indicator methodologies) and applications for its future use;
  - capacity to measure the indicators in the country in the long term; and institutional arrangements, policies and practices to improve performance against indicators;
- Regional workshop to share experiences from the project with governments from other countries in the respective regions and help to establish an agenda for cooperative action towards sustainable bioenergy sector development;
- Finalisation of results and recommendations, including discussion with stakeholders to gain buy-in to final report and inter-country lesson learning; and
- Discussion on next steps to embed lessons learnt and develop a platform to measure indicators periodically over the long term.

1.3 PROJECT METHODOLOGY IN INDONESIA

In order to test the indicators and study their practicality within the specific country context, whilst also contributing to national capacity development, national consultants were contracted. After the interviewing and screening phase conducted by FAO, the measurement of the indicators was entrusted to a team of researchers from the Surfactant and Bioenergy Research Center of the Bogor Agricultural University, supported by researchers from the Indonesian Soil Research Institute, and the Indonesian Geospatial Information Agency (BIG) based in Bogor, Indonesia. FAO stimulated the institutional coordination for the project by involving the relevant ministries and asking the government to name one ministry to lead coordination of the engagement of domestic stakeholders in the project, including through chairing a national multi-stakeholder task force to be established for the purposes of the project. In Indonesia, the government charged the Directorate General of Renewable Energy and Energy Conservation of the Ministry of Energy and Mines with the lead responsibility for this project.

The engagement of national consultants, ministries and other stakeholders was considered fundamental to obtaining a national perspective on the practicality of the GBEP indicators, to assessing the national capacity to measure the indicators in real-life conditions and to making use of the project to strengthen and diversify national discussions on the sustainability of their bioenergy.

Discussions with the aforementioned stakeholders were also held with the aim of identifying the most relevant and widespread technologies for the production and use of bioenergy in the country. Based on the indications emerged during these discussions and considering the emphasis placed by current national policies on liquid biofuels for transport, it was decided to focus on biodiesel from palm oil. Whilst liquid biofuels from other feedstocks (e.g. biodiesel from jatropha or candlenut[3]) have been or continue to be investigated as well in Indonesia in particular as potential solutions for enhancing bioenergy production from marginal lands, these technologies are not reported to have resulted in significant energy production thus far. In addition, sugarcane-based bioethanol production was discontinued in 2010 due to unfavourable market conditions, and therefore this form of modern bioenergy was not targeted by this analysis.

National actors were supported by FAO and other international experts throughout the project. In particular, FAO, along with experts from the German Institute for Energy and Environment (IFEU), provided technical support to the national consultants during trainings, workshop and meetings and continued support through electronic and telephonic communication on the meaning of and rationale behind the indicators and their indicative methodological approaches; how to adapt the existing GBEP methodological approach to the country context; and how to implement the chosen methodologies. FAO reviewed the information provided by the national consultants through an iterative dialogue, and complemented it with information available from the literature, international databases and other electronic sources. Throughout the project,

3 Aleurites moluccanus

meetings of the multi-stakeholder task force and of subsets of actors were held to discuss the developments of the project, recommendations for future steps and consequences of emerging results for policy development. Where room for capacity enhancement was found, FAO organized and carried out targeted training activities together with the support of national and international consultants. FAO also conducted bilateral interviews with key stakeholders to enrich the project conclusions and recommendations. In the mid-point and final meetings, as well as in the dedicated training sessions, international experts from intergovernmental organizations, ministries, bilateral development agencies and research institutions participated and shared their knowledge with the community of practice engaged in the implementation of the indicators on the ground. The experiences, recommendations and lessons learnt from the pilot testing of the GBEP indicators for bioenergy in Indonesia were discussed with national stakeholders and subsequently shared with representatives of governments from neighbouring countries during a workshop that was held in Jakarta in August 2014. In addition to raising awareness about the GBEP indicators and sharing experiences about their initial implementation, this regional workshop was also used to help establish agendas for cooperative action on sustainable bioenergy sector development.

1.4 THE GBEP SUSTAINABILITY INDICATORS FOR BIOENERGY

The Global Bioenergy Partnership (GBEP)[4] is a forum where over 70 Partners and Observers (simply referred to as 'members' throughout the rest of this report) amongst governments, intergovernmental organizations and civil society work in the areas of the sustainability of bioenergy and its contribution to climate change mitigation. GBEP provides a platform for sharing information and examples of good practice in sustainable bioenergy and the initiative builds its activities upon three strategic areas: sustainable development, climate change, and energy and food security. It also seeks to enhance collaborative project development and implementation, with a view to optimizing the contribution of bioenergy to sustainable development, taking into account environmental, social and economic factors. In 2011, GBEP published a set of twenty-four sustainability indicators for bioenergy, with contributions from all members and agreed on a consensus basis. The GBEP indicators are currently being implemented by the members in several countries worldwide in order to enhance their practicality and the capacity of countries to measure the indicators and derive policy recommendation from this process.

Even though several national and regional initiatives[5] either have defined or are in the

4 Global Bioenergy Partnership website: www.globalbioenergy.org

5 Detailed overviews of a number of these initiatives can be found in the Compilation of Bioenergy Sustainability Initiatives that was prepared by the FAO's Bioenergy and Food Security Criteria and Indicators (BEFSCI) project. This compilation, which is updated on a regular basis, is available at http://www.fao.org/bioenergy/foodsecurity/befsci/62379/en/

process of defining their own sustainability criteria for bioenergy (mainly focused on liquid biofuels), the uniqueness of the work of GBEP lies in the fact that it is currently the only initiative that has built consensus among a broad range of national governments and international organizations on the sustainability of bioenergy, and in the fact that the emphasis is on providing measurements useful for informing national-level policy analysis and development. Moreover, the GBEP work addresses all forms of bioenergy. The GBEP sustainability indicators do not feature directions, thresholds or limits and do not constitute a standard, nor are they legally binding on GBEP members.

GBEP sought to develop a holistic set of science-based and technically sound indicators for a national evaluation of the domestic production and use of modern bioenergy. All members were invited to contribute with their respective experiences and technical expertise to the development and refinement of the indicators.

GBEP first developed and provisionally agreed on a list of themes, and then established three sub-groups: (1) Environmental – co-led by Germany and UNEP; (2) Social – led by FAO; and (3) Economic and Energy Security – co-led by IEA and UN Foundation. These sub-groups undertook the detailed work on indicators for these themes, which were equally divided between the three sub-group headings. The GBEP report on the indicators also contains a section listing examples of contextual information about cross-cutting issues relating to the legal, policy and institutional framework of relevance to bioenergy and its ability to contribute to sustainable development. It is suggested that this contextual information might aid the analysis of the indicators with the ultimate goal of informing policy development.

During the process of developing the indicators and their underlying methodology sheets, GBEP members took into account and used the work of relevant organizations and international processes related to environmental quality, social welfare and sustainable economic development. Examples of some of the relevant international organizations whose work has informed the development of indicators include the International Energy Agency (IEA), the International Labour Organization (ILO), the UN Development Programme (UNDP), the UN Environment Programme (UNEP), the Food and Agriculture Organization of the United Nations (FAO), the UN Industrial Development Organization (UNIDO) and the World Health Organization (WHO).

The development of the indicators made use of existing guidance documents on sustainable development as discussed in the global community, especially taking into account the Millennium Development Goals (MDGs), the Commission on Sustainable Development (CSD), and Agenda 21. GBEP developed themes that are connected to the social impact of access to modern energy services, notably human health and safety and rural and social development. Access to modern energy services from bioenergy for households and businesses can promote social development and poverty reduction and as such can contribute to achieving various MDGs, including those related to health, education and gender equality.

GBEP developed indicators relevant to the economic themes of sustainability, including those that cover the concepts of economic development, energy security, resource availability and efficiency of use, infrastructure development, and access to technology. Indicators related to these themes were informed by the work of the CSD, UN agencies (e.g. FAO, UNDP, UNEP and UNIDO), IEA, and the work of agencies and ministries within the governments of GBEP members.

Within the environmental pillar, a number of central themes were considered as part of the discussion of the GBEP sustainability indicators, including those related to greenhouse gas emissions, productive capacity of the land and ecosystems, water and air quality, biological diversity, and land-use change. Within these themes, mitigating greenhouse gas emissions and protecting biological diversity are two of the important aspects that were discussed and incorporated within relevant indicators and their underlying methodologies.

Therefore, the development of the indicators was informed by relevant international processes also focusing on these themes, including the Convention on Biological Diversity (CBD), the Intergovernmental Panel on Climate Change (IPCC) and the UN Framework Convention on Climate Change (UNFCCC).

The selection criteria for the indicators were relevance, practicality and scientific basis. Additionally, the geographic scale was to be considered, as well as whether the full set of indicators was balanced and sufficiently comprehensive while still practical.

In the following pages, the twenty-four GBEP bioenergy sustainability indicators are set out under the three pillars, with the relevant themes listed at the top of each pillar. The order in which the indicators are presented has no significance. Full supporting information relating to the relevance, practicality and scientific basis of each indicator, including suggested approaches for their measurement, can be found in the methodology sheets for each indicator in the 2011 report on the indicators[6].

6 Part II of the GBEP Report on Indicators for Sustainable Bioenergy: Methodology Sheets. Available at http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/Indicators/The_GBEP_Sustainability_Indicators_for_Bioenergy_FINAL.pdf

7 In light of discussions on the issue and considering the state of the science on quantifying possible indirect land-use change (ILUC) impacts of bioenergy, it has not yet been possible to include an indicator on ILUC. GBEP notes that further work is required to improve our understanding of and ability to measure indirect effects of bioenergy such as ILUC and indirect impacts on prices of agricultural commodities. GBEP will continue to work in order to consolidate and discuss the implications of the current science on these indirect effects, develop a transparent, science-based framework for their measurement, and identify and discuss options for policy responses to mitigate potential negative and promote potential positive indirect effects of bioenergy.

ENVIRONMENTAL PILLAR	
THEMES GBEP considers the following themes relevant, and these guided the development of indicators under this pillar: Greenhouse gas emissions, Productive capacity of the land and ecosystems, Air quality, Water availability, use efficiency and quality, Biological diversity, Land-use change, including indirect effects[7]	
INDICATOR NAME	**INDICATOR DESCRIPTION**
1. Lifecycle GHG emissions	Lifecycle greenhouse gas emissions from bioenergy production and use, as per the methodology chosen nationally or at community level, and reported using the GBEP Common Methodological Framework for GHG Lifecycle Analysis of Bioenergy 'Version One'
2. Soil quality	Percentage of land for which soil quality, in particular in terms of soil organic carbon, is maintained or improved out of total land on which bioenergy feedstock is cultivated or harvested
3. Harvest levels of wood resources	Annual harvest of wood resources by volume and as a percentage of net growth or sustained yield, and the percentage of the annual harvest used for bioenergy
4. Emissions of non-GHG air pollutants, including air toxics	Emissions of non-GHG air pollutants, including air toxics, from bioenergy feedstock production, processing, transport of feedstocks, intermediate products and end products, and use; and in comparison with other energy sources
5. Water use and efficiency	Water withdrawn from nationally determined watershed(s) for the production and processing of bioenergy feedstocks, expressed as the percentage of total actual renewable water resources (TARWR) and as the percentage of total annual water withdrawals (TAWW), disaggregated into renewable and non-renewable water sources Volume of water withdrawn from nationally determined watershed(s) used for the production and processing of bioenergy feedstocks per unit of bioenergy output, disaggregated into renewable and non-renewable water sources
6. Water quality	Pollutant loadings to waterways and bodies of water attributable to fertilizer and pesticide application for bioenergy feedstock cultivation, and expressed as a percentage of pollutant loadings from total agricultural production in the watershed Pollutant loadings to waterways and bodies of water attributable to bioenergy processing effluents, and expressed as a percentage of pollutant loadings from total agricultural processing effluents in the watershed
7. Biological diversity in the landscape	Area and percentage of nationally recognized areas of high biodiversity value or critical ecosystems converted to bioenergy production Area and percentage of the land used for bioenergy production where nationally recognized invasive species, by risk category, are cultivated Area and percentage of the land used for bioenergy production where nationally recognized conservation methods are used
8. Land use and land-use change related to bioenergy feedstock production	Total area of land for bioenergy feedstock production, and as compared to total national surface and agricultural and managed forest land area Percentages of bioenergy from yield increases, residues, wastes and degraded or contaminated land Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production, including the following (amongst others): arable land and permanent crops, permanent meadows and pastures, and managed forests; natural forests and grasslands (including savannah, excluding natural permanent meadows and pastures), peatlands, and wetlands

SOCIAL PILLAR	
THEMES GBEP considers the following themes relevant, and these guided the development of indicators under this pillar: Price and supply of a national food basket, Access to land, water and other natural resources, Labour conditions, Rural and social development, Access to energy, Human health and safety	
INDICATOR NAME	**INDICATOR DESCRIPTION**
9. Allocation and tenure of land for new bioenergy production	Percentage of land – total and by land-use type – used for new bioenergy production where: a legal instrument or domestic authority establishes title and procedures for change of title; and the current domestic legal system and/or socially accepted practices provide due process and the established procedures are followed for determining legal title
10. Price and supply of a national food basket	Effects of bioenergy use and domestic production on the price and supply of a food basket, which is a nationally defined collection of representative foodstuffs, including main staple crops, measured at the national, regional, and/or household level, taking into consideration: changes in demand for foodstuffs for food, feed and fibre; changes in the import and export of foodstuffs; changes in agricultural production due to weather conditions; changes in agricultural costs from petroleum and other energy prices; and the impact of price volatility and price inflation of foodstuffs on the national, regional, and/or household welfare level, as nationally determined
11. Change in income	Contribution of the following to change in income due to bioenergy production: wages paid for employment in the bioenergy sector in relation to comparable sectors net income from the sale, barter and/or own consumption of bioenergy products, including feedstocks, by self-employed households/individuals
12. Jobs in the bioenergy sector	Net job creation as a result of bioenergy production and use, total and disaggregated (if possible) as follows: skilled/unskilled temporary/indefinite Total number of jobs in the bioenergy sector and percentage adhering to nationally recognized labour standards consistent with the principles enumerated in the ILO Declaration on Fundamental Principles and Rights at Work, in relation to comparable sectors
13. Change in unpaid time spent by women and children collecting biomass	Change in average unpaid time spent by women and children collecting biomass as a result of switching from traditional use of biomass to modern bioenergy services
14. Bioenergy used to expand access to modern energy services	Total amount and percentage of increased access to modern energy services gained through modern bioenergy (disaggregated by bioenergy type), measured in terms of energy and numbers of households and businesses Total number and percentage of households and businesses using bioenergy, disaggregated into modern bioenergy and traditional use of biomass
15. Change in mortality and burden of disease attributable to indoor smoke	Change in mortality and burden of disease attributable to indoor smoke from solid fuel use, and changes in these as a result of the increased deployment of modern bioenergy services, including improved biomass-based cookstoves
16. Incidence of occupational injury, illness and fatalities	Incidences of occupational injury, illness and fatalities in the production of bioenergy in relation to comparable sectors

ECONOMIC PILLAR	
THEMES GBEP considers the following themes relevant, and these guided the development of indicators under this pillar: Resource availability and use efficiencies in bioenergy production, conversion, distribution and end-use, Economic development, Economic viability and competitiveness of bioenergy, Access to technology and technological capabilities, Energy security/Diversification of sources and supply, Energy security/Infrastructure and logistics for distribution and use	
INDICATOR NAME	**INDICATOR DESCRIPTION**
17. Productivity	Productivity of bioenergy feedstocks by feedstock or by farm/plantation Processing efficiencies by technology and feedstock Amount of bioenergy end product by mass, volume or energy content per hectare per year Production cost per unit of bioenergy
18. Net energy balance	Energy ratio of the bioenergy value chain with comparison with other energy sources, including energy ratios of feedstock production, processing of feedstock into bioenergy, bioenergy use; and/or lifecycle analysis
19. Gross value added	Gross value added per unit of bioenergy produced and as a percentage of gross domestic product
20. Change in the consumption of fossil fuels and traditional use of biomass	Substitution of fossil fuels with domestic bioenergy measured by energy content and in annual savings of convertible currency from reduced purchases of fossil fuels Substitution of traditional use of biomass with modern domestic bioenergy measured by energy content
21. Training and re-qualification of the workforce	Percentage of trained workers in the bioenergy sector out of total bioenergy workforce, and percentage of re-qualified workers out of the total number of jobs lost in the bioenergy sector
22. Energy diversity	Change in diversity of total primary energy supply due to bioenergy
23. Infrastructure and logistics for distribution of bioenergy	Number and capacity of routes for critical distribution systems, along with an assessment of the proportion of the bioenergy associated with each
24. Capacity and flexibility of use of bioenergy	Ratio of capacity for using bioenergy compared with actual use for each significant utilization route Ratio of flexible capacity which can use either bioenergy or other fuel sources to total capacity

CHAPTER 2

COUNTRY SITUATION AND DOMESTIC BIOENERGY SECTOR

2.1 COUNTRY CONTEXT

2.1.1 Overview

Indonesia is an archipelago of over 17,000 islands in Southeast Asia, with a total land area of 186,071,969 ha (Agus et al, 2014). With almost 250 million inhabitants (FAOSTAT, 2012a), Indonesia has the fourth largest population in the world and a wide range of ethnic backgrounds. It is divided into 34 provinces and its islands can be grouped into the Greater Sunda Islands of Sumatra (Sumatera), Java (Jawa), the southern extent of Borneo (Kalimantan), and Celebes (Sulawesi); the Lesser Sunda Islands (Nusa Tenggara) of Bali and a chain of islands that runs eastward through Timor; the Moluccas (Maluku); and the western extent of New Guinea (Papua). The capital, Jakarta, is located near the north-western coast of Java.

The climate of Indonesia is characterized by two tropical seasons which vary with the equatorial air circulation (*The Walker Circulation*) and the meridian air circulation (*The Hardley Circulation*). The climate changes every six months with the presence of a dry season from June to September influenced by the Australian continental air masses, and a rainy season (December to March) which results from the encounter of air masses having high water vapour content.

Indonesia is one of most biologically diverse countries on Earth, home to approximately 12 percent of the world's mammals, 16 percent of the world's reptiles, 17 percent of the total species of birds on the planet (CBD, 2014). A considerable part of the natural ecosystems have been converted to agriculture (CBD, 2014).

With a GNI per capita of 3,420 USD (8,750 PPP) and a GDP of 878 billion USD, in 2012 Indonesia was classified as an upper middle income economy. In terms of value added, in 2012 the main economic sectors was industry (around 47 percent of GDP) followed by services (around 39 percent of GDP) and agriculture (around 14 percent of GDP) (World Bank, 2014a)

In 2011, Indonesia had a GINI index of around 38 percent, signalling a certain level of inequality in the distribution of income (World Bank, 2014b). In 2012, 15 percent of the population lived below the poverty line, and the prevalence of undernourishment was slightly below 10 percent of the population. In the same year, life expectancy at birth was 71 years (CIFOR, 2014; FAOSTAT, 2014)

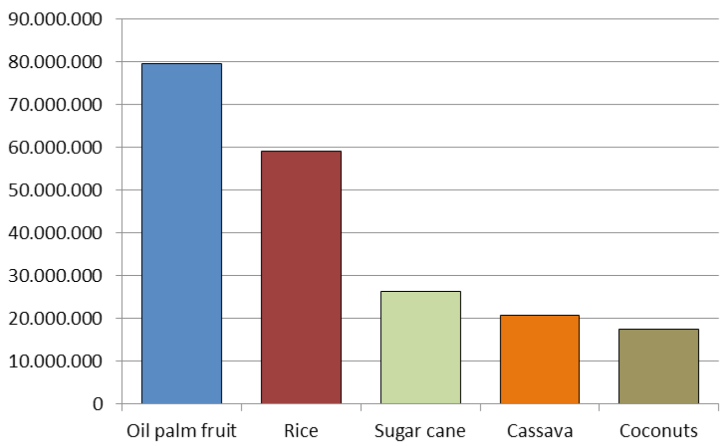
Indonesian social disparities are strongly linked to geographic inequality. For instance, the infant mortality rate in East Nusa Tenggara province is 57 deaths every 1,000 live births, three times that of Yogyakarta province, where the capital city is located. Under-five and infant mortality rates amongst the poorest households are generally more than twice those in the highest income families. Nearly two-thirds of the poorest families in Java and Bali have access to clean water, but less than 10percent of the poor families in Papua enjoy such access. According to the 2010 national census, some 3.5 million children were not attending primary or junior secondary school. An estimated 2.7 million Indonesian children are involved in some form of child labour and roughly half of these were under the age of 13 (UNICEF, 2011). Beyond inequalities and poverty, Indonesia still struggles with unemployment, inadequate infrastructure, political and local corruption events, a complex regulatory environment and unequal resource distribution among regions.

2.1.2 Agriculture

Rice is the most important agricultural commodity in Indonesia especially for domestic consumption. In 2005, rice made up around 23 percent of total agricultural output in volume terms with a total production of 54 million tonnes. Cassava and maize are the other two principal food crops in Indonesia, accounting for a further 13 percent of total agricultural output in volume terms. Other important agricultural products include sugar cane, palm oil, and rubber with a total share of 19 percent. These products are mostly exported to India, China and Europe. In 2012, Indonesia produced 120 million tonnes of oil palm fruit from which it extracted about 26 million tonnes of crude palm oil (Ministry of Agriculture, 2013). Other agricultural commodities' production has been consistently high over the years. In 2012, Indonesia produced some 69 million tonnes of rice, about 26 million tonnes of sugarcane, 21 million tonnes of cassava and 17.5 million tonnes of coconuts (FAOSTAT, 2012b).

Figure 2.1.1

Most produced commodities in Indonesia in 2012



Source FAOSTAT, 2012b

Livestock products account for about 5 percent of agricultural output in volume terms, with poultry being the largest component. Poultry is the major livestock industry, and its output increased rapidly from the 1960s to the mid-1990s. The industry was severely affected by the Asian financial downturn in 1997 and 1998, as consumers switched from poultry products to cheaper sources of protein, such as *tempeh*[8] and tofu (Hartono, 1999). Since the Asian financial downturn, poultry output has resumed rapid growth, although outbreaks of avian influenza have the potential to adversely affect the poultry industry.

Maize is the principal feed used in poultry production in Indonesia. Between 1971 and 2001, consumption of maize increased by an average of 6.4 percent a year (Swastika et al, 2004), thus, the strong performance of the poultry industry has translated to significant growth in the consumption of maize. In 2011, Indonesia produced 1.64 Mt of poultry meat and over 17 Mt of maize.

Agriculture is an important source of income for almost 40 percent of the population. Although its share of the national GDP declined from 19 percent reported for 1990 to 13 percent in 2007, has gained more relevance in recent years reaching 15 percent of the gross domestic production. Although the direction of structural transformation of the Indonesian economy has been in line with the evolution of other developing countries in the region, the pace of this transformation has been much slower than in countries such as Thailand or Malaysia, particularly in terms of share of agricultural employment (OECD, 2012a; OECD, 2012b)

2.1.3 Energy

According to the ESDM (2013), approximately 40 percent of Indonesian households rely on traditional biomass (mostly wood) for cooking. Most of these households are in rural areas and are likely to continue using traditional biomass in the near future. In 2012 biomass consumption accounted for 20 percent of all energy consumption in Indonesia (ESDM, 2013).

Fossil fuels, including coal, petroleum, natural gas, represent the main source of income for the country. They are extract and refined largely in Sumatra and Kalimantan and in offshore sites in the Java and South China seas. Even though refineries have been owned since 1968 by the public petroleum company *Pertamina*, foreign oil companies work under a production-sharing formula which allow the government of Indonesia to maintains the ownership of oil resources while the foreign companies work as contractors, supplying the necessary capital. Indonesia left the Organization of Petroleum Exporting Countries in 2008, as became a net petroleum importer in 2004. Indonesia's oil, oil products, and gas trade balance was negative in 2008 with a USD 1.4 billion deficit, but became positive again in 2009 with a USD 29.4 million surplus (IBP, 2011). Crude and condensate output averaged 944,000 bbl/d in 2010, down slightly from 948,000 in 2009. In 2010, the oil and gas sector is estimated to have contributed for USD 23.3 billion to government revenues, or 20.9 percent of the total.

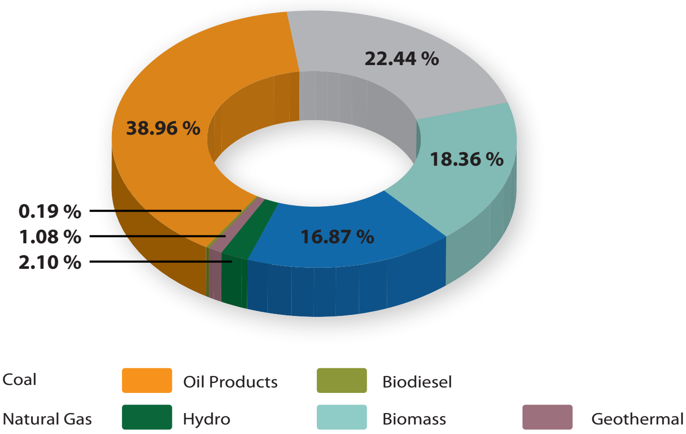
8 *Tempeh* is a food made by controlled fermentation of cooked soybeans.

The large majority of Indonesian electrical power is generated from fossil fuels. Until the late 20th century, the majority of the country's power was provided by oil and natural gas. As the government supported production of coal, and attempted to increase the domestic use of this resource. By the early 21st century, less than half the country's power stations were fueled by oil or gas. Many plants were coal-driven, some were hydroelectric, and a small portion of plants were powered by geothermal sources.

Subsequently to the significant increase in the global energy price in 2007-2008, the Indonesian Government raised fuel prices by an average of 29 percent in May 2008 in an attempt to reduce the burden of subsidies. Indonesia spent IDR 164.7 trillion (USD 18.1 billion) subsidizing fuel products in 2011, of which IDR 76.5 trillion (USD 8.4 billion) was spent subsidizing gasoline (IISD, 2012). The Indonesian Government implemented a policy package to help its citizens belonging to the low-income families compensating the purchasing power losses with direct cash payments. The Government has also significantly reduced kerosene subsidies with its kerosene-to-LPG conversion program. In January 2012, the Government announced plans to reduce subsidies by restricting access to subsidized gasoline and developing gas-based alternative transport fuels, to be implemented by April 2012 and, as of March 2012, the Government has announced a plan to raise the price of subsidized gasoline by IDR1,500 per liter, which is equivalent to one third of the current price (IISD, 2012).

Figure 2.1.2

Share of energy sources in Total Primary Energy Supply (TPES), 2012



Source: Edited from ESDM, 2013 and ESDM, 2014

2.2 MODERN BIOENERGY: POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

2.2.1 Policy and Legislation

In Indonesia, biofuels are targeted as the main renewable energy resource for future development due to their potential to provide alternatives for transport petroleum fuels. This was triggered by the fast increasing world crude oil prices and decreasing oil production in Indonesia. Bioenergy development is also seen as a means of increasing economic growth through investment and export, creating employment (especially in the plantation sector), and alleviating poverty in rural areas.

Indonesia is endowed with various sources of bioenergy feedstock types such as oil palm, maize, sugarcane molasses, cassava, and others are currently being explored and researched such as jatropha and candlenut (*Aleurites moluccanus*). The potential for domestic modern bioenergy production in Indonesia was taken in consideration starting from the early 2000s.

In 2006, Presidential Decree No. 10/2006 was issued to establish a National Team for Biofuel Development with the aim to (Silviati, 2008):

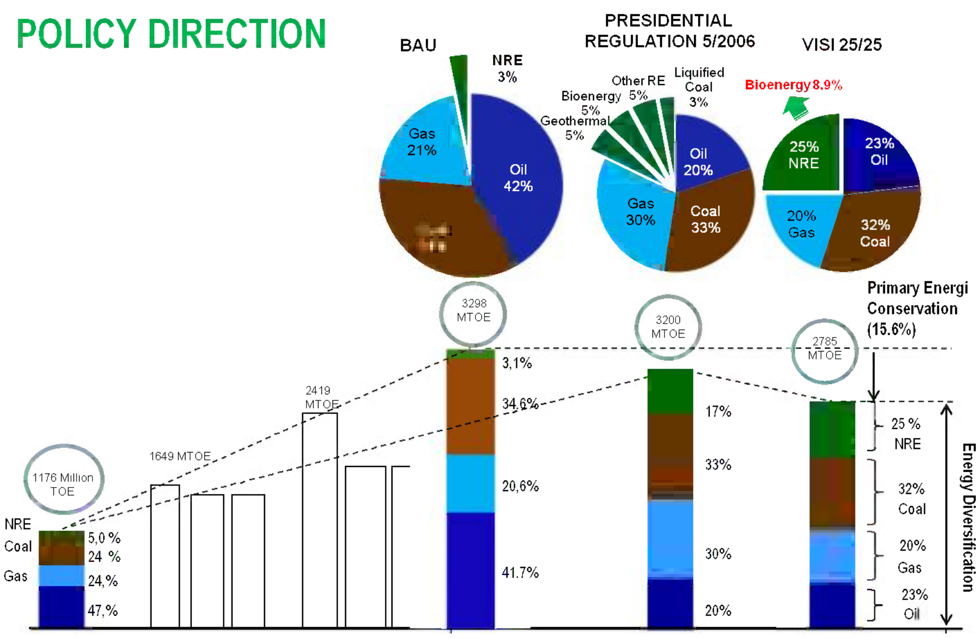
- Create a roadmap for a national biofuel development programme;
- Advise regional authorities on how to increase economic development through biofuel programmes;
- Analyse the economic, social and environmental aspects of biofuel production from various feed stocks; and
- Formulate regulations for all aspects of the fuel chain, including plantation, processing, marketing, and distribution.

The committee has formulated ambitious targets for bioenergy supply. By 2025, the Indonesian Government aims to obtain 25 percent of its total primary energy from renewable sources (biomass, geothermal, hydroelectric). Total supply of biofuels (both biodiesel and bioethanol) is expected to increase from 0.6 billion litres in 2007 to 22.26 billion litres by 2025. This is about 5 percent of total energy supply in 2025 (Fig. 2.2.1). Total bioenergy supply (including solid biomass) in 2025 is expected to reach 2,785 million tonnes of oil equivalent (MTOE) and it will account for 8.9 percent of total primary energy supply according to the Indonesian Ministry of Energy and Mineral Resources (ESDM, 2012).

Ministerial Decree No. 3675K/24/DJM/2006, issued by ESDM in 2006, regulated quality standards for the use of biodiesel up to a maximum of 10 percent of the volume of the fuel. Biofuel specifications have to meet the standard SNI 04-7182-2006, which is based on the European and US standards ASTM D 6751 and EN 14214.

Figure 2.2.1

Energy policy in Indonesia: Overview 2011 – 2025



Source: Indonesian Ministry of Energy and Mineral Resources (ESDM), 2012.

Several Ministries and government agencies have particular responsibilities in the biofuel development chain and this risks laborious procedures for obtaining the necessary licenses and permits. To streamline this process and to establish a one-stop-shop approach, the Biofuel Committee proposed to designate Special Biofuel Zones (SBZ) (CIFOR, 2011). SBZs are intended to be areas throughout Indonesia (at least 10,000 hectares in Java and 100,000 hectares outside Java) that meet certain criteria such as existing infrastructure, labour requirements, and conservation guidelines where bioenergy feedstock is produced and processed into modern biofuels. As of 2012, however, these areas have not been identified.

Biodiesel production licenses have been issued to more than 10 biodiesel producers with capacity in the range of 50,000 to 150,000 tonnes of biodiesel per year. These companies do not necessarily produce the feedstock (as intended in the SBZs) and have free agreements to acquire the raw material for the production of biodiesel from the market.

Usage of biofuels in Indonesia is supported by several statues and pieces of regulation, both directly and indirectly. The Biofuel Committee has produced a blueprint for biofuel development and a set of recommendations regarding funding, pricing, processing, consumption and production of the various biofuel crops.

A synthesis of the policies that directly interest biofuels in Indonesia is reported in Table 2.2.1.

Table 2.2.1

Synthesis of policies regulating directly or indirectly bioenergy development in Indonesia

Year	Policies and programs	Objective
2006	Strategic plan for energy security (Presidential Regulation No. 5/2006)	The National Energy Policy envisages liquid biofuels meeting at least five percent of domestic energy needs by 2025;
	Policy regime (Losari Concept)	Increase biofuel production in support of Indonesia energy-security plans. As part of this plan, the ESDM announced that Indonesia intended to meet 10 percent of transport fuel usage with biofuels by 2010. The biofuels would be made from cassava, sugarcane, palm oil and castor oil;
	After the approval of the biodiesel standard SNI 04-7182-2006 by the National Standardization Agency the Oil and Gas Directorate-General of the Department of Energy and Mineral Resources issued a decree on diesel oil	This decree regulates the use of fatty acid methyl ester (FAME) up to the maximum of 10 percent of the volume of automotive diesel fuel with which it is blended. The FAME to be mixed has to meet the biodiesel standard SNI 04-7182-2006;
	Presidential Decree No.10/2006 on Establishment of National Team for Biofuel Development, July 2006).	To implement the objectives of the National Energy Policy and the Losari Concept, President Yudhoyono tasked selected cabinet members with duties to promote biofuels as alternatives to petroleum fuels;
2007	At the Jakarta Joint Initiative for Biofuel Development, at which 67 agreements for biofuel development were signed	Few of these projects were implemented, as escalating feedstock prices in 2007 and early 2008 made biofuel production increasingly unprofitable;
2008	Ministerial Regulation No. 32/2008 concerning Supply, Utilization and Marketing of Biofuel as an Alternative Energy	The government provides special incentives for the biofuel investors, including: • A reduction in stamp duties; • Agreements with 50 countries to avoid double taxation; • Relief from import duties for goods used in the production of biofuels; • An investment tax allowance in the form of a reduction in taxable income by a value equal to up to 30 percent of the realized investment spread over six years; • Accelerated depreciation and amortization; • A loss-carried-forward facility for a period of no more than 10 years; • A 10 per cent income tax on dividends, possibly lower if stipulated in the provisions of an existing applicable tax treaty; and • An exemption from the Value Added Tax for selected strategic goods.
	ESDM Decree No. 32/2008	The ministerial decree states that a licensed biofuel entity that is performing the obligations for mandatory biofuel consumption may be given fiscal and non-fiscal incentives;
2009	Presidential Decree No. 45/2009	The government will guarantee provision and distribution of biofuel in Indonesia. The decree also states that the market price index of biofuel will be set by Ministry of Energy & Mineral Resources;
2010	ESDM Decree 0219 K/12/MEM/2010 on the determination of biofuel market price index	Biodiesel benchmark price is the export benchmark price of fatty acid methyl ester. Bioethanol benchmark price is Argus ethanol price (FOB Thailand) plus 5 percent (bioethanol program has been terminated in 2010 due to a disagreement in market price index formulation between ESDM and Fuel Ethanol producers).
2011	ESDM and Parliament agreement	Increase biofuel subsidies in fiscal year 2012 from 2,000 Indonesian rupiah (IDR) per liter to 2,500 – 3,000 IDR per liter for biodiesel and 3,000 – 3,500 IDR per liter for ethanol.

Even if the production of industrial ethanol has annually grown by 3 percent from 2006 to 2010, since 2010 there is no Fuel Ethanol (FE) produced in Indonesia because of disagreement in market price index formulation between ESDM and FE producers; ethanol producers requested the Ministry of Energy and Mines to revise the formula by adopting domestic FE price as a benchmark, as opposed to prices set for the conditions of the Thai bioethanol market.

Several decrees and legal instruments have been put in place from 2006 to 2012 with the aim to governing bioenergy developments, particularly liquid biofuels including regulations to support small- and medium-size biofuel enterprises (Ministry of Finance issued Decree No. 117/PMK.06/2006 to provide subsidised loans to farmers to help them develop biofuel plantations) and other investment policies aimed at supporting the development of the sector. Land allocation policies, such as Decree No. P.22/Menhut-II/2009 issued by the Minsitry of Forestry, are intended to provide practical guidelines for implementation, stipulating the size and manner in which forest areas can be converted to estate crop plantations. Forest areas of up to 100,000 ha per company or a group of companies can be converted to plantations, but the clearance permit is given progressively starting at 20,000 ha. This kind of policies has stimulated plantation expansion operated by large scale investment groups. In addition, regulations and policy initiatives that contribute to ensuring environmental sustainability have facilitated the creation of the Indonesian Sustainable Palm Oil (ISPO) standard as put forward in the Ministry of Agriculture's decree No. 19/Permentan/OT.140/3/2011.

As of 2012, though, the performances of the national biofuel sector have not met policy expectations. According to CIFOR (2011), one reason is the failure to significantly reduce fossil fuel subsidies, which distort the energy market and make biofuels uncompetitive. Another reason, beyond the capacity of government to control, is the high international price of CPO, which discourages biofuel production and lure relevant actors to promote CPO export. Logistical hurdles have also limited biodiesel distribution to remote provinces, preventing the fulfillment of the blending mandate at the national level. Various sectoral policies on energy have provided a strong basis for the development of biofuels in Indonesia. The establishment of a taskforce and presidential instructions to government agencies to accelerate the procurement and use of biofuels has been constructive in producing a road map and outlining the role of relevant actors. However, coordination among government agencies in making sure that the supply and use of biofuel feedstocks are in line with the roadmap is difficult. Given that palm oil is intended for various purposes and the price of CPO is volatile, it is impossible to ensure the portion of palm oil allocated to fulfilling the biofuel target, and to identify that certain plantations are allocated for biofuels. While oil palm plantation permits continue to be issued, there are no clear attempts to ensure that they correlate with the plan to produce biofuels (CIFOR, 2011).

Biodiesel

Palm oil is the main biodiesel feedstock in Indonesia. Indonesian CPO production reached 23.6 million metric tonnes (MMT) in marketing year (MY) 2010/2011. The production increased to 25 MMT in MY 2011/2012 and hit 26.0 MMT in MY 2012/2013, mostly due to expanded harvested surface. Indonesian biodiesel production increased significantly to 2.2 billion liters in 2012. Consumption of biodiesel reached 669 million liters in 2012, while the remaining production was exported. An additional increase in consumption is predicted for 2013, to a total of 700 million liters. Indonesian biodiesel export increases very significantly by almost 117 percent from 563 million liters in 2010 to 1.22 billion liters in 2011. The total plantation area in 2012, according to Ministry of Agriculture (2013), was 9.5 million hectare and is projected to reach 13 million ha by 2020. In 2011, the Government of Indonesia signed a Presidential Instruction (No.10/2011) regarding a Moratorium on the Granting of New Licenses and Improvement of the Management of Primary Forest and Peat Moss Areas (CIFOR, 2011). The Presidential Instruction No. 10/2011 aims to suspend the granting of new concession licenses for logging and conversion of forests and peatlands for two years from the date of enactment, with the suspension allowing for better planning for forest governance through the institution of necessary coordination processes, data collection and, potentially, new regulations (CIFOR, 2011).

Palm oil is widely used domestically as cooking oil, however, to a much lesser extent for domestic use as biofuel. The primary markets for Indonesian CPO are overseas and the bulk of the production is exported; in 2012, Indonesia exported about 18.85 million tonnes of CPO for an aggregated value of USD 17.6 billion (Ministry of Agriculture, 2013). The food markets are largely predominant; in India and China CPO is used as cooking oil whereas in Europe, markets are mostly confectionery manufacturing and, to a lesser extent, the energy market. The international price for palm oil and the higher value placed on food has meant that most palm oil is expected or used in food production. However, according to the International Institute for Sustainable Development (IISD, 2013) on the EU-27 scale, the biofuels industry has increased its use of palm oil by 365 per cent over 2006–2012, which can be linked primarily to the growth in biodiesel production stimulated by government policies during the same period. In 2012, EU imports of CPO that were processed into biodiesel accounted for 1.9 million tonnes. The two main CPO suppliers are Indonesia and Malaysia and it is not possible to track the country of origin of the vegetable oil used for food and for fuel. This amount was absorbed primarily by the European transport sector and a minor component by the electricity generation sector, in addition to the 1.4 million tonnes of biodiesel imported as such from Indonesia.

By 2025, Indonesia aims to supply 25 percent of its diesel demand for all sectors, thus not limited to transport, with domestically produced biodiesel. This is part of the newly proposed National Bioenergy Policy, a document approved by the Indonesian House of the Representative on January 28 2014 (Prakoso and Siahaan, 2014) and produced on the basis of Regulation 25/2013 enacted by the Ministry of Energy and Mines (USDA, 2014). In order to meet this additional demand, biodiesel production would need to increase by over five times compared to 2012.

Bioethanol

Indonesia has not produced fuel ethanol (FE) since 2010 due to economical inefficiencies. Production costs associated with producing FE has continued to rise since 2009 due to the increasing price of molasses, the primary Indonesian ethanol feedstock. Consequently, domestic FE producers have terminated their production since 2010. Domestic FE prices and the Government's ethanol subsidy of IDR 2,000 per liter are not enough to keep producers' margins positive. The new Ministerial Subsidy formula for biofuels takes into account the fluctuation of feedstock price, to include molasses. The new formula is hoped to enable Indonesian bioethanol to be more profitable for the producers, as they will benefit from a price that can compensate both production cost and required profit margins (USDA, 2014). However, as of 2012, the proposed formula was still under revision by the Ministry of Finance. Therefore, for the extent of this project, the GBEP indicators have not been applied to bioethanol production.

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CHAPTER 3

RESULTS OF PILOT-TESTING OF GBEP SUSTAINABILITY INDICATORS FOR BIOENERGY IN INDONESIA

ENVIRONMENTAL PILLAR

3.1 INDICATOR 1: LIFECYCLE GHG EMISSIONS

Description:
Lifecycle greenhouse gas emissions from bioenergy production and use, as per the methodology chosen nationally or at community level, and reported using the GBEP Common Methodological Framework for GHG Lifecycle Analysis of Bioenergy 'Version One'.

Measurement unit(s):
Grams of CO_2 equivalent per megajoule (gCO_2eq/MJ)

3.1.1 Testing of indicator 1 in Indonesia

With regard to the measurement of Indicator 1, the full LCA for bioenergy production and use was performed, including emissions due to biomass feedstock production, manufacture and use of fertilizers, co-products and by-products, land-use change, transport of the biomass, processing into fuel, and the distribution. A comparison with the reference fossil fuel was also performed. The reality of bioenergy production in Indonesia is complex and one single scenario that well represents all variables involved in the sector does not exist. Therefore, for the testing of this indicator, FAO has partnered with experts from the Institute for Energy and Environment (IFEU) who offered their support to the team of Indonesian GHG scientists engaged in the assessment of the GBEP Indicators. An operation of knowledge transfer and capacity development was organized and put in place by FAO through a series of in-country meetings, hands-on workshops, and specific training activities aimed at i) assessing the capacity of Indonesia to measure LCA GHG emission and ii) enhancing their capacity in order to enable local scientists to monitor the indicator over the long period. The result of the aforementioned activities is the production of eight representative scenarios that are intended to inform policymakers on the most sustainable strategy for bioenergy development in Indonesia.

3.1.2 Key findings

The assessment of Indicator 1 in Indonesia was performed between October 2012 and August 2014. It involved the participation of a task force of Indonesian GHG scientists from several institutions and Ministries in addition to FAO staff and international experts. A primary data collection campaign was planned and performed in collaboration with one of the major palm oil and biodiesel producers operating in Indonesia. In addition, based on a vast and updated literature review, it was possible to identify two representative examples of palm oil production types: one based on the characteristics of the average large estate plantation and the other based on the characteristics of the average smallholder's farm in Indonesia as of 2012. The data groups (i.e. 1 – Average Large Estate; 2 – Average Smallholder) were then tested for the four most common biodiesel production scenarios in Indonesia. These are based on the occurrence of two important emission sources in lifecycle assessment of GHG emissions from palm oil biodiesel: i) the existence of Land Use Change, its trajectories and the soil type it interested (e.g. mineral vs peat soils) and ii) the presence of methane (CH_4) capture systems. All combinations of the aforementioned were also tested. Among the known emission sources of the biodiesel value chain, land use change and peat decomposition may contribute up to about one half of the total emissions (Agus & Sarwani, 2013; Sarwani et al. 2013) depending on the type of land utilized (whether peatland is involved in the production) and land use change trajectory. In the phase where agricultural expansion involves rapid land area expansion and if the expansion replaces land with high carbon stock such as forest and peatland for the production of palm oil ultimately used as feedstock for biodiesel production, the product may become a major contributor of emission. Therefore the analysis of land use change emissions is crucial in the LCA.

Among the several co- and by-products generated by the palm oil mills, the palm oil mill effluent (POME) is the liquid waste generated from the oil extraction process in palm oil mills (Chin et al, 2013). This effluent is characterized by high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) (Poh et al, 2010) and high content of suspended solids. In Indonesia, POME cannot be discharged into the bodies of water without adequate waste treatment to abate its oxygen demand. The most common technique for reducing POME's BOD is known as ponding system. The POME is stored in large ponds where anaerobic microbial activity decreases the BOD. As a result of this process, the treated POME can be discharged into the nearby bodies of water while complying with the national water pollution regulation. During the anaerobic treatment in the ponds, POME releases methane (CH_4), a greenhouse gas which has a global warming potential[9] more than 20 times higher than carbon dioxide[10] (IPCC, 2007).

As of 2012, in Indonesia there were 608 registered palm oil mills and only 5 percent of

9 Global warming potential is an index that attempts to integrate the overall climate impacts of a specific action (e.g., emissions of CH_4, NO_x or aerosols). It relates the impact of emissions of a gas to that of emission of an equivalent mass of CO_2 (IPCC, 2007). Further information available at http://www.ipcc.ch/ipccreports/sres/aviation/index.php?idp=71

10 On a 100 years horizon, as defined by IPCC, 2007.

these were equipped with methane capture systems (ESDM, 2014).

Given the relevance of emissions from POME, scenarios which include and exclude the presence of methane capture systems have been performed in order to understand the impact of this technology on LCA GHG emissions.

In order to assess the GHG emission from LUC, an experimental measurement based on actual land use change trajectories in Indonesia between 1990 and 2010 was performed. The assessment of the trajectories built upon the work of Gunarso et al. 2013 whose methodology was adapted to the specific case of Indonesia. For a detailed explanation of the methodological approach followed for the assessment of the LUC trajectories in Indonesia in the context of this project, refer to section 3.8.2 (Indicator 8) of this report.

Emissions from LUC

Land use changes to oil palm plantations in Sumatra, Kalimantan and Papua, were analysed using Landsat TM images for 1990, 2000, 2005 and 2010. These three islands have consistently made up for more than 90 percent of the surface planted with oil palm in Indonesia over the study period. As a consequence, this analysis considers of 90 percent of the territory of Indonesia and its findings can be considered descriptive of the national level situation. Satellite images were overlaid with the map of Indonesian soil types in order to assign land use changes taking place on peat versus mineral soils and generate the *activity data*[11]. The activity data were then used for the calculation of the net rates of conversion between land-use types caused directly by bioenergy feedstock production.

The two sources of emissions related to LUC considered in this research are:

- Emissions due to the changes in the above ground biomass C stock; and
- Emissions from peat decomposition.

For the assessment of emissions from LUC only CO_2 emissions were included in the analysis. Instead, for all other components of this LCA, other GHG gases such as methane (CH_4) and nitrous oxides (NO_x) were accounted for in addition to CO_2.

In principle, carbon (C) *emissions* from LUC occur when a land with a higher C stock is converted to an area with a lower carbon stock (e.g. from forest to agricultural land), whereas *sequestration* occurs when a land with a lower C stock is converted to an area having a higher C stock (e.g. from grassland to perennial woody plantation). Carbon stock data is the most practical type of information to use in the calculation of GHG emissions from land use change (Hairiah et al. 2011). Various estimates exist on the carbon stock data for several land cover types. For this study the methodology adopted by the National Planning Agency of Indonesia (Santosa, et al. 2014) was chosen (table 3.1.1).

Time average C stock is the average C stock in the plant biomass over the life cycle of the system. The lifecycle of oil palm plantation in Indonesia is about 25 years. Assuming a linear growth of the C stock, the time averaged value of 40 tonnes of carbon per hectare

11 Activity data are defined as data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time (UNFCCC, website).

(Mg ha^{-1} or tonne/ha) reflects the amount of carbon stored as plant biomass that starts at near zero during land preparation and reaches about 80 Mg ha^{-1} at 25 years of age. This time averaged C stock (40 Mg ha^{-1}) takes into account the fluctuation of palm frond and fruit bunch C stock.

Table 3.1.1

Carbon stock values of various land cover classes and the emission factors from land use change to oil palm plantation

Initial land use	Time averaged C stock (Mg C/ha)	Emission factor[12] (Mg CO_2/ha)
Undisturbed Forest	195	569
Disturbed Forest	169	473
Undisturbed Swamp Forest	196	573
Undisturbed Mangrove	170	477
Disturbed Swamp Forest	155	422
Disturbed Mangrove	120	294
Rubber Plantation	63	84
Oil Palm Plantation	40	0
Timber Plantation	64	88
Mixed Tree Crops	30	-37
Shrubs	30	-37
Swamp Shrubs	30	-37
Upland annual crops	10	-110
Settlement	4	-132
Grass	4	-132
Swamp Grass	4	-132
Rice Field	2	-139
Coastal Fish Pond	0	-147
Bare Land	2.5	-138
Mining	0	-147
Water Body	0	-147

Source: edited from Santosa, et al. 2014

For instance, when a disturbed forest on mineral land with a C stock of 169 Mg ha^{-1} is converted to oil palm plantation with a carbon stock of 40 Mg ha^{-1}, the 129 Mg ha^{-1} C loss is considered as the emitted carbon or an equivalent of 473 Mg CO_2 ha^{-1}. Conversely, if an area dominated by shrub vegetation (shrubland) with a carbon stock of 30 Mg ha^{-1} is converted to oil palm plantation, it entails the gain of 10 Mg C ha^{-1} or a sequestration of 37 Mg CO2 ha^{-1}.

12 Emission factor = (C stock – C stock oil palm)*3.67

On this basis, the land use changes occurred between 1990 and 2010 in the three main Indonesian islands where biodiesel feedstock is produced. They were calculated and the real changes in above ground biomass C stock were assessed.

Emission Factors from Peat Decomposition

Human activities that may accelerate GHG emissions from peatland include deforestation and drainage, as well as burning and fertilization. Drainage and burning are the major sources of emission, but generation of the activity data for the latter is cumbersome and highly uncertain (Agus et al. 2013b). As a consequence, this analysis could only consider emissions related to peatland drainage (emissions from peat decomposition).

For this analysis, the IPCC (2013) emission factors were selected as these are supported by wealth of data, especially for emissions from peat decomposition under oil palm plantation.

Table 3.1.2

Emission factors from Peat Decomposition (t CO_2/ha/yr^{-1})

Land use	Emission factors (IPCC, 2013)	
	Land use that remain in the same land use category	Land use that change to oil palm plantation[5])
Undisturbed Swamp Forest	0.0[i]	20.0
Undisturbed Mangrove	0.0[i]	20.0
Disturbed Swamp Forest	19.5	29.7
Disturbed Mangrove	19.5[ii]	29.7
Rubber Plantation	55.1[iii]	47.5
Oil Palm Plantation	40.4	40.2
Timber Plantation	73.4	56.7
Mixed Tree Crops	55.1[iii]	47.5
Swamp Shrubs	19.5	29.7
Upland annual crops	51.4	45.7
Settlement	51.4[iv]	45.7
Swamp Grass	35.2	37.6
Rice Field	34.5	37.2
Coastal Fish Pond	0.0	20.0
Bare Land	51.4	45.7
Mining	51.4[iv]	45.7
Water Body	0.0	20.0

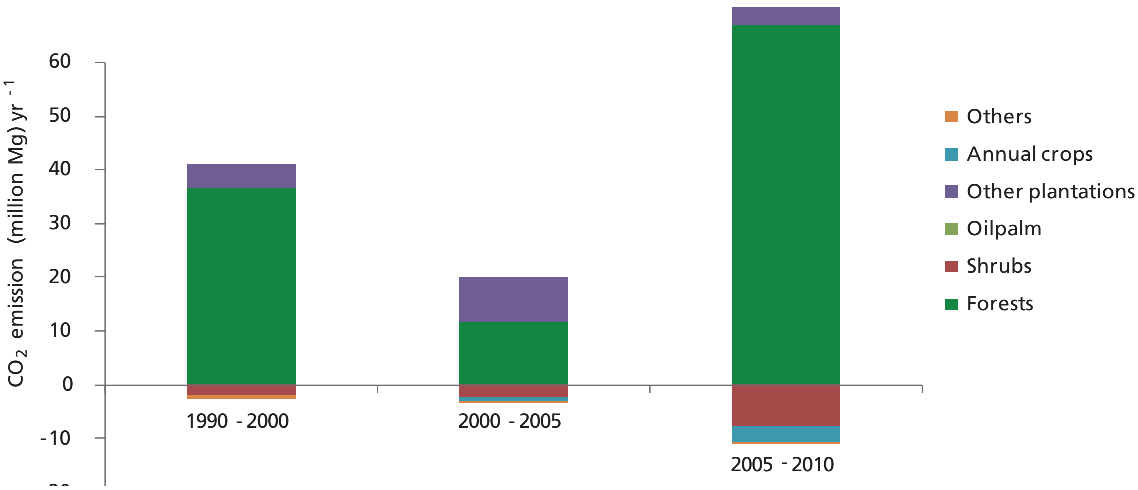
Source: IPCC, 2013.
i) Assumed not affected by drainage and thus zero emission; ii) Assumed the same as disturbed swamp forest;. iii) Assumed the same as long rotation plantations (Table 3); iv) Assumed the same as bareland; v) Average of emission factor of a land use type and that of oil palm plantation.

The detailed rationale for the calculations of land use change to oil palm in Indonesia is discussed in Indicator 8. The methodology, analysis and detailed key findings are reported under section 3.8.2.

The GHG emissions associated with the land use changes recorded between 1990 and 2010 in Indonesia (calculated under indicator 8) and are summarized below.
The conversion of shrublands and annual cropland on mineral soils, particularly between 2005 and 2010, has prompted the sequestration of about 10 million tonnes of CO_2 every year; on the other hand, the conversion of high C stock areas to oil palm plantations has emitted about 60 Mg CO_2 yr^{-1} over the same reference period. The vast majority of these emissions come from the conversion of forests to oil palm plantations in Sumatra and Kalimantan on mineral soils (figure 3.1.1).

Figure 3.1.1

Above ground emissions from LUC to oil palm on mineral land, 1990 - 2010

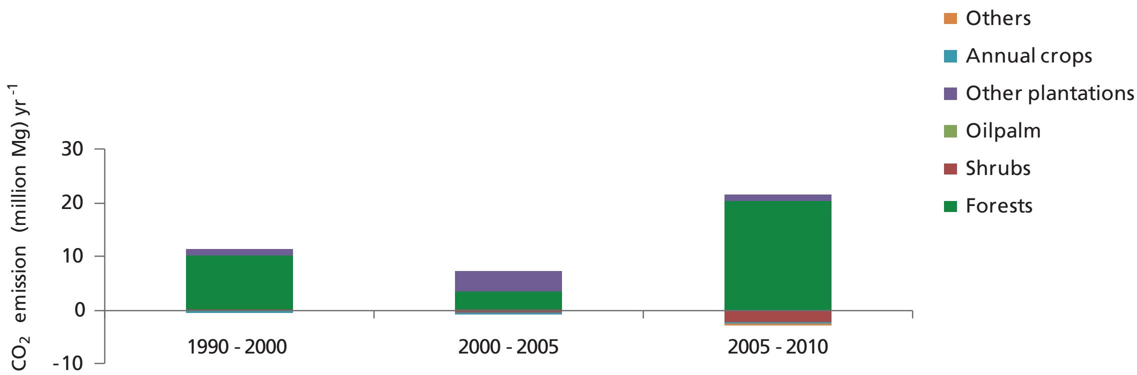


Source: own calculations

Emissions from above ground biomass as a consequence of conversion of land use classes to oil palm on peat soils has mirrored the pattern observed on mineral soils over the same reference periods. As shrubs and annual crops conversion has resulted in sequestration of CO_2, the conversion of forests and perennial plantations (e.g. timber, rubber, etc) has released several million tonnes of carbon dioxide into the atmosphere as shown in figure 3.1.2.
The aggregated CO_2 emissions from 1990 to 2010 (figure 3.1.3) clearly show the dominance of forest as the main source of emissions (about 49 million Mg yr-1) from land use change, while emissions from other plantation conversion was minimal (about 7 million Mg yr-1) despite the comparable converted surface.

Figure 3.1.2

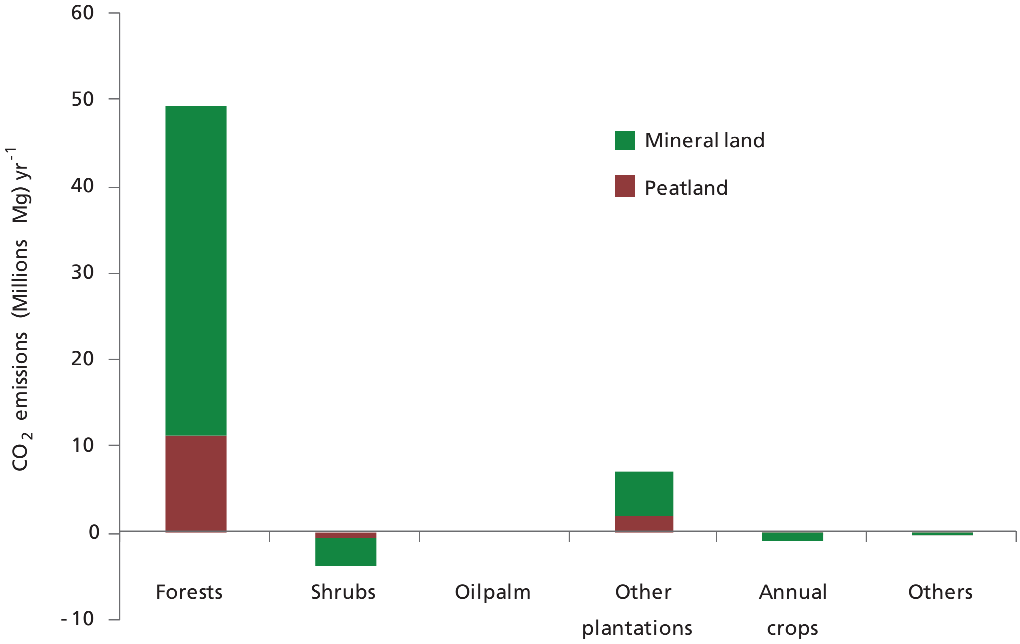
Above Ground emissions from LUC to oil palm on peatland, 1990 - 2010



Source: own calculations

Figure 3.1.3

Above-ground biomass annual emissions due to land use change to oil palm plantations on peatland and mineral soils in Sumatra, Kalimantan and Papua, 1990 - 2010

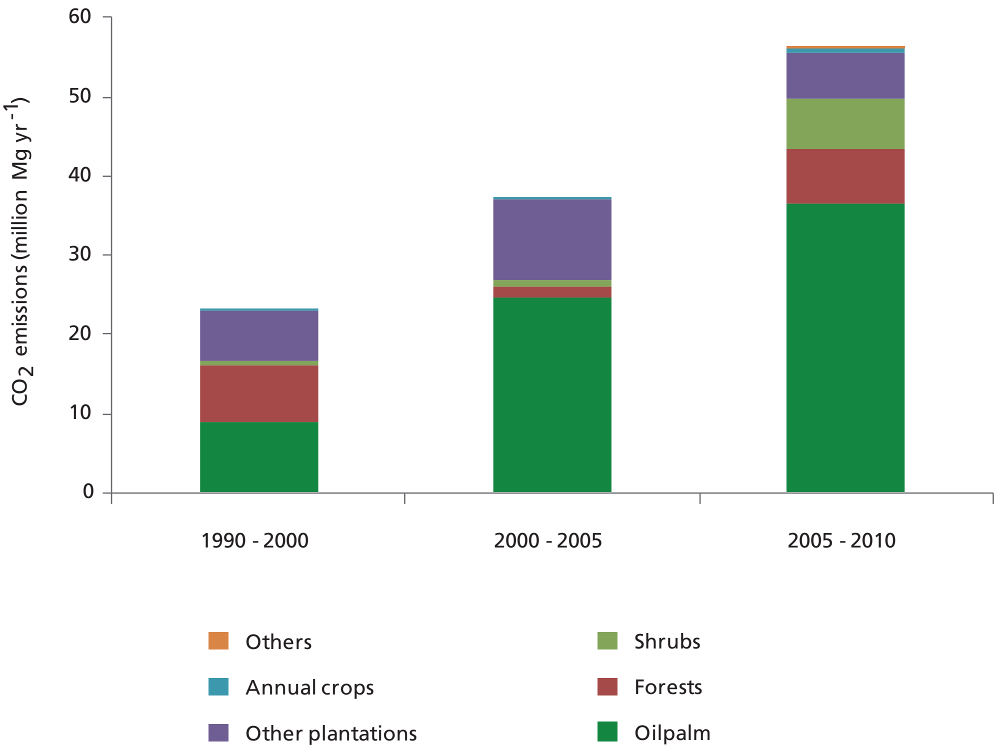


Source: own calculations

Unlike emissions from above ground biomass, emissions from peat decomposition steadily increase as long as area of oil palm plantation on peatland expands. Sumatra was the main source of peat decomposition emission because of relatively large plantation area in this island. Peat emission in Kalimantan was relatively small, but tended to increase very drastically in the 2005-2010 period. Unlike emission from land use change which occurs around the time of land conversion (Agus et al., 2013a and 2013b), peat emissions does not only come from newly developed plantations, but also from existing plantation as peat continually emits CO_2 when drained (Agus et al. 2013b; Berglund & Berglund, 2011; Hooijer, 2014). Figure 3.1.4 shows that emissions from existing oil palm plantations on peat increase constantly as the area of oil palm plantation on peatland increases. For the land in transition to oil palm plantation, emissions fluctuate depending on the area undergoing transition. For example, peat emission from forest in transition to oil palm plantation was relatively low in 2000-2005 relative to those in 1990-2000 and 2005-2010 (Figure 3.1.4) indicating a relatively low forest area on peatland converted to oil palm plantation in 2000-2005 in Indonesia.

Figure 3.1.4

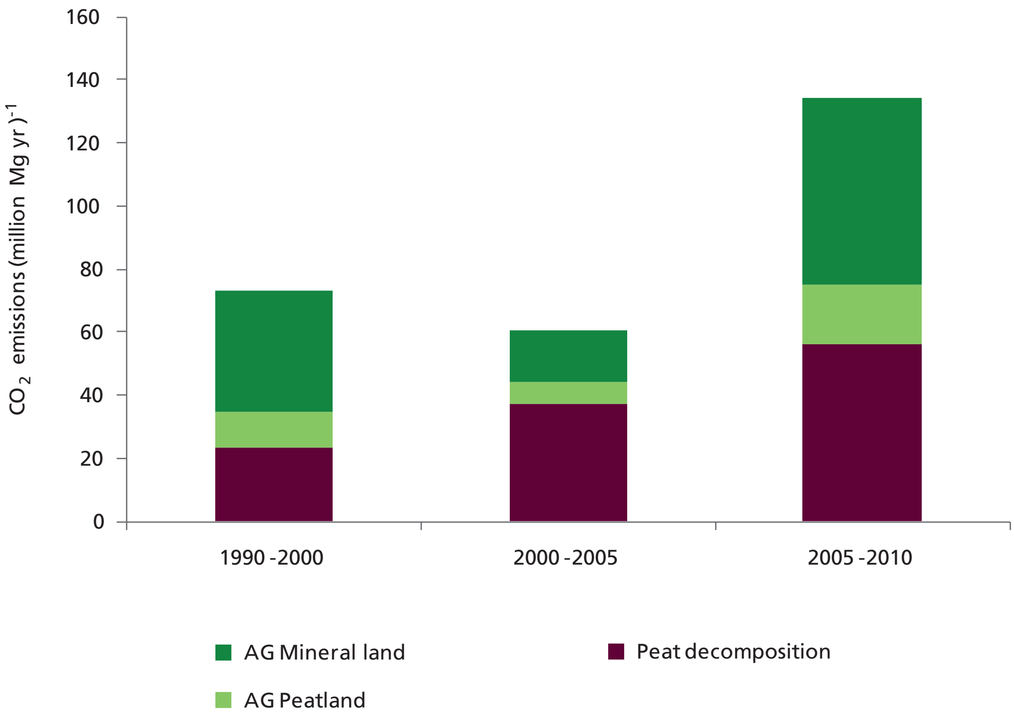
Estimated annual peat decomposition emissions from oil palm plantation by initial land use types, 1990 - 2010



Source: own calculations

Figure 3.1.5

Aboveground and peat decomposition CO_2 emissions resulting from LUC to oil palm plantations in Indonesia (study coverage > 90 percent of territory interested by oil palm cultivation), 1990 – 2010



Source: own calculations

Based on the calculations in Figure 3.1.5, the conversion of land from different land use classes into oil palm plantation in Indonesia has emitted, between 1990 and 2010, some 764.5 million tonnes of CO_2 at a rate of some 38.2 million tonnes per year.

For the land use change component of Indicator 1, the actual cumulative emissions due to LUC to oil palm occurred between 1990 and 2010 should be expressed on a surface basis. In the reference period, on the three islands object of this study (coverage > 90 percent of total oil palm planted surface in Indonesia in 2010), a total of 6.4 million hectares of land has been converted to oil palm for an average weighted emission of 13.73 tonnes of CO_2 per hectare per year. The analysis of site specific conditions (e.g. for an operator's certification procedure) may present a different set of conditions. For instance, if LUC has occurred from a previous land use class having lower C stock than oil palm plantations, the sequestration effect would return a negative value of emissions from LUC. However, due to the need to express average national figures as demanded by the GBEP methodological approach on the one hand and the impossibility to track the exact origin and history of the feedstock used for bioenergy production in Indonesia on the other hand, the value of 13.73 tonnes of CO_2 emitted per ha is considered for the calculation of the LCA GHG emissions.

Table 3.1.3

Average CO_2 emission per ha of land converted to oil palm between 1990 and 2010 including aboveground emissions from both soil types and peat decomposition from peat soils

Source	1990-2010
Peat decomposition (Mg CO_2 ha^{-1} yr^{-1})	37.73
AG Peatland (Mg CO_2 ha^{-1} yr^{-1})	8.26
AG Mineral land (Mg CO_2 ha^{-1} yr^{-1})	7.45
Mean Cumulated (Mg CO_2 ha^{-1} yr^{-1})	**13.73**

Feedstock production

The production of oil palm fresh fruit bunches (FFB), which contain the palm oil, the feedstock most widely used in Indonesia for the making of biodiesel, requires a series of agricultural practices which cause GHG emissions.

Numerous field survey and a literature review on the soil management practices adopted in Indonesian oil palm cultivation (see indicator 2 for further details) have produced average values reported in table 3.1.4, and 3.1.5 for an average large estate and an average smallholder in Indonesia.

All calculations have been performed with the tool BioGrace© version 4.0c[13], an accredited bioenergy-specific GHG calculation instrument, by local GHG experts. The Indonesian GHG experts were supported by international scientists from the BioGrace development team and FAO staff during the project period also through a capacity development programme and training sessions.

Table 3.1.4

Cultivation stage inputs and yield at an average large estate in Indonesia

Average Large Estate		
Yield		
FFB	20,000	kg ha^{-1} $year^{-1}$
Moisture content	34.0%	
Energy consumption		
Diesel	3,349	MJ ha^{-1} $year^{-1}$
Agro chemicals		
Urea	122.6	kg N ha^{-1} $year^{-1}$
CaO-fertiliser (kg CaO)	91.9	kg CaO ha^{-1} $year^{-1}$
Muriate of Potash (MOP) 60% K_2O	133.7	kg K_2O ha^{-1} $year^{-1}$
Rock phosphate 21% P_2O_5 23% SO_3	133.4	kg P_2O_5 ha^{-1} $year^{-1}$
MgO (kg MgO)	53.4	kg MgO ha^{-1} $year^{-1}$
EFB compost (palm oil)	22,000	kg ha^{-1} $year^{-1}$
Pesticides	0.4	kg ha^{-1} $year^{-1}$
Field N_2O emissions	18.86	kg ha^{-1} $year^{-1}$

Source: own calculations based on FAO, 2005 and PUPUK SAWIT, 2013

13 Available at http://www.biograce.net/content/ghgcalculationtools/recognisedtool/

Table 3.1.5

Cultivation stage inputs and yield at an average smallholder in Indonesia

Average Smallholder Farm		
Yield		
FFB	16,000	kg ha^{-1} $year^{-1}$
Moisture content	34.0%	
Energy consumption		
Diesel	3,349	MJ ha^{-1} $year^{-1}$
Agro chemicals		
Urea	61.3	kg N ha^{-1} $year^{-1}$
CaO-fertiliser (kg CaO)	46.0	kg CaO ha^{-1} $year^{-1}$
Muriate of Potash (MOP) 60% K_2O	66.9	kg K_2O ha^{-1} $year^{-1}$
Rock phosphate 21% P_2O_5 23% SO_3	66.7	kg P_2O_5 ha^{-1} $year^{-1}$
MgO (kg MgO)	26.7	kg MgO ha^{-1} $year^{-1}$
EFB compost (palm oil)	0.0	kg ha^{-1} $year^{-1}$
Pesticides	0.4	kg ha^{-1} $year^{-1}$
Field N_2O emissions	1.28	kg ha^{-1} $year^{-1}$

Source: own calculations based on FAO, 2005 and PUPUK SAWIT, 2013

Consequent to feedstock production, the other stages of the biodiesel production value chain that are accounted in this LCA are the transport of the feedstock to the processing facility, the processing of the feedstock (in the palm oil mills) into intermediate products (crude palm oil – CPO), waste management (e.g. POME), processing into fuel (i.e. transesterification) and final distribution. Unlike feedstock production, the operations for the production of biodiesel in Indonesia are often performed by few large palm oil mills and annexed biodiesel plants and therefore the processes and related emissions are similar regardless the origin of the feedstock. Data on the input, efficiencies and related GHG emissions of the stages were collected in the selected biodiesel operator located in Riau, northern Sumatra, in 2012.

Lifecycle Analysis of GHG emissions

The results of the full LCA GHG emission calculation is presented for the three identified feedstock producers and each was tested for a total of four scenarios:

- **Scenario 1**, or *best case scenario*, did not include emissions from Land Use Change, assuming that no land conversion has taken place or that emissions are not attributable to biodiesel; in addition, under scenario 1, emissions originated from the treatment of the palm oil mill effluents (POME) are captured by adequate methane capture systems and it is assumed that only 15 percent of the methane escapes.
- **Scenario 2**, did not include LUC but it assumed that the mill is not equipped with methane capture systems and that all methane gas produced by the anaerobic fermentation of POME is emitted to the atmosphere. As mentioned above, this

is often the case since less than 5 percent of the palm oil mills in Indonesia are equipped with methane capture systems.

- **Scenario 3**, included the average value of LUC as calculated in Table 3.1.3 (average national figure 13.73 tonnes of CO_2 ha^{-1} $year^{-1}$). This scenario, however, considered that the mill is equipped with methane capture systems.
- **Scenario 4**, or *worst case scenario*, implied the occurrence of LUC (as Scenario 3) in addition to the lack of adequate methane capture systems in the palm oil mills.

The results of GHG emission calculations are expressed as grams of CO_2 equivalent per MJ of fuel and are presented in table 3.1.6. The comparison of the results with the emission of the reference fuel (83.8 g CO_2eq/MJ) is presented in figure 3.1.6.

Table 3.1.6

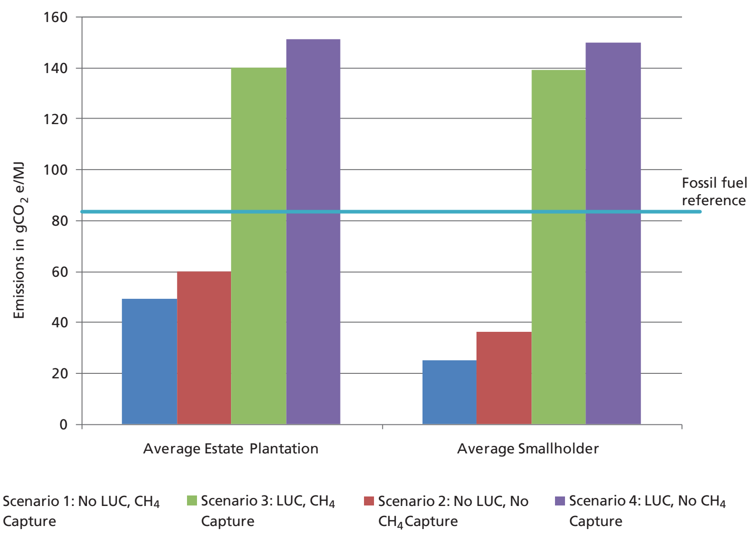
GHG emission calculations for the case of an average large estate and the case of an average smallholder for each of the four applicable scenarios

	Scenario 1: No LUC, CH_4 Capture	Scenario 2: No LUC, No CH_4 Capture	Scenario 3: LUC, CH_4 Capture	Scenario 4: LUC, No CH_4 Capture
Average Large Estate	49.1	60.1	140.4	151.4
Average Smallholder	25.1	36.2	139.2	150.2

The post-harvesting related emissions are considered on the basis of the survey in the selected biodiesel plant in north Sumatra and are assumed standard in Indonesia. Values expressed in grams of CO2 equivalent per MJ of biodiesel (g CO2eq/MJ).
Source: own calculations

Figure 3.1.6

Comparison of the results of the LCA GHG emission calculations with the emission of the reference fuel (83.8 g CO_2eq/MJ)



3.1.3 Main conclusions and recommendations

Results of indicator measurement

The lifecycle GHG emission calculation of the Indonesian palm oil-based biodiesel has revealed several aspects of interest. During this project an in-depth study of actual emissions caused by land use change trajectories to oil palm, has offered the opportunity to calculate the average amount of carbon dioxide emitted by one hectare of land converted to oil palm cultivation between 1990 and 2010 in Indonesia. In the same period, oil palm planted surface in Indonesia has experienced unprecedented growth passing from about 1.3 million ha in 1990 to over 8.5 million ha in 2010 and reaching 9.5 million ha in 2012 (Ministry of Agriculture, 2013). Such an expansion has procured emissions from the conversion of high C stock areas (e.g. forests, timber plantations, etc) to oil palm plantations (above ground emission of carbon dioxide). In addition, about 1.25 million ha of peatland have been drained and converted to oil palm cultivation until 2010 which results in high GHG emissions from the decomposition of the peat. On the basis of the aforementioned findings, the average weighted emission per ha of land converted in Indonesia between 1990 and 2010 was calculated to be 13.73 Mg CO_2 ha^{-1} yr^{-1}. Site specific analysis are likely to return a different value of emissions from LUC (e.g. much higher if conversion interested a swamp forest on peat soils, much lower – or even negative – if shrubland on mineral soils have been converted to oil palm plantations) however, for the assessment of the GBEP Indicator 1, a representative estimate of the average emission from LUC was made. The results of the LCA, confirmed that, when occurring, LUC is clearly the single most important contributor to total GHG emissions in the Indonesian palm oil industry, as confirmed by the extensive literature on the matter (Agus & Sarwani, 2013; Sarwani et al. 2013). This analysis has clearly shown the dominance of forest conversion as the main source of emissions (about 49 million Mg of CO_2 yr^{-1}) from land use change, while emissions from other plantation conversion was minimal (about 7 million Mg of CO_2 yr^{-1}) despite the comparable converted surface. Given the large incidence of land use change phenomena in the historic development of palm oil plantations between 1990 and 2010 in Indonesia, it is clear that emissions from LUC are borne by the vast majority of the plantations currently in production.

Another important contributor to GHG emissions is the methane released by the anaerobic fermentation of the palm oil mill effluents (POME) in the ponds annexed to palm oil mills. This analysis has discovered that only about 5 percent of the over 600 Indonesian palm oil mills were equipped with methane capture systems as of 2012. The methane generated by the POME is responsible for the emission of about 20 g CO_2eq per MJ of biodiesel produced given the average set of conditions of the Indonesian biodiesel sector.

In light of the above, it is recommended to prioritize development strategies for the palm oil biodiesel sector which aim at increasing yields of existing palm oil plantations and deprioritize further land expansion. In the cases where expansion takes place, it is highly recommended to prioritize the choice of low carbon stock areas (e.g. shrubland and grasslands) on mineral soils and avoid high carbon stock areas (namely all types of forest and woody plantations) and conversion of peatland in order to reduce the LUC related GHG emissions. The relevance of these recommendations is also confirmed by a number of studies (Bala et al., 2007; Carlson et al. 2012; DeFries et al. 2007).

In addition, the implementation of methane capture systems for the POME, capable of abating emissions by a considerable share, is suggested to be supported by adequate programmes and incentives. During this project it was not possible to compile a complete list including all the facilities equipped with methane capture systems (to date only 9 mills have been listed) and it is recommended that a mapping of the aforementioned operators is conducted in order to gain further insights on the attribution of emissions from POME to biodiesel production.

Future monitoring of indicator 1 in Indonesia

Based on the results of this indicator, it is suggested to monitor the development of the palm oil sector with particular regard to the yields (production intensification) and land conversion (production extensification). With regard to the monitoring of the performances of the palm oil-based biodiesel sector in Indonesia, the methodology, the specific tool used for the measurement of indicator 1, and the training delivered on the use of the calculation tool were offered as the best compromise between complexity and accuracy in order to minimize difficulties for the future monitoring of GHG emissions from bioenergy. Through the training of scientists from the academia, government officials from the Ministry of Energy and the Ministry of Agriculture (and several technical agencies), FAO together with international GHG calculation experts has offered to the country the basic knowledge necessary for the consistent monitoring of this indicator in the future. It is however recommended that, given the complexity of the topic, the community of practice instituted during the project continues to use the methodology and tools tested for the purpose of practicing and developing even further their capacity to assess GHG emissions from bioenergy.

Relevance, practicality and scientific basis of indicator 1

The testing of Indicator 1 in Indonesia has confirmed the relevance of this instrument to inform policymakers on the performances of the national bioenergy sector as one reason for pursuing increased use of bioenergy worldwide is its potential to reduce GHG emissions compared to the fossil fuels it would replace. This testing has confirmed that the Life Cycle Assessment (LCA) is an important tool for estimating GHG emissions and comparing the GHG emissions from different energy sources at the national level. The assessment through the use of the GBEP Common Methodological Framework has also offered the chance to discover and describe the main feedstock production typologies and to gain in-depth information on the efficiency of each production stage. This indicator is data intensive and availability of adequate data for all components of this indicator might be an issue in some developing countries. In addition, the important contribution of private sector operators has been an asset to understand the details of fundamental stages of the biodiesel production value chain and without this contribution the measurement would have been difficult. For the Land Use Change component of this indicator, the strong interrelations with Indicator 8 were exploited. Landsat images were retrieved and analysed with the support of senior experts from the Indonesian Soil Research Institute in order to assess the area of land converted to bioenergy feedstock production between 1990 and 2010. Without this precious contribution, the understanding of the dynamics of land use changes that interested oil palm cultivation in Indonesia could never be achieved. However, there exists the risk that countries may not dispose of adequate material, human, financial and/or institutional resources to carry out such a cutting-edge type of research.

With regard to the practicality of this indicator, the need to define an average national figure for GHG emissions related to the production of bioenergy, in the specific case of Indonesia palm oil biodiesel, is a methodological challenge. In fact, site-specific or operator-specific calculations which are at the basis of the procedures for certifications under various schemes, offer well defined boundaries and do not leave much room for discussion of the results. The intrinsic diversity and variability of the biodiesel production pathways found in Indonesia require the formulation of assumptions and the production of scenarios to be used as proxies to define GHG emissions attributable to bioenergy. In order to be fair and efficient, this process requires a few fundamental conditions being: i) that a large and well sorted working group of national experts is involved from the early stages of the project to discuss the implications of the assumptions made, accept them and validate the results; ii) that the capacity of the local experts is assessed and enhanced through the organization of workshops and trainings in order to harmonize the knowledge surrounding the calculation of lifecycle GHG emissions from bioenergy; and iii) that the institutions in the country favor the collection of often sensitive information first, and consequently support the discussions on the outcomes of the analysis among different stakeholders. If the aforementioned conditions are verified, the results can be accepted and discussed constructively in order to learn lessons and set the basis for future monitoring.

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3.2 INDICATOR 2: SOIL QUALITY

Description:
Percentage of land for which soil quality, in particular in terms of soil organic carbon, is maintained or improved out of total land on which bioenergy feedstock is cultivated or harvested.

Measurement unit(s):
Percentage

3.2.1 Testing of indicator 2 in Indonesia

In general, for the case of Indonesia there is an adequate amount of information on the impacts of land degradation and a good assessment base of the proximate and root causes. Indonesia has in fact been the site of many years of intensive soil science research. However, there is much less information on the impact on the ground of these actions. For this study FAO has partnered with experts from the Indonesian Soil Research Institute and the Bogor Agricultural University in order to review and distill information present in literature. In addition, field surveys in oil palm plantations in Sumatra and Kalimantan performed between June and October 2012 have returned important data used for the assessment of this indicator.

3.2.2 Key findings

Concerns over erosion and declining productivity in Indonesia have long been expressed since the 1860's, but in the past century erosion has worsened, with farmers blaming the severe erosion on the rapidly growing population and increasingly intensive cultivation. High input farming (particularly the use of fertilizers) and good soil and water management techniques have sustained productivity, however the consequences of such soil management may raise sustainability concerns in the long run, especially in areas of Java and Sumatra.

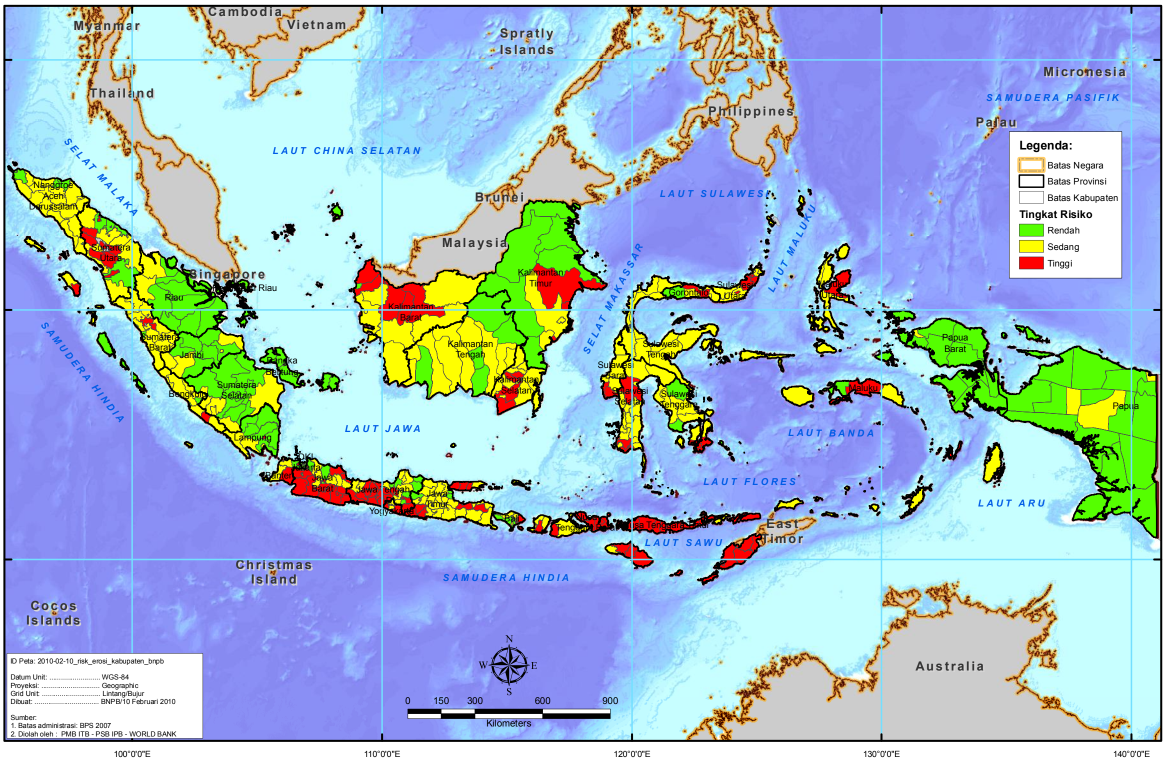
Soil erosion

According to Firmansyah (2007), forms of land degradation in Indonesia include soil erosion, and the loss of soil organic matter and nutrient leaching. Out of Indonesia's total land area of 186 million hectares (Agus et al, 2014), 12.1 percent (22.6 million ha) are affected by erosion phenomena (Firmansyah, 2007). In Fig. 3.2.1, the areas in red are provinces with a high risk of erosion, yellow provinces show a moderate erosion risk and green areas show low or no erosion risk.

Erosion occurs most frequently and severely in areas characterized by steep slopes and mountainous geography. The eastern side of Sumatra, where large areas in the vast swamp plains are planted with oil palm, shows no intense risk of erosion as these areas do not have steep slopes. On the other hand, Java and Kalimantan show moderate to highest risk of erosion in their provinces. Particularly in East Kalimantan, where a relevant quantity of palm oil is produced, the erosion risk is high. The high erosion risk in this area is exacerbated by the use of heavy machinery for agricultural operations and transport of goods through trucks and lorries over unpaved roads (see indicator 23 for further details). For this project, field surveys were performed in plantations in East Kalimantan and North Sumatra to retrieve primary data on soil quality in areas where oil palm is cultivated.

Figure 3.2.1

Erosion risk in Indonesia. In red are the provinces showing high erosion risk, moderate risk in yellow, low risk in green



Source: Geospasial BNPB, 2010

The plantations visited in north Sumatra have surfaces ranging between 1,000 and 5,000 ha, as well as varying soil types, both mineral and peat soils. The planting of oil palm trees took place in different times over the last thirty years: in 1982, 1985, 1987, 1994, 2000 and in 2010 depending upon the location within the estate. In these plantations, actions to prevent erosion were consciously adopted. The presence of cover crops such as reeds, ferns and mosses, and contour ridging with hedgerows of elephant grass (*Pennisetum purpureum*), vetiver (*Vetiveria zizanioides*) or lemon grass (*Cymbopogon citratus*) were documented. In the plantations studied, empty fruit bunches (EFB) and shells are partly used as fuel, while the rest is returned to the land as organic fertilizer. Additionally, palm oil mill effluents (POME) are channeled to the cascading pools located near the mill. The

POME stored in the last pond then flows to the plantation through trench lines enriching the soil with nutrients.

Figure 3.2.2

EFB returned to the field and composting. The presence of a dense herbaceous understory layer in the inter-rows of this oil palm plantation is appreciable from this image

In the plantations studied, several land management practices are employed. Vetiver grass is planted on riverbanks as bank protection against vessel-induced loads (Fig. 3.2.5) (Jaspers-Focks and Algera, 2001). According to a study performed by Hermawan (1996), vetiver hedges in plantations in Indonesia are capable of reducing soil loss from 120 t/ha/year (control) to 13.21 t/ha/year and 0.56 t/ha/year for second and third year of cultivation respectively.

In inter-rows between oil palms, Legume Cover Crops (LCC) are employed as land conservation methods for their double action on runoff impact reduction and nitrogen fixation capacity. The surveys found LCCs in the plantations to be composed of *Mucuna bracteata, Pueraria javanica, Calopogonium mucunoides* and *Flemingia congesta*.

Figure 3.2.3

Legume Cover Crop found in open areas of oil palm plantations in north Sumatra

These legumes are planted throughout the estate, especially in open areas undergoing land preparation for replanting. In areas of the plantation where palm trees are 8 years or older

LCC are no longer found because of the wide, dense canopy produced by the palm trees. At this point only ferns and shade tolerant small grasses compose the understory of oil palm plantations (Fig. 3.2.4).

Figure 3.2.4

Understory dominated by ferns found in dense canopy areas of oil palm plantations in north Sumatra

Figure 3.2.5

Vetiver grass is planted on a riverbank in order to offer protection against vessel-induced loads and reduce erosion in an oil palm plantation in north Sumatra

A Study from Agus et al (2012), on the potential of Legumes Cover Crops as soil amelioration in Indonesian plantations, reports that *Flemingia congesta* hedgerows are capable of fixing 12 to 57 kg of nitrogen per hectare each year from the atmosphere to the soil. In order to establish a baseline value related to soil quality on peat soils, soil depth and subsidence were measured in the plantations through a survey (Fig. 3.2.6).

The depth of these soils varies between 1.5 and 4.5 meters, depending upon the location and on average is 2.66 meters (table 3.2.1).

Table 3.2.1

Peat soil depth and type

Sampling point	Planting year	Peat depth (meters)	Peat Type
A	1992 (replanted in 2010)	4.0	Saprist
B	1994	1.5	Saprist
C	1994	2.0	Saprist
D	2000	4.5	Saprist
E	2000	2.5	Saprist
F	2000	1.5	Saprist

Source: Field Survey

Figure 3.2.6

Measurement of peat soil's depth in an oil palm plantation in north Sumatra

Mineral soils' depth and other physical properties were surveyed in two oil palm plantations in east Kalimantan and presented in Table 3.2.2. The effective soil depth, the depth that is penetrated by plant roots, is comprised between 60 and 100 cm in the survey locations. Soil drainage and infiltration velocity measured in the survey locations show a degree of variability.

Table 3.2.2

Mineral soils' characteristics in locations of the survey

Soil Classification USDA (2006)	Effective Depth of Soil	Layer (cm)	Texture	Texture Class	Consistency	Drainage Condition
Typic Dystrudept	100 cm	0 – 30	Sandy clay	Rather coarse	Loose	Rather quick
		30 - 60	Sandy clay loam	Rather fine	Loose	
Typic Endoaquept	100 cm	0 - 30	Sandy clay	Rather coarse	Loose	Slow
		30 – 60	Sandy clay loam	Rather fine	Loose	Slow
Typic Hapludult	100 cm	0 – 30	Clay	Rather fine	Friable	Good Enough - Rather Poor
		30 - 60	Clay loam	Rather fine	Rather friable	
Typic Hapludult	60 cm	0 – 30	Sandy clay	Rather fine	Friable	Good Enough - Rather Poor
		30 - 60	Sandy clay loam	Rather fine	Rather friable	

Source: Field Survey

Soil Organic Carbon

Soil organic matter is comprised of all the soil components which are derived from plants and animals. The chemical composition of the soil organic matter varies but one main component is carbon, which accounts for about 58 percent of the total organic matter in the soil. Soil organic matter is a key soil component and plays a critical role in a range of physical, chemical and biological soils processes (FAO, 2005a).

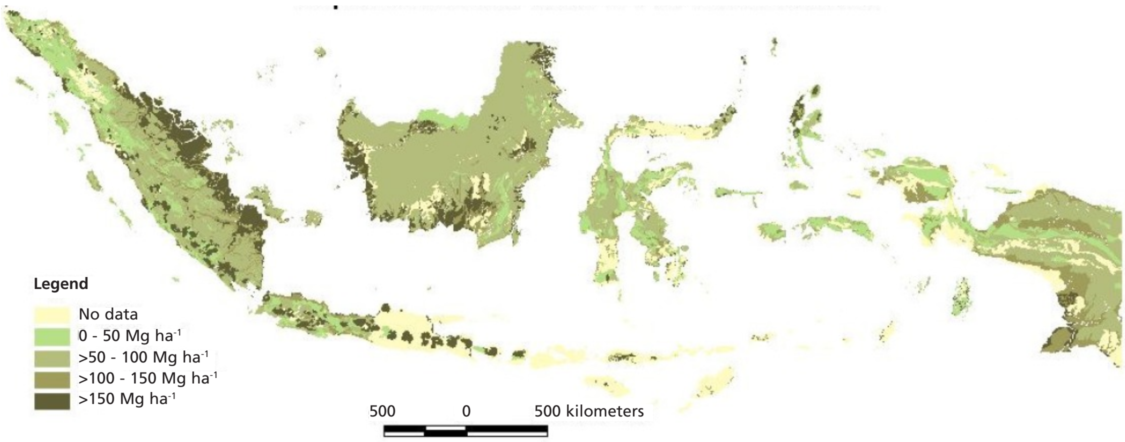
Soil Organic Carbon (SOC) concentration is a useful indicator of soil condition and the quantity of soil organic carbon is emerging as a key factor in greenhouse gas mitigation.

The recommended measures of soil organic carbon are baseline values (expressed as a percentage and as density) and change in SOC over time.

The Indonesian Center for Agricultural Land Resources Research and Development (ICALRRD), of the Indonesian Ministry of Agriculture, is the agency that since 1980s has began working on mapping carbon content in the soils of Indonesia. In 2010, ICALRRD produced maps of predicted soil carbon stocks with a coverage of 84 percent of the surface of the country (Shofiyati et al, 2010). Based on the availability of data, the researchers at ICALRRD estimated carbon stocks of both mineral and peat soils in Indonesia. The analyses comprised several data sources of soil organic carbon and soil bulk density from secondary data and field surveys in different locations in Indonesia. The research determined that carbon stocks for 81.5 percent of the mineral soils in Indonesia (data missing for the remaining 18.5 percent of the territory interested by mineral soils) is around 17.6 Gt. Carbon stocks present in peat soils were calculated estimating a carbon content of 50 kg carbon/m^3 of peat soil. As a result, it was calculated that the first 30 cm layer of the 21 million ha of Indonesian peat land are capable of stocking some 3.15 Gt of carbon (Shofiyati et al, 2010).

Figure 3.2.7

Map of Soil Carbon Stock in Indonesia. In yellow the areas for which no data is available



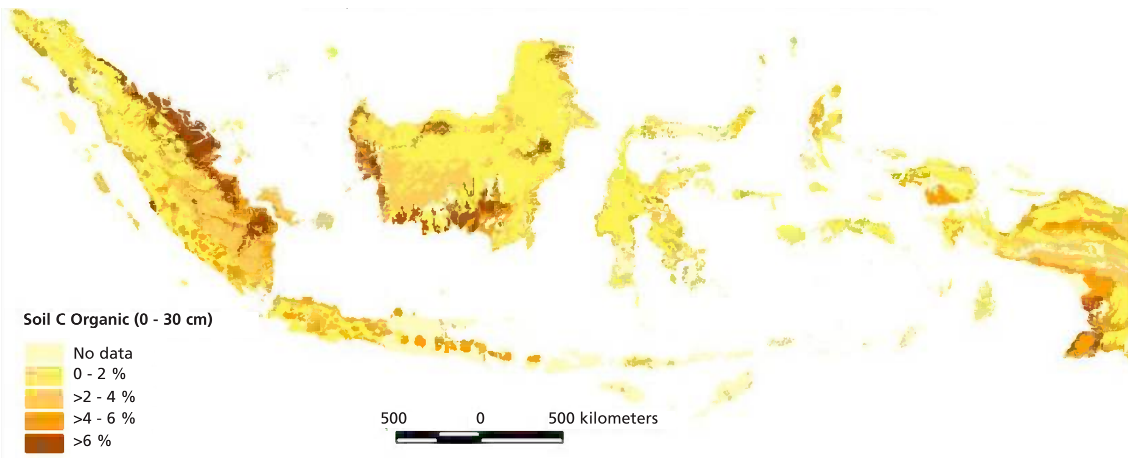
Source: Shofiyati et al, 2010

According to Shofiyati et al (2010), SOC constitutes 1.43 to 5.24 percent of mineral soils (average 3.35 percent) and 25.10 - 60.18 percent of peat soils (average 42.08 percent) in Indonesia.

The measurement of SOC in 26 survey stations in two oil palm estates in Riau Province performed by FAO during this project have returned values ranging between 1.6 and 7.34 percent (average 2.26 percent) on mineral soils.

Figure 3.2.8

Map of Soil Organic Carbon in the first 30 cm of soil in Indonesia



Source: Shofiyati et al, 2010

The values from the field surveys are in line with values found in literature for SOC and Soil Carbon Stocks in Indonesia (Shofiyati et al, 2010). However, due to the great variability of the aforementioned parameters and the complexity of soil types found in Indonesia, further studies with a broader coverage are recommended.

Nutrients management

In Indonesia, oil palm cultivation relies on fertilizer as a mean to shorten the delay in production of newly transplanted trees and increase productivity of mature plants. According to FAO (2005b; 2005c), oil palm cultivation requires four main macronutrients (N, P_2O_5, K_2O, MgO) and several micronutrients, among which boron (B), copper (Cu) and zinc (Zn). Nutrient recommendation rates for mature and immature plantations in Indonesia are reported in table 3.2.3.

Table 3.2.3

Oil palm nutrients recommended rates for Indonesia

Nutrient	Age	Kg/ha/year	Kg/plant/year (c.a. 135 plants/ha)
Nitrogen (N)	mature immature	120 45	0.88 0.33
Phosphorus (P_2O_5)	mature immature	50 55	0.37 0.40
Potassium (K_2O)	mature immature	345 130	2.55 0.96
Magnesium ($MgSO_4$)	mature immature	145 175	1.07 1.29
Sodium borate	mature immature	5 5	0.03 0.03

Source: adapted from FAO, 2005b and c

Although the literature offers a vast repository of information on nutrient management in oil palm cultivation, real fertilizer rates in Indonesia vary greatly depending upon the age of the plants and the management type. As shown in table 3.2.3, nitrogen and potassium requirements for mature trees are more than double those of young plants, but often estate plantations use twice the amount of nutrients compared to smallholders at every comparable growth stage. Typically, in Indonesian oil palm plantations, planting density is roughly 135 trees per hectare and fertilizers are administrated directly in the proximity of the tree. In commercial estate plantations, compound fertilizers are preferred over single nutrient administration whereas smallholders more often rely on separated nutrients administrated singularly. These are urea for the supply of N, rock phosphate for the supply of P and potassium chloride (MOP) for the supply of K (FAO, 2005c).

Through field surveys and interviews performed during this project, it was found that in estate plantations in North Sumatra and East Kalimantan a common complex mix fertilizer is applied. The composition of the compound fertilizer diffused in estate plantations in Indonesia is reported in table 3.2.4. Commonly, estate plantations apply the fertilizer at a rate of 4 kg/tree/year for immature plants and 8 kg/tree/year for mature plants. Smallholders supply 2 kg/tree/year of nutrients for young plants and up to 4 kg/tree/year for mature plants in their fields. Due to the high nutrients demand (particularly for potassium), in the oil palm plantations studied nutrients are administrated through several applications (4 to 8 depending upon the age of the tree) in order to reduce leaching effects more likely with single administrations of fertilizer. Smallholders reported to perform two nutrient applications per year. In addition to chemical fertilizers, palm oil mills apply palm oil mill effluents (POME) and empty fruit bunches (EFB[14]) to their plantations as organic amendments and fertilizers. In plantations adjoined to palm oil mills, EFB are applied at a rate of 20-25 tonnes per hectare. Several authors have reported the that returning EFB to the oil palm fields increase FFB production up to 35 percent (Loong et al, 1987; Gurmit et al, 1989; Chan et al, 1980). To this end, it should be noted that in most cases EFB are applied only to the plantations located nearby palm oil mills and often owned by the mills. As of 2012, EFB are not returned to smallholders' fields. According to the Ministry of Agriculture (2013) an independent smallholder in Indonesia produces on average 16 t/ha of FFB as compared to estate plantations which average a production of 20 tonnes of FFB per ha.

Table 3.2.4

Composition of commonly employed compound fertilizer in Indonesian oil palm plantations

Fertilizer Component	%
Nitrogen (N) (%)	11.35
Phosphate (P_20_5) (%)	12.35
Potassium (K_2O) (%)	12.83
Magnesium (MgO) (%)	4.94
Sulfur (S) = ($MgSO_4$) (%)	5.10
Calcium (Ca Mg) (%)	8.51
Water (%)	1.85

Source: adapted from PUPUK SAWIT, 2013

For the extent of this project, soil tests aimed at quantifying the concentration of nutrients in the soils used for the cultivation of oil palm were performed.

Soil Organic Carbon content in mineral soils in Indonesia shows great variability due to the complex soil mix of the country. However, the analysis of secondary data and

14 EFB is oil palm firous wastes resulting from the palm-oil extraction and milling processes especially from Thereser Process.

information collected through the field surveys performed show comparable values in the range of 1.43 – 7.34 percent for SOC, depending upon the soil type. These values should constitute the baseline for future monitoring of SOC in bioenergy related operations in Indonesia in order to measure changes in SOC.

Soil analysis did not investigate nutrient accumulation dynamics of interest in soil quality analysis, however, in the section of this paper dedicated to water quality, correlations between nutrient's application and nutrient leaching in the form of pollutant loadings into the water bodies were made.

3.2.3 Main conclusions and recommendations

Results of indicator measurement

This project studied the state of Indonesian soils at national level, and collected primary data on soil quality and soil management practices in oil palm plantations at local level as a proxy to describe soil quality in farmland where bioenergy feedstock is produced. Information found in literature highlighted the importance of erosion risk as one of the main soil quality parameters to keep into account. For the case of biodiesel feedstock, the areas where palm oil is cultivated are mostly in Sumatra and Kalimantan. Several provinces in Kalimantan have moderate to high risk of erosion and it was confirmed by interviews and direct observation that heavy machineries and agricultural practices directly related to oil palm cultivation and processing contribute to exacerbating this phenomena. Furthermore, a study of the most effective soil quality conservation practices found in Indonesia was carried out. The results show that, as of 2012, the inclusion of best soil quality conservation practices, including legume crop cover, riverbank protection and vetiver grasses, is a diffused and accepted practice in estate plantations. Doubts about the diffusion of these good practices among smallholders still remain. In terms of SOC, this indicator assessed baseline values in existing oil palm plantations and it has verified the results of the primary data collection campaign with the available literature (Shofiyati et al, 2010). SOC in oil palm plantations in east Kalimantan and north Sumatra range from 1.43 and 7.34 percent of the soil mass (0 – 30 cm layer), on mineral soils. Soil quality assessment on peat soils included peat depth measurements which shown that oil palm plantations grown on peat soils having average depth of 2.66 metres. Indonesia, to date, does not have a nationwide assessment of *changes* in SOC content in the soils and only baseline values were assessed.

As the main interaction between farmers and soil in oil palm cultivation is through the use of fertilizers, a detailed review of the nutrient management regimes found in Indonesia was also performed. From this study it emerged that estate plantations use twice the amount of inorganic fertilizers than smallholders; the latter, in addition, do not return important quantities of nutrients through organic fertilizers, namely EFB, because these are used in plantations near palm oil mills.

Future monitoring of indicator 2 in Indonesia

Estate plantations are characterized by higher nutrient input and higher FFB productivity if compared to smallholder's plantations. The variability of production output with regard to smallholders may be due to several factors, including soil quality and nutrient management. As emerged from field surveys, smallholders usually apply single nutrients to their plants at a rate that is almost half that of estate plantations. In many cases, mills buy FFB from small holders, then apply POME and EFB to the company's plantation (in accordance to Ministry of Environment's regulation 28 and 29 of 2001), but preventing, in the mean time, smallholders from returning organic amendments and nutrients to their fields. Application of palm oil mill and plantation residues to the fields improves soil quality and productivity and it is recommended to explore possible ways to return some of the POME and FFB to the smallholder's plantations. To this end, future monitoring of this indicator may inform about possible changes in soil quality linked to the increased application of EFB to the fields of smallholders.

More importantly, as of 2012, in Indonesia, a map of SOC *changes* does not exist. In order to assess this important soil quality indicator an ad-hoc national programme should be implemented. The programme would require to measure SOC content in different soils throughout Indonesia and map the sampling sites georeferencing the exact sampling locations. Since SOC changes are appreciable after a minimum of 5 years (Chappell et al, 2013), this interval should be chosen in order to perform the consequential sampling on the same sites.

Relevance, practicality and scientific basis of indicator 2

The indicator has proven relevant to Indonesian context and the extensive literature review performed during its assessment has confirmed the scientific basis and the value of assessing soil quality parameters in order to inform about the sustainability of bioenergy feedstock production. With regard to the practicality of the tool, the scarcity of information on *changes* of soil quality parameters, particularly in terms of soil organic carbon, has limited the descriptive capacity of this study. SOC changes databases are not common in many countries and this may require to perform primary data campaigns in order to assess the percentage of land used for bioenergy feedstock production for which soil quality is maintained or improved. These analyses, however, are complex and time and resource intensive as they involve a large number of samples to be mapped with extreme accuracy over a large surface in order to be representative and, lastly, measurements need to be repeated after at least 5 years in the same locations and using the same methodology. These requirements limit the practicality of the indicator and its methodology in a context like the one tested.

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3.3 INDICATOR 3: HARVEST LEVELS OF WOOD RESOURCES

Description:

Annual harvest of wood resources by volume and as a percentage of net growth or sustained yield, and the percentage of the annual harvest used for bioenergy

Measurement unit(s):

m^3/ha/year, tonnes/ha/year, m^3/year or tonnes/year

percentage

3.3.1 Testing of indicator 3 in Indonesia

For the testing of indicator 3 in Indonesia, data on forest cover and forest productivity over the period 2000–2012 were compiled and analysed, together with data on annual harvest of wood resources and on the share of it used for bioenergy.

However, part of the indicator was estimated on the basis of a survey and national figures, as data on net annual growth and sustained yield, disaggregated by province, was not available when the testing was carried out. As of 2014 a National Forest Inventory was under development in Indonesia and detailed information that account for the variability in mean annual increment (MAI) and other forest parameters could not be retrieved. Once completed, the Inventory should provide disaggregated information related to the net annual growth / sustained yield, enabling the completion of the measurement of indicator 3.

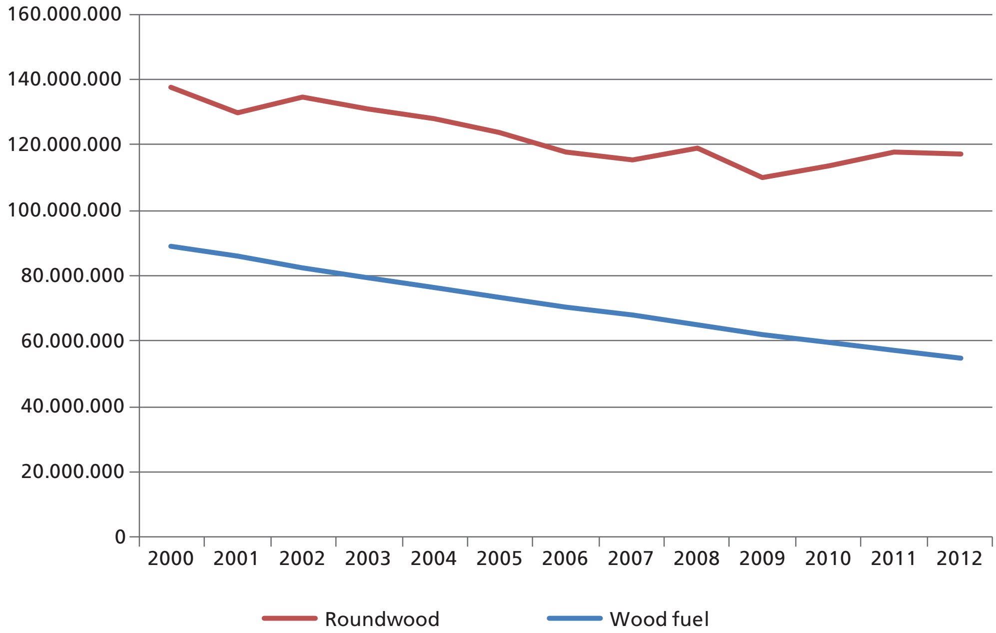
3.3.2 Key findings

According to FAOSTAT (2014), woodfuel production in Indonesia has declined steadily since the 1960s (Fig. 3.3.1). In 1961 the country had an estimated production of 236 million m^3 of woodfuel mainly employed for cooking purposes, in 1970 production declined to some 200 million m^3. Such a trend continued through the following decades and in 2000 about 88 million m^3 of woodfuel were produced in Indonesia. In 2012, Indonesia produced some 55 million m^3 of woodfuel (FAOSTAT, 2014). This decrease likely occurred as consequence of economic, social and cultural changes that have taken place in the country over the last 50 years. The decreasing trend of woodfuel production in Indonesia followed the diminishing roundwood[15] output of Indonesian forests. In 2000 Indonesia produced some 138 million cubic meters of roundwood, then in 2012 this value decreased to 117.5 million cubic meters (FAOSTAT, 2014).

15 According to FAO Forestry Definition (2014) available at http://www.fao.org/forestry/statistics/80572/en/, the term *roundwood* includes: All roundwood felled or otherwise harvested and removed. It comprises all wood obtained from removals, i.e. the quantities removed from forests and from trees outside the forest, including wood recovered from natural, felling and logging losses during the period, calendar year or forest year. It includes all wood removed with or without bark, including wood removed in its round form, or split, roughly squared or in other form (e.g. branches, roots, stumps and burls (where these are harvested) and wood that is roughly shaped or pointed. It is an aggregate comprising wood fuel, including wood for charcoal and industrial roundwood (wood in the rough). It is reported in cubic metres solid volume underbark (i.e. excluding bark).

Figure 3.3.1

Annual harvest of all wood resources (roundwood) and the amount used for bioenergy (woodfuel) 2000-2012 in m³/year.

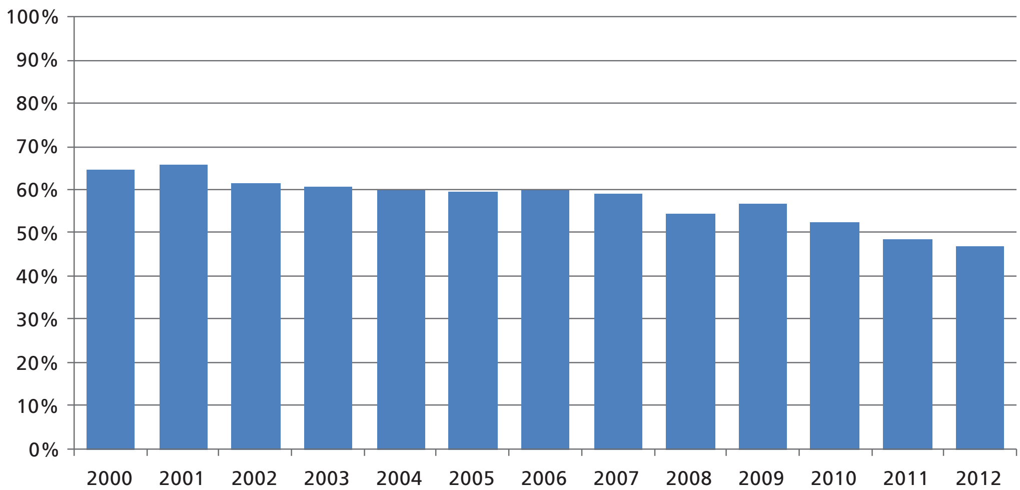


Source: FAOSTAT, 2014

In 2012, about 46 percent of the annual harvest of wood resources in Indonesia was used for bioenergy. Over the period 2000 – 2012, on average, between 45 and 65 percent of total annual harvest of wood resources have been used as woodfuel in the Southeast Asian country, as shown in figure 3.3.2.

Figure 3.3.2

Percentage of the annual harvest used for bioenergy in Indonesia 2000-2012



Source: FAOSTAT, 2014

On the populated island of Java, only about one-third of the woodfuel comes from local forests, and in West-Java as much as 93 percent of total fuelwood comes from non-forest areas, mainly from mixed home-gardens (FAO- RWEDP, 1999). On other islands in Indonesia, most of the woodfuel is produced in secondary forests, planted forests, or agroforestry systems.

According to FAO (2009), over the period of 1977-2000, the average commercial log production from natural production under certification systems was about 22.14 m^3/ha, with a mean annual increment (MAI) of 1.13 m^3/ha/year for Indonesian forests. Other authors, (e.g. Sumitro, 1991), have reported a MAI of intensively managed dipterocarp forests in Indonesia of 2 m^3/ha/year.

As of 2012, Indonesia had not completed its update on the National Forestry Inventory, therefore only general annual increment figures could be found to measure this indicator. For the extent of this project, a survey was carried out to assess the amount of woodfuel consumed per household in rural Indonesia (and consequently levels of extraction per ha). Interviews with residents in the area of Merbau, Rantau Prapat, north Sumatra, revealed average fuelwood use per household to be approximatively 1 m^3/month in the area. In the survey locations in north Sumatra, the rate of woodfuel harvesting was estimated to be 0.509 m^3/ha/year whereas, on average, forest productivity has been comprised between 1.13 m^3/ha/year and 2 m^3/ha/year (FAO, 2009; Sumitro, 1991). This range, expressed on the basis of the share of sustained yield harvested for energy purposes in north Sumatra, was estimated between 25 and 45 percent of the net growth.

3.3.3 Main conclusions and recommendations

Results of indicator measurement

As of 2012, forest cover in Indonesia was about 97 million hectares, comprising 52 percent of total national land surface. From 1990 to 2012 forest surface in Indonesia decreased by about 21.5 percent. The main driver of this expansion, however, has been the need for the expansion of agricultural land, including but not limited to demand prompted by the oil palm sector, which encompasses, at least from 2008, that of feedstock for modern bioenergy (see indicator 8). In fact, the analysis of indicator 3 has shown that the use of woodfuel in Indonesia has steadily declined over time: from some 200 million m^3 in 1970 production declined to some 55 m^3 in 2012. In 2012, about 46 percent of the annual harvest of wood resources in Indonesia was used for energy purposes.

The second part of the indicator was estimated on the basis of a survey and national figures, as data on net annual growth and sustained yield, disaggregated by province, was not available when the testing was carried out. As of 2014, a National Forest Inventory was still under development in Indonesia, thus detailed information that account for the variability in mean annual increment (MAI), as well as other forest parameters, could not be retrieved. Once completed, the Inventory should provide disaggregated information related to the net annual growth / sustained yield, enabling the completion of the measurement of indicator 3.

In survey locations in north Sumatra, the rate of woodfuel harvesting was estimated to be 0.509 m^3/ha/year whereas average forest productivity varied between 1.13 m^3/ha/year and 2 m^3/ha/year (FAO, 2009; Sumitro, 1991). This range, expressed on the basis of the share of sustained yield harvested for energy purposes in north Sumatra, was estimated between 25 and 45 percent of the net growth.

Future monitoring of indicator 3 in Indonesia

The data seems to reveal that a very significant proportion of harvested wood is still used for energy purposes, despite a strong decrease in woodfuel consumption in recent years. Therefore, monitoring of this indicator in the future would be important in Indonesia, along with Indicator 22, in order to assess whether statistics on the use of woodfuel match the shares of energy coming from traditional use of biomass.

The forthcoming National Forest Inventory might include detailed information on the net annual growth or sustained yield, likely disaggregated by forest type, province and management system, which is likely to enable a higher completion degree of the measurement of this indicator.

Relevance, practicality and scientific basis of indicator 3

Based on the experience with the testing of indicator 3 in Indonesia, a few recommendations can be made regarding possible future improvements to the indicator methodology.

1. For the lack of information about net growth or sustained yield, a possible alternative would be to undertake surveys and a literature review regarding the state of a country's managed forests to determine if over-harvesting is considered to have occurred and, if so, where. This information could then be overlaid with the information on sources of wood for modern energy purposes.
2. In order to understand the way in which woodfuel use affects the sustainability of wood harvesting, it would be useful to gather information on the end use and, in particular, the use efficiency (which has a critical impact on the amount of wood needed to be harvested and therefore on the sustainability of wood harvesting for energy purposes). Such information could be gathered through surveys of those involved in this sector and supplemented with expert estimates; and
3. Data should indicate the impact of bioenergy production on the traditional uses of biomass and the indicator could be improved by developing and including a methodology to derive this information.

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3.4 INDICATOR 4: EMISSIONS OF NON-GHG AIR POLLUTANTS, INCLUDING AIR TOXICS

Description:

Emissions of non-GHG air pollutants, including air toxics, from

(4.1) bioenergy feedstock production,

(4.2) processing,

(4.3) transport of feedstocks, intermediate products and end products, and

(4.4) use; and in comparison with other energy sources

Measurement unit(s):

Emissions of $PM_{2.5}$, PM_{10}, NO_X, SO_2 and other pollutants can be measured and reported in the following ways as is most relevant to the feedstock, mode of processing, transportation and use.

4.1 mg/ha, mg/MJ, and as a percentage

4.2 mg/m^3 or ppm

4.3 mg/MJ

4.4 mg/MJ

3.4.1 Testing of indicator 4 in Indonesia

For the testing of indicator 4 in Indonesia, the national regulation concerning non-GHG air pollutants was reviewed and an analysis of the literature on emissions from bioenergy sources was conducted. In addition, direct interviews and surveys in the operation sites of a selected biodiesel company (located in Dumai, Riau Provice, Sumatra, Indonesia), have provided useful data and information for the assessment of the indicator.

For the purpose of this project, CO, NO_x, SO_2, and PM_{10} were measured for the following stages of the biodiesel supply chain: feedstock production, feedstock processing into fuel, transport of feedstock, intermediate and final products, and fuel use. Emissions of Volatile Organic Compounds (VOC) (e.g. 1,3-butadiene, acetaldehyde, acrolein benzene) and other non-GHG pollutants were not addressed due to lack of sufficient data. The selected biodiesel operator surveyed, which produced more than 14 percent of total national biodiesel output in 2012, has offered relevant information for this case study on non-GHG emissions from their operation sites.

Further relevant data were obtained from interviews, yearly reports for vehicles running accounts and Environmental Management and Monitoring studies.

Starting from information found in literature, calculations were performed to derive emission values for all stages of biodiesel production and use. The non-GHG emissions from these phases were then summed and presented as a well-to-tank value. Unfortunately, non-GHG pollutant values related to all stages of the production of fossil diesel (e.g. extraction, refining, etc) in Indonesia were not found and could not be used for comparison with B100.

Comparisons between the non-GHG emissions associated with the use (tank-to-wheel) of several different blends of biodiesel (B10, B20, B30 and B50) and fossil diesel in a number of vehicle classes were found and used to highlight the performances of different biofuel blends in a variety of scenarios in Indonesia.

3.4.2 Key findings

Emissions from feedstock production

In Indonesia, the production of oil palm fresh fruit bunches (FFB) is not intensively mechanized. Labour and animal traction are employed for most agricultural operations from planting to harvesting, particularly in smallholder farming systems, who represent roughly 35 percent of total feedstock output and 45 percent of total planted area. (Ministry of Agriculture, 2013). However, certain agricultural operations, such as those in estate plantations, are carried out mechanically. Agricultural inputs, moreover, commonly travel from production sites to the fields over large distances by truck. Data concerning non-GHG emissions for transport of material to the fields (e.g. fertilizers, pesticides, etc), based on the operations of the selected biodiesel operator, are presented in table 3.4.1.

Table 3.4.1

Non-GHG emissions from feedstock production, palm oil biodiesel

No.	Category	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$
		mg/MJ Biodiesel				
1	Agricultural operations on farm[16]	4.10029	0.08493	0.00234	0.07029	n.a.
2	Fertilizer transport	0.35138	0.74042	0.03430	0.05856	n.a.
	Total	4.45167	0.82535	0.03664	0.12885	n.a.

Source: direct survey at the operation site of a selected biodiesel producer (Dumai, Riau Provice, Sumatra, Indonesia), 2012

Carbon monoxide (CO) emissions from feedstock production were 4.45167 mg per MJ of biodiesel produced in the facility, NO_x was emitted at a rate of 0.82535 mg/MJ, SO_2 emission was 0.03664 mg/MJ, and emission of PM_{10} was 0.12885 mg/MJ. Data concerning emission of $PM_{2.5}$ could not be retrieved as the legislation in force[17] in Indonesia does not regulate this pollutant; therefore data was not collected by the producers.

16 Includes emissions from operations such as weeding, pruning, fertilizing, daily maintenance, harvesting, etc.
17 The analysis was carried out in 2012.

Mechanized agricultural farm operations, such as weeding, pruning, fertilizing, daily maintenance, harvesting, etc, are the main contributors to the emission of carbon monoxide and PM_{10} (4.10029 mg/MJ and 0.07029 mg/MJ respectively) in the feedstock production stage, whereas the transport of inputs is the major responsible for NO_x emissions (0.74042 mg/MJ) and SO_2 emissions (0.03430 mg/MJ).

Emissions from feedstock processing

The Government of Indonesia (GOI) introduced emission standards for stationary sources through regulation No.7/2007[18] for boiler emissions and through regulation No.13/1995[19] for electricity generator emissions. The Indonesian emission standards consider NO_x, SO_2, PM_{10} but do not require the measurement of $PM_{2.5}$. Information concerning carbon monoxide emissions in Indonesia are available for both light and heavy duty vehicles and were included in this analysis. Information on CO emissions from stationary sources could not be retrieved.

Table 3.4.2

Non-GHG emissions from feedstock processing, palm oil biodiesel. Stationary sources*

Factory	Equipment	CO	NO_x	SO_2	$PM_{2.5}$	PM_{10}
		mg/m³				
Gov. Regulation Standard	Boiler[i]	n.a.[iii]	800.000	600.000	n.a.	300.000
	electricity generation[ii]	n.a.	1000.000	800.000	n.a.	350.000
Palm oil mill	Boiler	n.a.	0.190	5.010	n.a.	65.230
	electricity generation	n.a.	15.940	0.000	n.a.	48.320
Refinery Factory	Boiler 1	n.a.	0.130	2.510	n.a.	61.250
	Boiler 2	n.a.	0.097	2.137	n.a.	65.943
	Boiler 3	n.a.	0.040	2.020	n.a.	73.510
	Boiler 4	n.a.	0.120	1.880	n.a.	63.070
	HP Boiler	n.a.	0.050	1.160	n.a.	48.560
Biodiesel Factory	Boiler 1	n.a.	0.050	1.160	n.a.	48.560
	Boiler 2	n.a.	0.050	1.160	n.a.	48.560
	Generator 1	n.a.	1.510	0.000	n.a.	1.510
	Generator 2	n.a.	1.510	0.000	n.a.	1.510

Source: direct survey at the operation site of a selected biodiesel producer (Dumai, Riau Provice, Sumatra, Indonesia), 2012
Notes:
**) Environmental Management and Monitoring Study, 1st semester 2012*
i) Measured under KepMenLH No.7/2007
ii) Measured under KepMenLH No.13/1995
iii) n.a = not available

18 KepMenLH No.7/2007
19 KepMenLH No.13/1995

In table 3.4.2 and table 3.4.3, emissions from each processing stage in the survey site operation facilities are reported.

Table 3.4.3

Non-GHG emissions from feedstock processing of FFBs into biodiesel from stationary sources and operational vehicles

No.	Factory	Category	CO	NO_x	SO_2	$PM_{2.5}$	PM_{10}
			mg/MJ Biodiesel				
1	CPO Mill	Stationary combustion	n.a	0.00478	0.06327	n.a.	0.83093
		Operational vehicles	0.46125	2.35735	0.09259	n.a.	0.08942
2	Refinery	Stationary combustion	n.a	0.00003	0.00075	n.a.	0.02630
		Operational vehicle	0.00528	0.01113	0.00052	n.a.	0.00088
3	Biodiesel station	Stationary combustion	n.a	0.00005	0.00087	n.a.	0.03652
		Operational vehicle	0.03733	0.09031	0.00005	n.a.	0.00723
	Total		**0.50386**	**2.46365**	**0.15805**	**n.a.**	**0.99128**

Source: direct survey at the operation site of a selected biodiesel producer (Dumai, Riau Provice, Sumatra, Indonesia), 2012

The total estimated emissions from the biodiesel plant processing were 0.50386 mg/MJ, 2.46365 mg/MJ, 0.15805 mg/MJ and 0.99128 mg/MJ for CO, NO_x, SO_2, and PM_{10} respectively. The highest share of non-GHG air pollutants (mainly NO_x and PM_{10}) emission is from the processing phase, and is attributable to vehicle operations in the CPO mills (e.g. tractors and trucks used to load and unload the FFBs in the mill).

Emissions from transport of feedstock, intermediate and end products

The single component of the biodiesel production chain responsible for the highest share of non-GHG air pollutant emissions is the transport of feedstock, intermediate and end products. In Indonesia feedstock and other product transport stages are commonly carried out using diesel fuelled trucks and lorries. Moreover, the operational efficiency of these vehicles is affected by the high average age and often poor maintenance status of the fleet (GFEI, 2010), particularly in rural areas of the country where the feedstock is produced. The fleet's conditions and the relatively low incidence of alternative transport systems in

Indonesia result in significant emissions from the transport stages of the biodiesel chain, particularly in terms of NO_x (GFEI, 2010). Emissions for the transportation of feedstock, and its intermediate and end products vary depending on the distance travelled, as vehicles navigate between the estate plantations and the CPO mills, CPO mills and the refinery, the refinery to the biodiesel blending plant and from the biodiesel plant to the final consumers. Average estimates based on the conditions found in the selected biodiesel operator case study are presented in table 3.4.4.

Table 3.4.4

Non-GHG emissions from feedstock, intermediate and end products transport, palm oil biodiesel

No.	Category	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$
		mg/MJ Biodiesel				
1	Feedstocks Transports	2.83660	5.97713	0.27691	0.47277	n.a.[ii]
2	Intermediate Products Transports					
	a. CPO Mill to Refinery	0.19681	0.41470	0.01921	0.03280	n.a.
	b. Refinery to Biodiesel Factory[i]	-	-	-	-	n.a.
3	End Products Transport	0.00243	5.134322	0.23786	0.40611	n.a.
	Total	**3.03584**	**11.526152**	**0.53398**	**0.91168**	**n.a.**

Source: direct survey at the operation site of a selected biodiesel producer (Dumai, Riau Provice, Sumatra, Indonesia), 2012
Notes:
i) Via multipurpose pipeline
ii) n.a = not available

Table 3.4.5 reports the results of a literature review on the experimental analysis of pollutant emissions from different vehicle classes and biodiesel blends in Indonesia. Interestingly, for every vehicle category and biodiesel blend tested in Indonesia, different authors recorded lower emissions of all non-GHG air pollutants when compared with fossil diesel (Wirawan et al., 2005; BPPT-KFA, 1992). Particularly significant is the reduced emission of hydrocarbons (HC), sulphur dioxide (SO_2) and particulate matter (PM_{10}) of the biodiesel blends when compared to regular diesel.

Table 3.4.5

Emission differences from diesel fuel compared to different biodiesel blends

Vehicle Type	Fuel Type	Emission %				
		CO	NO_x	HC	SO_2	PM_{10}
Passenger cars	Diesel	0.00	0.00	0.00	0.00	0.00
	B10	-5.14	-5.14	-12.40	-10.00	-38.64
	B20	-9.82	-2.31	-50.41	-20.00	-46.02
	B30	-18.95	-7.46	-58.68	-30.00	-48.86
	B50	-24.66	-17.58	-95.43	-50.91	-92.01
Heavy-duty vehicles	Diesel	0.00	0.00	0.00	0.00	0.00
	B10	-5.15	-5.13	-12.07	-10.00	-38.64
	B20	-9.84	-2.31	-50.34	-20.00	-45.83
	B30	-18.97	-7.46	-58.62	-30.00	-48.86
	B50	-24.59	-11.74	-66.90	-50.00	-60.23
Buses	Diesel	0.00	0.00	0.00	0.00	0.00
	B10	-5.03	-5.14	-12.07	-2.25	-38.69
	B20	-9.84	-2.30	-50.34	-20.00	-45.99
	B30	-18.99	-7.45	-58.62	-30.00	-48.91
	B50	-24.71	-11.73	-66.90	-50.00	-60.22
Light-duty vehicles	Diesel	0.00	0.00	0.00	0.00	0.00
	B10	-5.19	-5.18	-12.04	-10.00	-38.72
	B20	-9.83	-2.33	-50.54	-20.00	-45.96
	B30	-19.01	-7.44	-58.71	-30.00	-48.94
	B50	-24.64	-11.74	-66.88	-50.00	-60.43

Source : Wirawan et al.(2005); BPPT-KFA (1992)

Table 3.4.6, presents the summary of non-GHG pollutant emissions from biodiesel production, transport and use (well-to-wheel).

Table 3.4.6

Emission of non-GHG air pollutants from palm oil biodiesel by stage of the value chain

No.	Place	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$
		mg/MJ Biodiesel				
1	Feedstocks Production	4.45167	0.82535	0.03664	0.12885	n.a.
2	Processing	0.50386	2.46365	0.15805	0.99128	n.a.
3	Transportation	3.03584	11.526152	0.53398	0.91168	n.a.
4	Use	24.59760	540.92043	0.00000	0.00000	n.a.
	TOTAL	32.58897	555.73558	0.72867	2.03181	

Source: own calculations

In this study, average values and aggregated groups of technologies were sampled from different sources and used to produce a baseline estimate. It is likely that studies of specific scenarios (e.g. specific boiler technology, adjusted age of the transport fleet, specific biodiesel blend used, stationary or dynamic engine load during the tests, etc) produce different results independently from the methodology employed.

3.4.3 Main conclusions and recommendations

Results of indicator measurement

The low level of mechanization in the production cycle of FFBs, the primary biodiesel feedstock in Indonesia as of 2012, results in relatively low emission of non-GHG pollutants and air toxics attributable to the agricultural phase of the value chain. With the exception of SO_2 and PM_{10}, the usage stage of the bioenergy chain is, by far, the main responsible for the emission of non-GHG pollutants. In the case of NO_x, 98 percent (540.9 mg/MJ) of total emissions (555.7 mg/MJ) comes from the combustion of the end product (table. 3.4.6). The dedicated literature reports consistently lower emissions from biodiesel blends use when compared to fossil diesel use for all air pollutants tested in Indonesia. This factor should be taken into consideration particularly in discussions surrounding policies aimed at abating levels of air pollutants in cities in Indonesia. Interventions meant to enhance air quality in large urban areas should be informed of the opportunities offered by alternative fuels as these yield reduced emission rates of pollutants when compared to traditional transport fuels.

Future monitoring of indicator 4 in Indonesia

The indicator is of high relevance to Indonesia, given that i) the Capital city of the nation, Jakarta, experiences alarming levels of air pollutants (WMO, 2012; The Jakarta Post, 2013) and that ii) the use of biodiesel blends (B10 and B50) has the potential to significantly reduce non-GHG air pollutant exhaust emissions compared with diesel and hence represent a means of improving urban air quality.

In Jakarta as well as in other megacities in Indonesia, the transportation sector is the main contributor of emissions of air pollutants. The number of two-stroke motorcycles in Jakarta is reduced every year but high levels of pollutants are still observed. The difficulties may be due to high growth rate of vehicle population in Jakarta, which was almost 100 percent from 1995 to 2000. The government has also promoted the Trans-Jakarta busway, unleaded gasoline, and other alternative fuels (including biofuels) with the aim to improving air quality. New sources such as open biomass burning in areas surrounding the city have not been addressed adequately. Therefore, more comprehensive air pollution research needs to be carried out in order to provide relevant information for decision makers (WMO, 2012).

As the transportation sector is recognized to be the major non-GHG emission source in Indonesia, recommendations for the reduction of non-GHG air pollutant emissions, particularly in densely populated areas, should be addressed toward this component of the Indonesian economy. The uptake of more comprehensive and stringent emission standards (e.g. Euro 5, and higher) and the development of incentives for the renewal of the transportation fleet (particularly in the case of light motorcycles and heavy duty vehicles) are recommended.

As of 2012, $PM_{2.5}$ was not monitored in Indonesia. According to the World Health Organization, $PM_{2.5}$ is an even stronger risk factor than the coarse fraction of PM_{10} (particles in the 2.5–10 μm range) and long-term exposure to $PM_{2.5}$ is associated with an increase in long-term risk of cardiopulmonary mortality by 6–13 percent per 10 μg/m^3 of $PM_{2.5}$ (WHO, 2013). Therefore, it is recommended that Indonesia take measures to include this non-GHG air pollutant in the list of air toxics to be monitored for emissions from both stationary sources and operational vehicles. It is advisable that the whole industrial and transport sectors (including but not limited to the bioenergy component of the sectors), also regulate $PM_{2.5}$, as these have been described as the main contributors to air pollution in Indonesia according to the World Meteorological Organization of the UN (WMO, 2012).

Lastly, dust is not recommended to be included in the category of the particulate air pollution and regulated under air pollution statutes. Currently, dust (fraction of particulate matter greater than 10 μm) is not monitored; however, due to the condition of many roads in Indonesia this air pollutant may be accountable for impacts on human health.

Relevance, practicality and scientific basis of indicator 4

Indicator 4 was found to be very relevant for Indonesia, given the environmental and health challenges posed by the emission of air toxics in densely populated areas such as Jakarta, caused mainly by the transportation sector, and the potential reduction in the emission of non-GHG pollutants in urban areas associated with the use of biodiesel blends (table 3.4.5).

During the course of this project, FAO discovered possible parts of the GBEP report on the indicators (FAO, 2011) where room for improvement exists. The measurement units suggested for the processing phase (indicator component 4.2) are mg/m^3 or ppm, whereas if the options read mg/MJ (if emissions per unit energy are measured) or ppm/MJ (if changes in ambient concentrations per unit energy are measured) the concept of attribution to the processing of the bioenergy form produced would be more clearly identified.

Moreover, in the methodological approach it is suggested that, where feasible, a full lifecycle analysis should be conducted. This approach does not appear to be preferable, in light of the fact that the impacts of non-GHG air pollutants are mainly local and that large differences in terms of emissions and exposure to air toxics exist throughout the biodiesel value chain (e.g. feedstock production vs transport of feedstock and end products, etc).

Comparing tailpipe emissions is straightforward, given that these emissions, whether from biofuel blends or fossil fuels, occur in the same place. However, it is less straightforward to compare non-GHG air pollutant emissions produced in a field with emissions produced in an oil refinery.

The most reasonable methodological approach seems to be to ask which ultimate outcome we are most interested in and determine how the different fuels impact upon this outcome. The outcome of interest would seem to be human health, and hence a more scientifically robust methodology might seek to attribute changes in human health in the component of the value chain and in the areas where the major contribution to air pollution is made. In Indonesia, this appears to be i) the transport of the feedstock and intermediate and end product and ii) the fuel use in the case of biodiesel. In fact, the emission of pollutants in the other stages of the biodiesel value chain is thought to have a lesser impact on human health (e.g. low emissions from the feedstock production stage) when compared to emissions of air pollutants from the use of the fuel.

Finally, it is also recommended to include CO in the list of non-GHG air pollutants explicitly mentioned in the section of the GBEP report (FAO, 2011) on this indicator that suggests measurement units for the indicator, and indeed consistently throughout where priority pollutants are indicated.

Furthermore, during the compilation of this indicator, some issues relating to the adaptation of the GBEP methodological approach to the Indonesian context and to data availability arose. The following recommendations are suggested in order to improve the practicality of indicator 4:

- Identify the stages having the highest relevance in terms of emissions of non-GHG air pollutants and focus measurements and analyses on these. In the case of palm oil biodiesel in Indonesia, stages 4.3 (transport of the feedstock and end products) and fuel use (4.4) were the main contributors to non-GHG air pollutant emissions (particularly in terms of NO_x and PM_{10}). Other sources of non-GHG air pollutants from biodiesel production may have lower relevance and the measurement of these contributors may be impractical.
- In order to reduce the impracticality of measuring very low emissions of non-GHG air pollutants, mass balance analyses may be used to estimate these parameters.
- In order to include all sources of emission of non-GHG air pollutants, it is recommended to collect data for at least two complete well-to-wheel cycles.

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3.5 INDICATOR 5: WATER USE AND EFFICIENCY

Description:
(5.1) Water withdrawn from nationally determined watershed(s) for the production and processing of bioenergy feedstocks, expressed
(5.1a) as the percentage of total actual renewable water resources (TARWR) and
(5.1b) as the percentage of total annual water withdrawals (TAWW), disaggregated into renewable and non-renewable water sources;
(5.2) Volume of water withdrawn from nationally determined watershed(s) used for the production and processing of bioenergy feedstocks per unit of bioenergy output, disaggregated into renewable and non-renewable water sources

Measurement unit(s):
(5.1a) percentage
(5.1b) percentage
(5.2) m^3/MJ or m^3/kWh; m^3/ha or m^3/tonne for feedstock production phase if considered separately

3.5.1 Testing of indicator 5 in Indonesia

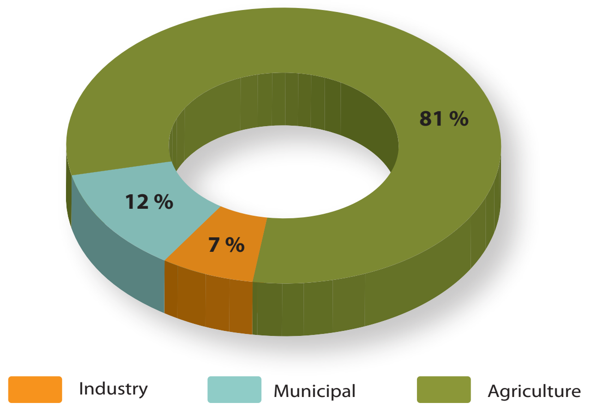
The testing of indicator 5 in Indonesia began with the study of the current situation related to water supply, demand and uses, and with the characterization of water basins in the country. Subsequently, the analysis of water requirements and actual water withdrawn by oil palm plantations, has offered information on the share of total annual renewable water resource withdrawn by bioenergy feedstock cultivation. Lastly, the results of a primary data collection on water use efficiencies in a major biodiesel production plant in north Sumatra (Riau Province) has offered information on the share of total annual water withdrawals for bioenergy production.
Water resources were estimated using FAO AQUASTAT, whereas for overall information concerning water availability and water demand, national experts from the Indonesian Oil Palm Research Center were consulted.

3.5.2 Key findings

According to FAO AQUASTAT (2010) TARWR is 2,019 km^3/year. Surface water resources are an estimated 1,972.6 km^3/year and groundwater resources 457.4 km^3/year. Most of the groundwater, which is an estimated 90 percent or 411.7 km^3/year, returns as baseflow to the rivers (FAO AQUASTAT, 2010). Total annual water withdrawals in 2012 was 0.06 percent of the TARWR. Figure 3.5.1 shows the share of water use by sector in Indonesia, with agriculture accounting for 81 percent of total annual water withdrawals, followed by the municipal sector with 12 percent. In addition to water for feedstock production, the bioenergy sector also requires water for the processing of the biomass: this amount is part of industrial water use, which accounts for 7 percent of total annual water withdrawals (FAO AQUASTAT, 2010).

Figure 3.5.1

Water withdrawal by sector in Indonesia



Source: FAO AQUASTAT, 2010

Issues of water resource management, both quantitative and qualitative, are increasingly important on Java and on other islands, including Kalimantan, Sumatra, Sulawesi, Papua, but all with differing problems, and hence different approaches to be undertaken. Problems in Java are characterized by overpopulation, as well as water and other natural resources degradation and depletion. The other islands are mainly characterized by water and other natural resources degradation due to land use change and improper open mining practices (FAO AQUASTAT, 2010).

Overexploitation of groundwater has resulted in some critical problems, including contamination by pollutants entering groundwater, salinization of aquifers and land subsidence. Land subsidence is mainly the result of a strong decrease in the levels of deep groundwater in areas with high groundwater extraction. Over-extraction of groundwater results in external costs including those related to the lowering of the shallow groundwater table, and costs related to land subsidence and pollution of shallow groundwater (FAO AQUASTAT, 2010).

Biodiesel production

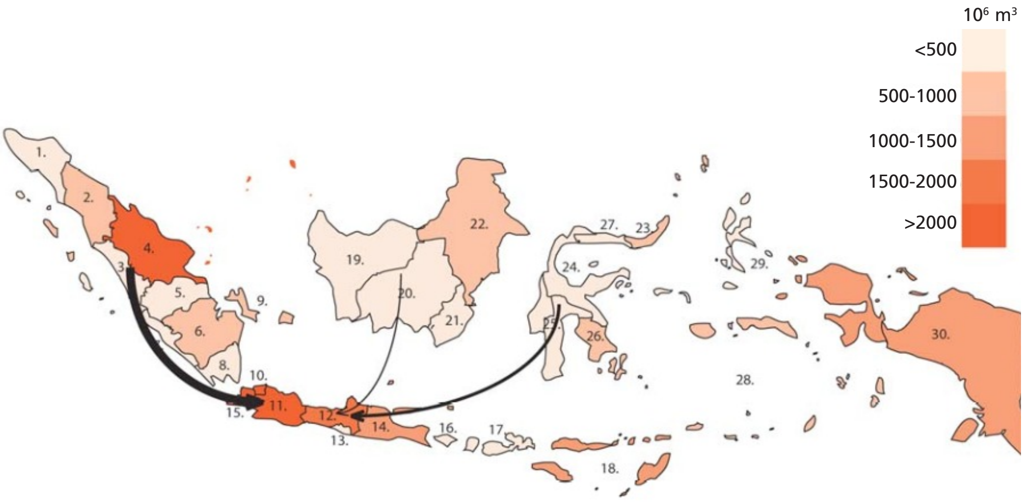
In Indonesia, oil palm cultivation is rain fed. On this basis, this indicator may focus solely on the impact of water withdrawn for agricultural production (blue water) in addition to naturally occurring water for agriculture (green water). Nevertheless, according to UNESCO-IHE (2009), in the water footprint of agricultural commodities production, green water is a relevant component that should also be included. In particular, the relevance of accounting for green water withdrawals, operated by the plants' root system rather than through irrigation, gains even greater relevance when water flows outside the watershed in the form of products or it is somewhat redistributed as a consequence of transport and trade.

The island group that exports most virtual water[20] to other countries is Sumatra (Figure 3.5.2). The large flow of virtual water out of Sumatra is mainly due to palm oil according to UNESCO (2009) as this commodity contributes more than 60 percent to the total virtual water export of Indonesia. Indonesia is the world's largest producer of oil palm and the largest part of the production is meant for the world market. Java's Provinces are the only ones in Indonesia with a net virtual water inflow (Table 3.5.2). In total, Indonesia exports more virtual water to other countries than it imports, resulting in a net outflow of virtual water from Indonesia (UNESCO-IHE, 2009).

On this basis, UNESCO recommends to monitor green water consumption in agricultural production even beyond irrigation as pressure on the national water resources is growing and is expected to increase in the future. When water becomes scarcer, trade in virtual water can save water, reduce the pressure on the water resources and assure a high degree of food self-sufficiency within Indonesia (UNESCO-IHE, 2009).

Figure 3.5.2

Virtual water flow in Indonesia. The province of Riau, due to its large surface planted with oil palm, which exports both domestically and internationally, is the main virtual water exporter of Indonesia. Java Province is the only net importer of virtual water.



Source: Adapted from UNESCO-IHE, 2009

On this basis, a calculation of water use including green water was performed for the case of Indonesian palm oil-based biodiesel.

20 Virtual-water content – The virtual-water content of a product is the freshwater 'embodied' in the product, not in real sense, but in virtual sense. It refers to the volume of water consumed or polluted for producing the product, measured over its full production chain. If a nation exports/imports such a product, it exports/imports water in virtual form. The 'virtual-water content of a product' is the same as 'the water footprint of a product', but the former refers to the water volume embodied in the product alone, while the latter term refers to that volume, but also to which sort of water is being used and to when and where that water is being used. The water footprint of a product is thus a multidimensional indicator, whereas virtual-water content refers to a volume alone. (http://www.waterfootprint.org/?page=files/Glossary)

Information concerning water withdrawal for oil palm cultivation (agricultural water) based on real evapotranspiration measures of oil palm plantations in Indonesia, and biodiesel processing (industrial water) were subsequently retrieved and tentative values for water withdrawals as share of TARWR (5.1a) and per unit of energy output (5.2) were estimated.

According to Widodo and Bambang (2010) oil palm plantations in Indonesia return an average evapotranspiration rate of 42.7 m^3/ha/day. As of 2012, about 8 percent of total oil palm planted area in Indonesia can be attributed to the production of biodiesel feedstock, resulting in a water consumption of about 11,87 km^3/year.

Table 3.5.1

Water use associated with palm oil-based biodiesel production, Indonesia

Parameter	Value
TARWR in Indonesia (FAO AQUASTAT, 2010)	2,019 Gm^3/yr
Oil palm cultivation, water requirement per hectare (Widodo and Bambang, 2010)	15,585 m^3/ha/yr
Planted area of oil palm 2012 (Ministry of Agriculture, 2013)	9.52 Mha
Total water requirement for oil palm cultivation in Indonesia	148.37 Gm^3/yr
Water requirement for oil palm cultivation for biodiesel feedstock production in the Indonesia[21]	11.87 Gm^3/yr
Percentage of TARWR withdrawn for oil palm cultivation for biodiesel production in Indonesia	0.0059 %
Total water withdrawn for feedstock processing into biodiesel in Indonesia	0.000024597 Gm^3/yr
Total water withdrawn for biodiesel feedstock production and processing in Indonesia	**11.87 Gm^3/yr**
5.1a: Total water withdrawn for biodiesel feedstock production and processing as a percentage of TARWR in Indonesia	**0.0059%**
5.2: Volume of water withdrawn for biodiesel feedstock production and processing in Indonesia per unit of energy output[22]	**0.66 m^3/MJ**

Sources: Ministry of Energy, 2014; Ministry of Agriculture, 2013; FAO AQUASTAT, 2010; FAO survey at bioenergy company in north Sumatra, September 2012

Information concerning water use levels at the feedstock processing stage was retrieved through direct surveys in the operation site of a major Indonesian biodiesel producer in the northern side of Sumatra, Riau Province. From data collected during the survey it was calculated that for the production of about 3.25 x 10^{-7} m^3 of water (blue water) per MJ of biodiesel were employed in 2012. This amount is negligible in comparison with the amount of water used at feedstock production level.

The results of the indicator show that the agricultural phase of the bioenergy value chain is

21 This is based on the share of crude palm oil that is used for biodiesel production in Indonesia, i.e. 8 percent as of 2012 (Ministry of Energy, 2013).

22 Based on data and calculations related to water withdrawals included in the table, combined with oil palm production data in Indonesia.

the principle stage responsible for water use; overall, Indonesian biodiesel production was estimated to use about 0.0059 percent of total actual renewable water resource in Indonesia as 0.66 m^3 of water are needed per MJ of biodiesel.

3.5.3 Main conclusions and recommendations

Results of indicator measurement

As expected, the results confirmed that the bulk of the water withdrawals associated with bioenergy production are linked to the feedstock cultivation phase. In fact, the water used for feedstock processing is a negligible amount if compared to the water needed for the production of FFB. This is also why an assessment of the shares of renewable and non-renewable water was not performed. Indonesian biodiesel production was estimated to use about 0.0059 percent of total actual renewable water resource in Indonesia as 0.66 m^3 of water are needed per MJ of biodiesel.

Future monitoring of indicator 5 in Indonesia

As the bioenergy sector continues to expand in Indonesia, monitoring of indicator 5 in key watersheds with significant levels of bioenergy feedstock cultivation and processing will be of crucial importance.

Although Indonesia is a country with abundant freshwater, and despite that areas of the country where bioenergy is produced have a low variability between dry and wet season and rarely experience water stresses, the management of water resources in Indonesia over recent years has been increasingly worrying. According to FAO AQUASTAT (2010), these conditions require an improvement in water resources management. There should be an integrated management and treatment of both surface water and groundwater. With this approach, a better water resources planning, development and management could be attained (FAO AQUASTAT, 2010).

Indicator 5 has proven to be suitable to describing the implications of agriculture on the use of water resources even if the commodities are produced through rain fed agriculture and it is therefore an interesting tool for future analysis of water use efficiency in the country.

Relevance, practicality and scientific basis of indicator 5

As explained in the previous section, the relevance of the issues addressed by indicator 5 was confirmed during the testing of the GBEP sustainability indicators for bioenergy in Indonesia, which also highlighted the importance of the future monitoring of this indicator in the country.

In Indonesia, data on TARWR at the watershed level was not available and the analysis was done on the basis on water requirements per unit of planted surface and consequently inferred at the national level. However, the chance to select a given watershed would have most likely been more informative of the real water balance of the well-defined oil palm production areas. In fact aggregating the results and presenting average national figures might not be a meaningful exercise, as these figures might not reveal potential situations of water stress, including severe ones, in specific watersheds where bioenergy feedstocks are cultivated and processed.

An issue that might affect the practicality of indicator 5 relates to the boundaries of watersheds, that in most cases do not overlap with those of the administrative units for which statistics on production of bioenergy feedstocks and products are available. Due to this issue, in some cases it might be difficult to determine the amount of water withdrawn in a specific watershed for bioenergy production.

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3.6 INDICATOR 6: WATER QUALITY

Description:
(6.1) Pollutant loadings to waterways and bodies of water attributable to fertilizer and pesticide application for bioenergy feedstock production, and expressed as a percentage of pollutant loadings from total agricultural production in the watershed
(6.2) Pollutant loadings to waterways and bodies of water attributable to bioenergy processing effluents, and expressed as a percentage of pollutant loadings from total agricultural processing effluents in the watershed

Measurement unit(s):
(6.1) Annual nitrogen (N) and phosphorus (P) loadings from fertilizer and pesticide active ingredient loadings attributable to bioenergy feedstock production (per watershed area):

- in kg of N, P and active ingredient per ha per year
- as percentages of total N, P and pesticide active ingredient loadings from agriculture in the watershed

(6.2) Pollutant loadings attributable to bioenergy processing effluent:

- pollutant levels in bioenergy processing effluents in mg/l (for pollutant concentrations and biochemical and chemical oxygen demand – BOD and COD), and (if also measured) °C (for temperature), μS/m (for electrical conductivity) and pH
- total annual pollutant loadings in kg/year or (per watershed area) in kg/ha/year
- as a percentage of total pollutant loadings from agricultural processing in the watershed

3.6.1 Testing of indicator 6 in Indonesia

For the testing of indicator 6 in Indonesia, primary data collection campaigns were carried out in two oil palm estates in Sumatra and pollutant concentrations in the bodies of water where reported. Due to lack of information on the annual discharge of the rivers tested, it was not possible to express this as a percentage of pollutant loadings from total agricultural production in the watershed(s).
Due to lack of data on pollutant loadings to waterways and bodies of water from agricultural and biodiesel processing effluents, indicator component 6.2 could not be measured.

3.6.2 Key findings

For the measurement of this indicator, water quality data were collected in two estate plantations in north Sumatra with surface of about 1,000 and 5,000 hectares. Twenty one water samples were taken from the main furrow in the upstream, middle, and downstream sections of the bodies of water that flow along the borders of the plantations.
The laboratory analyses were performed by the *Environmental Productivity Laboratory*, Faculty of Fisheries, Bogor Agricultural University (IPB), Indonesia. The main parameters analyzed were the concentration of ammonium, nitrate, phosphate, and active compounds from pesticides.

Table 3.6.1

a) Scientist from the Bogor Agricultural University taking water samples from a body of water within an oil palm plantation in north Sumatra, Indonesia; b) Main furrow flow in an estate plantation in north Sumatra, Indonesia (2012)

Fertilizer leaching from palm oil plantations contributes to increased pollutant levels in nearby bodies of water. Peat is a decomposing medium with variable available nutrient content, particularly nitrogen. In fact, due to the overall high nitrogen content in peat soils, usually N inputs are not necessary.

Fertilizer application in smallholder plantations was estimated through direct interviews with local farmers. Oil palm estates determined nutrient needs through laboratory analyses of the 14^{th} leaf on a palm tree to carry out a structured nutrient management plan. As a subsequent result, estate plantations tend to apply a more constant amount of nutrients to the palms than most smallholders. The consequences of high nutrient application, especially during the wet season, may raise some concerns related to leaching effects and pollutant loads in nearby bodies of water.

For the extent of this project, pollutant loadings in the water of rivers bordering oil palm plantations in north Sumatra were tested in order to determine a possible correlation between different fertilizer application rates and water quality. The results of the analysis shown that, on mineral soils, ammonia (NH_3) levels in the water bodies in company plantations and in smallholder plantations were both below 0.140 mg/l. Moreover, upstream and downstream values did not show significant differences.

Tests of nitrate levels in rivers flowing along the borders or inside plantations showed an increase in pollutant's content from 0.341 mg/l (upstream) to 2.955 mg/l downstream from the plantation, but still below the 10 mg/l threshold set by the national regulation.

Phosphate levels in both estates and smallholder plantations exceded the maximum pollutant concentration permitted by law (0.2 mg/l). Palm Oil Mill Effluent (POME) from milling is commonly applied to the plantation in large estate companies and it is not channeled to rivers or other naturally occurring bodies of water. Lim (2005) reported that the application of empty fruit bunches (EFB) between the palm circles increased pH of the surface peat from 3.2 to 5.4 and the soil exchange of K from 0.20 to 8.38 cmol/kg and may reduce the need for synthetic fertilizer application.

Table 3.6.2

Pollutant loadings in upstream, middle, and downstream conditions on mineral and peat soils

Parameter	Location	Mineral River Stream			Peat River Stream			Max. Std.	Method
		Up	Middle	Down	Up	Middle	Down		
		mg/l			mg/l				
Ammonia (NH_3)	Estates	<0.140	<0.140	<0.140	0.390	0.3514	0.4682	(-)	APHA ed. 21th 4500-NH_3 C, 2005
	Smallholders	<0.140	<0.140	<0.140	<0.140	<0.140	<0.140		
Phosphate (PO_4)	Estates	1.594	0.768	**0.828**	8.083	11.305	**12.207**	0.2 mg/l	APHA ed. 21th 4500-P D, 2005
	Smallholders	0.184	2.579	**0.212**	1.370	1.130	**3.300**		
Nitrate (NO_3)	Estates	0.341	0.382	**2.955**	8.610	11.630	**10.757**	10 mg/l	APHA ed. 21th 4500-NO_3 B, 2005
	Smallholders	2.290	1.845	1.645	13.490	16.330	**31.290**		

Source: Data from water samples in CDSAP laboratory, Bogor Agricultural University, 2012

Table 3.6.3

Composition and concentration of POME used for land application in North Sumatra, Indonesia

Characteristics	Unit	Result	Methods
pH		7.28	electrometric
Zinc (Zn)	mg/l	0.15	A.A.S
Cooper (Cu)	mg/l	0.09	A.A.S
Cadmium (Cd)	mg/l	<0.001	A.A.S
Lead (Pb)	mg/l	<0.01	A.A.S
Oil & Grease	mg/l	42	Partition Gravimetric
COD	mg/l	1083.58	Open Reflux
BOD	mg/l	634.2	Winkler

Source: direct analysis under this project performed by SUCOFINDO laboratory, Medan.

The BOD limit of waste waters for land application in Indonesia is 5,000 mg/l. In the case study locations, waste waters for land application have a maximum BOD of 836.17 mg/l whereas waste waters discharged into the rivers are pre-treated and reach a BOD level of 81.71 mg/l.

Pesticides application

As in the case of nutrients, the rate of application of pesticides varies between estate plantations and smallholder plantations. The amount and type of pesticides are also different depending on the soil type and the pest targeted.

Table 3.6.4

Pesticides application rates in oil palm cultivation

Active ingredient	Unit	Mineral Land		Peat Land	
		Estates	Smallholders	Estates	Smallholders
Methylsulfuron	l/ha/year	1.088	-	0.004	-
Glyphosate isopropyl amine	kg/ha/year	0.057	0.580	0.170	0.230 - 0.600
Paraquat diclorida	kg/ha/year	-	0.070 - 0.330	-	0.130 - 0.350
Metil Metsulfuron	kg/ha/year	-	0.040 - 35.714	-	0.060
2,4 D dimethyl amine	l/ha/year	-	-	0.005	-
Amonium Glifosinate	l/ha/year	-	-	0.031	-
Triclopir butoxi etil Ester	l/ha/year	-	-	0.020	-

PT Listrindo Kencana. 2009

Pesticide levels in the surface waters of oil palm plantations were not analysed, but application rates were estimated from interviews and surveys among feedstock producers. From the surveys it emerged that smallholders still rely on *Paraquat*[23] and 2,4 D dimethyl amine for weed control whereas in estate plantations these active ingredients have been substituted by selective herbicides. The Pesticides Action Network (PAN) in 2002 reported that *Paraquat* is persistent and may accumulate in the soil with repeated application and constitute a threat to worker's health.

3.6.2 Main conclusions and recommendations

Results of indicator measurement

Oil palm cultivation is input intensive (see indicator 2) and the results of this study show that large quantities of pollutants, mainly nitrate and phosphate are discharged into the rivers and bodies of water near the plantations. Although a nationwide assessment was not possible, due to the lack of large scale survey and/or accurate modelling of pollutant discharge and flow, a preliminary indication of the loadings of pollutants into the waters of Indonesia was performed.

Table 3.6.2 shows that phosphate concentration in the downstream waters along oil palm plantations exceeds the maximum levels as set by law. This result was expected since oil palm cultivation greatly relies on phosphorus fertilizers for the growth of FFB. Plantations on mineral soils retain larger quantities of this nutrient whereas peatsoils are characterized

23 Paraquat is one of the most widely used herbicides in the world.

by high baseflow and therefore the transport of nutrients from the soil medium to the nearest body of water is rapid. In addition, peat is a decomposing medium which releases variable quantites of nitrogen in the water flow that reaches nearby rivers. This translates, in the case of smallholder plantations, into concentrations of nitrates three-fold the maximum level permitted by law. Lastly, pesticide levels in the surface waters of oil palm plantations were not analysed but application rates were estimated from interviews and surveys among feedstock producers. Pesticides that have been recognized for their toxicity, and are being phased out in many countries, are still largely employed in oil palm cultivation in Indonesia.

Future testing of indicator 6 in Indonesia

The main issues identified in the testing of this indicator relate to the limited extent of ongoing monitoring and analysis of water quality in Indonesia and, specifically, of the impacts of agriculture and bioenergy on the state of water bodies.

A good starting point could be to identify the major sources of water pollutants in the biofuel lifecycles, identify a range of options for reducing the pollutant loadings associated with these sources, and assess and compare the impacts of implementing these options. The main source of water pollution would seem to be fertiliser application. Good practices that reduce fertiliser application without undermining productivity exist, such as Integrated Plant Nutrient Management[24]. It can be observed that this objective would bring multiple benefits of both an environmental and economic nature. Low-input agro-ecological approaches could also bring social benefits.

In addition to the above course of action regarding good practices to mitigate water pollution “hotspots”, a concerted campaign to measure some basic indicators of risk of water pollution due to fertiliser and pesticide use would be another useful step. One option would be to start with regular and widespread monitoring of N and P balances and concentration of nitrates and pesticides in ground and surface waters.

Relevance, practicality and scientific basis of indicator 6

The topic of the impact of biofuel production on water quality does not seem to be among the highest priorities in Indonesia. This may in part be due to the lack of information relating to these impacts. However, certainly measures that would lead to good performance against this indicator, such as more efficient use of fertilisers and pesticides are relevant to Indonesian stakeholders, including the private sector, particularly because of their relationships with GHG emissions (from fertilizer production and use) and implications with biodiversity in the landscape.

This indicator relies on local data and analysis and therefore has intensive measurement requirements. However, very useful information could be obtained by the relatively practical measurement of N and P balances and complemented by monitoring of concentrations of these nutrients and key pesticides in ground and surface waters. These

24 For an overview of this good practice see FAO (2012).

and other approaches are set out in the GBEP report on the indicators (FAO, 2011). The GBEP methodological approach could perhaps be further enhanced by more details on how to practically make use of information on the implementation of good practices relating to major pollutant risks, including not only fertiliser and pesticide application.

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3.7 INDICATOR 7: BIOLOGICAL DIVERSITY IN THE LANDSCAPE

Description:
(7.1) Area and percentage of nationally recognized areas of high biodiversity value or critical ecosystems converted to bioenergy production;
(7.2) Area and percentage of the land used for bioenergy production where nationally recognized invasive species, by risk category, are cultivated;
(7.3) Area and percentage of the land used for bioenergy production where nationally recognized conservation methods are used.

Measurement unit(s):
Absolute areas in hectares or km^2 for each component and for total area used for bioenergy production. Percentages of bioenergy production area can be calculated from these, and given either separately for each relevant category (i.e. different types of priority areas for 7.1 and specific methods for 7.3) or as a combined total across such categories.

3.7.1 Testing of indicator 7 in Indonesia

The identification of the potential presence of High Conservation Value (HCV) areas on the islands of Sumatra and Kalimantan, that, in 2012, had a combined surface of more than 90 percent of total oil palm planted area in Indonesia, has been done using the Desktop Analysis approach as suggested by the HCV 2008 identification Toolkit (HCV, 2008). The identification process was performed using secondary data gathered from relevant Indonesian ministries and local agencies, and from International non-governmental organisations.

3.7.2 Key findings

Indicator component 7.1
With Presidential Decree No. 32/1990 on the Management of Protected Areas, and Decree No. 837/Kpts/Um/ii/1980 on Criteria and Procedures for the Establishment of Protected Forest, Indonesia has defined its nationally recognized set of protected areas of high biodiversity value. The region of Sumatra, which includes the main island and several minor islands surrounding the former, includes 82 land and 5 marine conservation areas covering a surface of 17.8 million hectares or 37.37 percent of total surface of the Sumatran Region. Under the HCV approach, these areas are classified as HCV 1.1 areas (HCV, 2008).

Table 3.7.1

Protected areas of Sumatra

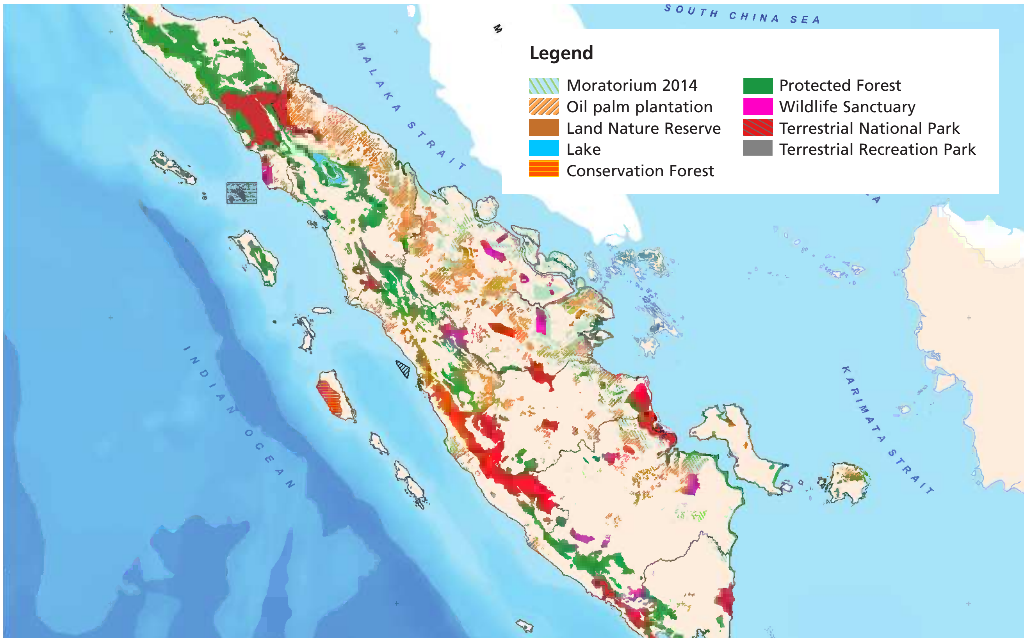
Description	Area (ha)
Core Region	
Land Nature Reserve	58,447.32
Marine Nature Reserve	21,932.72
Lake	134,576.06
Conservation Forest	821,662.16
Protected Forest	5,892,981.39
Nature Forest Reserve and Marine Tourism	37,420.56
Sea-Water	286,751.56
Terrestrial Wildlife Reserves	832,546.34
Terrestrial Nature Park	3,066,538.93
Marine Nature Park	54,499.69
Terrestrial Nature Tourism Park	62,556.13
Marine Nature Tourism Park	214,755.84
Peat> 3 m	2,158,508.98
Total Core Area (A)	**13,643,177.67**
Buffer Area	
Nature Reserve	61,438.79
Lake	11,860.55
Conservation Forest	259,124.65
Protected Forest	2,295,233.79
Coastal Beach	360,475.21
Riparian	479,317.42
Wildlife Reserve	212,037.19
National Park	542,464.49
Total Buffer Area (B)	**4,221,952.09**
Total Protected Area (A+B)	***17,865,129.76***

Source: Remark Asia , 2014

In 2010 oil palm plantations in Sumatra covered about 4.74 million hectares (Gunarso et al, 2013), almost entirely on the main island. Land protected areas in the sole island of Sumatra cover approximatively 11.07 million ha. Of these about 52,527 ha of oil palm plantation overlap with core region of nationally recognized protected areas (0.47 percent). The share attributable to the bioenergy feedstock (8 percent of total CPO output) was estimated to be 4,202 ha or 0.04 percent of the nationally recognized high biodiversity areas in Sumatra.

Figure 3.7.1

Map of nationally recognized high biodiversity value areas and oil palm plantations in Sumatra, Indonesia (2010)



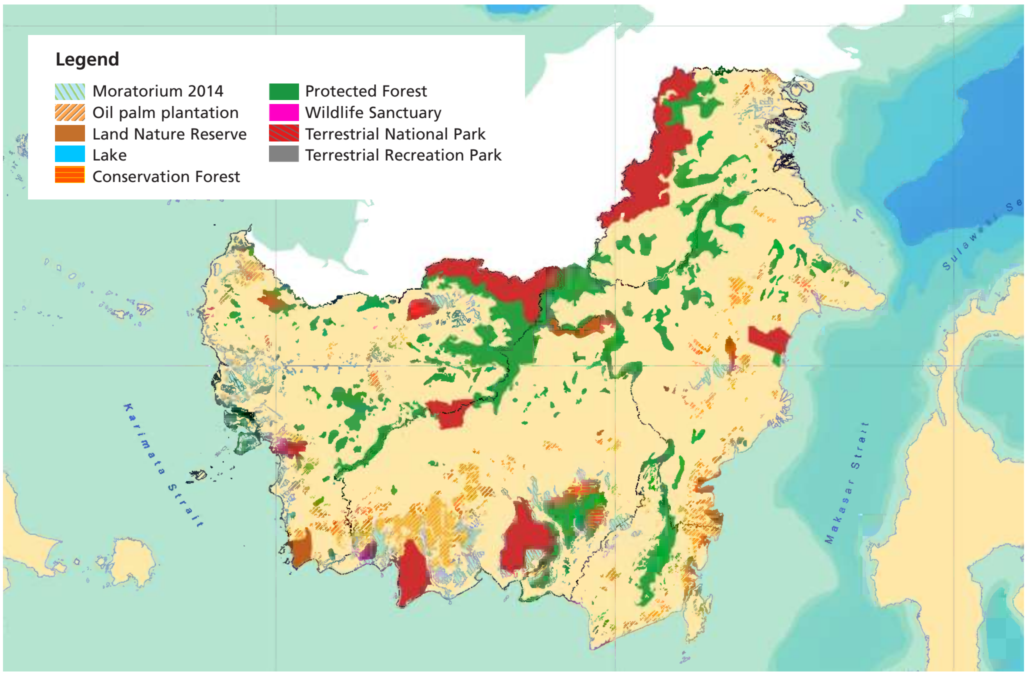
Source: Remark Asia, 2014

The analysis for Kalimantan revealed that the island has a total surface of nationally recognized high conservation value (HCV 1.1) accounting for 12.2 million hectares. Using the same criteria of analysis as in the case of Sumatra, it was estimated that oil palm plantations in Kalimantan overlap with about 26,488 ha or 0.22 percent of the total nationally recognized high biodiversity value area. The share attributed to biodiesel feedstock can be calculated in absolute terms as 2,119 ha equal to 0.02 percent of total nationally recognized areas of high biodiversity value.

The overlap between oil palm plantations and nationally recognized areas of high biodiversity value and critical ecosystems for both islands is 6,321 ha or 0.03 percent of total protected area in these two islands (indicator component 7.1).

Figure 3.7.2

Map of nationally recognized high biodiversity value areas and oil palm plantations in Kalimantan, Indonesia (2010)



Source: Remark Asia, 2014

In addition to protected areas, the rational for the definition of critical ecosystems and high conservation value areas includes several other aspects. According to FAO (2011), the conversion of areas of high biodiversity value or critical ecosystems can have significant negative impacts on species and ecosystems, including through fragmentation and landscape changes. Therefore, it seems relevant to the assessment of this indicator to include in the measurement the conversion of other categories of HCV areas (in addition to those areas already protected and classified as HCV 1.1) that have outstanding biodiversity value and/or include high conservation value portions of the landscape according to the HCV areas identification toolkit (HCV, 2008).

In order to perform this analysis for the two main oil palm producer islands in Indonesia, in addition to HCV 1.1 areas, the following areas have been mapped:

HCV 1.2 - Areas where critically endangered species are found;

HCV 1.3 - Areas that contain habitat for viable populations of endangered, restricted range or protected species;

HCV 1.4 - Areas that contain habitat of temporary use by species or congregations of species;

HCV 2 - Important natural landscape areas for natural ecological dynamics;

HCV 2.1 - Large natural landscapes with capacity to maintain natural ecological processes and dynamics;
HCV 2.2 - Areas that contain two or more contiguous ecosystems;
HCV 2.3 - Areas that contain representative populations of most naturally occurring species;
HCV 3 - Areas containing rare or endangered ecosystems.

It should be noted that as of 2012, not all of the aforementioned areas were nationally recognized under some form of protection. However, in order to inform policy of the most sensitive areas for which protection instruments seem necessary due to their high conservation value and/or presence of critical ecosystems, and in order to frame the role of bioenergy feedstock production with regard to these areas, the surfaces where oil palm cultivation overlaps with the HCV categories 1.2 through 3 were assessed in addition to the measurement of interactions between biodiesel feedstock production areas and HCV 1.1 areas (indicator component 7.1).

In order to perform this measurement an in-depth study of the biodiversity at the species level as well as at the ecosystem level was performed for both islands. The results of this overview are presented below.

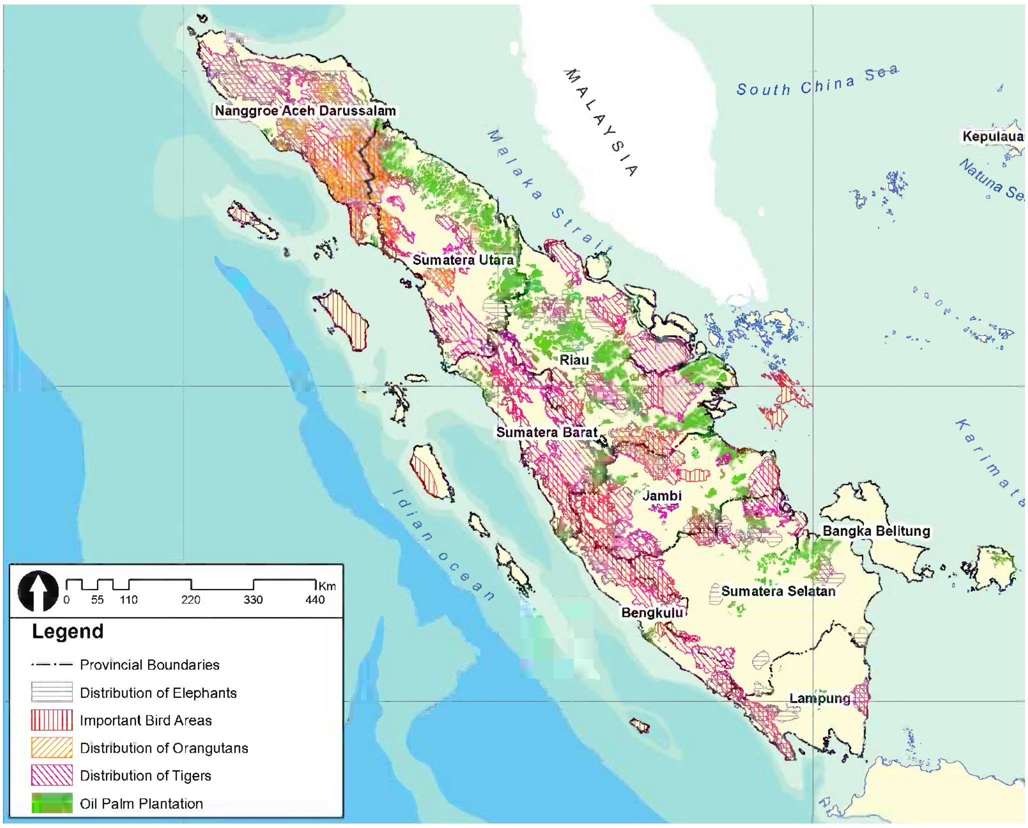
Sumatra is home to sixteen endemic species of mammal, and a further 17 are endemic to the adjacent Mentawai Islands. Sumatra's endemic primate diversity per unit area is unmatched anywhere on Earth (UNESCO, 2004). Eight endemic mammals in Sumatra and the Mentawai Islands are listed in the IUCN Red List of Threatened Species and on the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (IUCN, 2014).

Sumatra's bird list numbers 582 species, of which 465 are resident and 14 are endemic, making it the second richest biogeographic region for birds in Indonesia after Papua. According to BirdLife International (2013), there are 34 Important Bird Areas (IBAs) in Sumatra, of which 54 percent are outside protected areas and 18 percent are in critically threatened lowland forests. Of 300 Sumatran reptile and amphibian species, 69 (23 percent) are endemic. Sumatra's freshwater systems hold 270 species, of which 42 (15 percent) are endemic. Most of Sumatra's endemic plant species are found in lowland forests below 500 meters of altitude, though only about 15 percent of the total may have been classified to date.

According to IUCN (2014), there are 9 wildlife species categorized as Critically Endangered (CR) Species in Sumatra which is also the only island in the world that has three keystone fauna species, namely the Sumatran tiger (*Panthera trigis sumatrensis*), the Sumatran elephant (*Elephas maximus sumatranus*), and the Sumatran orangutan (*Pongo abelii*). Figure 3.7.3 shows the habitat distribution of iconic fauna species and IBAs in Sumatra as of 2012.

Figure 3.7.3

Critically Endangered species and Important Bird Areas habitats in Sumatra



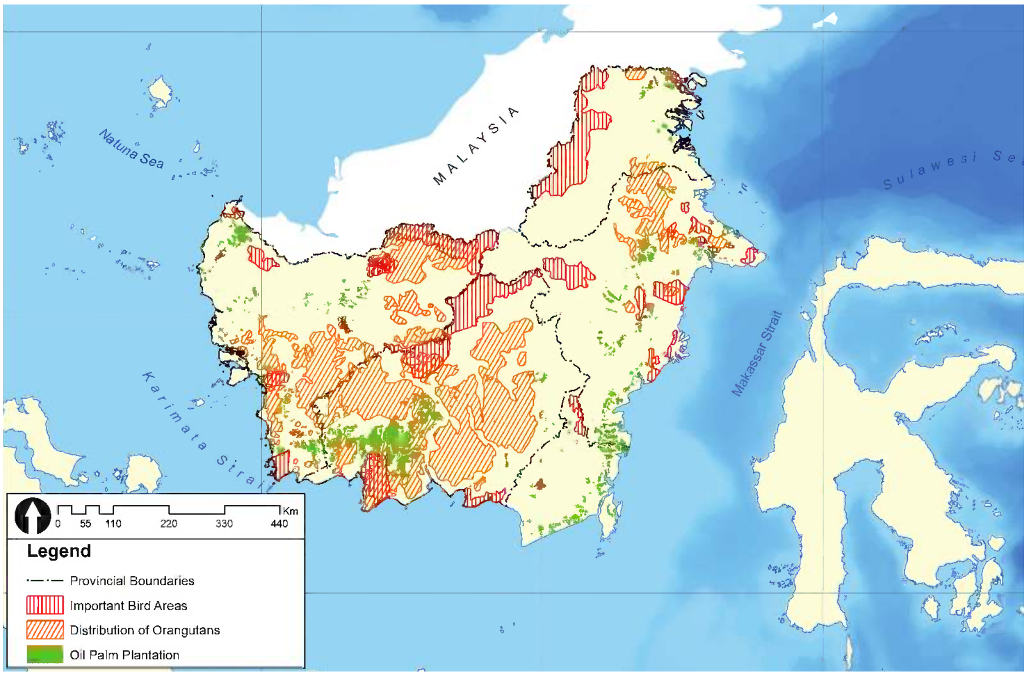
Source: Remark Asia, 2014

In Kalimantan there are 203 plant species listed as protected under IUCN (2014) and 22 species of plants protected by the CITES. In addition, there are 324 fauna species protected under the IUCN Red List criteria (IUCN, 2014), 110 species of animals protected under CITES, 172 animal species protected by the Indonesian government and 175 animals species endemic to Kalimantan, including charismatic species such as the Borneo Orangutan *Pongo pygmeaues wurmbii*. Figure 3.7.4 represents the habitat of endangered species found in Kalimantan.

The areas of high biodiversity value in Indonesia are far greater than the nationally recognized protected areas. From the analysis of other high conservation value parameters (e.g. HCV 1.3, 1.4, 2, 2.1, 2.2, 2.3 and 3) the areas of high conservation value and critical ecosystems of Sumatra and Kalimantan extend over 19.7 and 35.9 million hectares respectively. Oil palm plantations overlap with HCV for around 655,000 ha in each of the two major palm oil producer islands of Indonesia (Figure 3.7.5 and 3.7.6). In other words, this means that in Sumatra, about 13.8 percent of the oil palm planted overlaps with areas of high biodiversity value or critical ecosystems and in Kalimantan this share increases to 22.6 percent. The attribution to the feedstock used for biodiesel production, returns an estimated overlap of about 105,000 ha or 1.37 percent of the total oil palm planted area in the two islands in 2010.

Figure 3.7.4

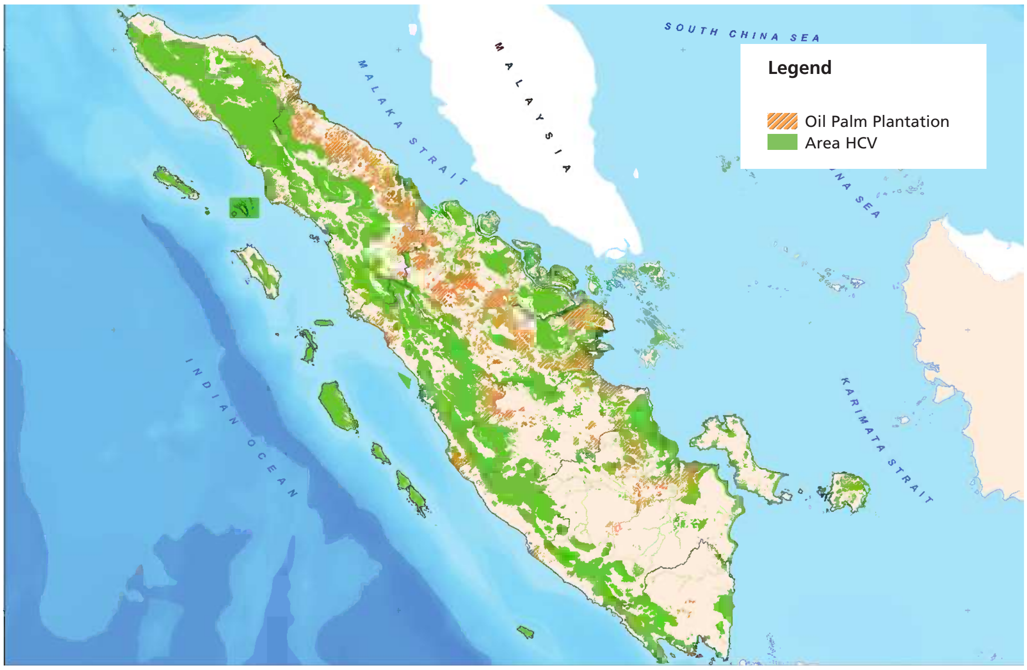
Critically Endangered species and Important Bird Areas habitats in Kalimantan



Source: Remark Asia, 2014

Figure 3.7.5

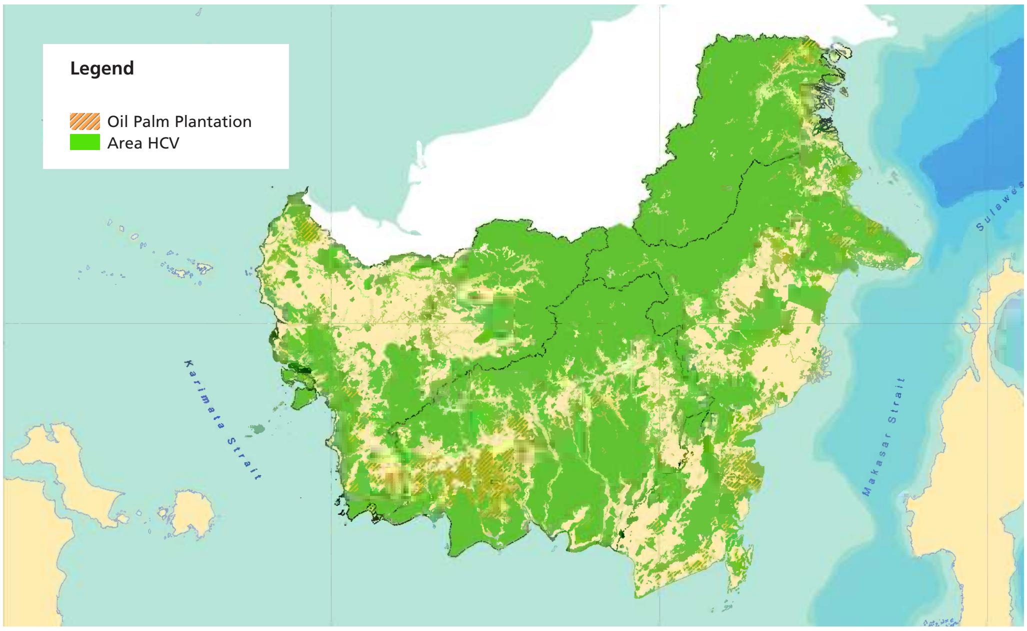
Oil palm plantations overlap with HCV areas in Sumatra



Source: Remark Asia, 2014

Figure 3.7.6

Oil palm plantations overlap with HCV areas in Kalimantan



Source: Remark Asia, 2014

Indicator component 7.2

The African Oil Palm (*Elaeis guineensis*) is not classified as an invasive species in Indonesia (ISSG, 2014); thus, whilst further investigation to determine definitively if other invasive species are used or introduced in the palm oil biodiesel production system, the value for indicator component 7.2 for biodiesel production is probably 0.

Indicator component 7.3

The Zoological Society of London has studied the interactions between oil palm cultivation and biodiversity in the landscape for several years. In 2007, a study focused on the specifics of the aforementioned interactions that oil palm cultivation has on mammals in Jambi, Sumatra (Maddox et al, 2007). The study concluded that oil palm crop is a very poor habitat for most mammals. Ninety-five percent of mammal species recorded in the area demonstrated a preference for non-oil palm habitats, 55 percent were never recorded in oil palm and only 10 percent showed any ability to survive within the oil palm crop on a long-term basis. Intolerance towards oil palm was strongest in the most endangered species and conversion of land to oil palm plantations has major detrimental effects on most terrestrial mammal species, both through the initial impact of habitat loss and through restrictions on remaining local populations by habitat fragmentation.

To date, biodiversity conservation methods such as ecological corridors, setting aside areas of the plantation concession where conversion does not take place (some plantation is Sumatra have dedicated 15 percent of the concession to conservation areas) are not nationally recognized and included into a framework of action that plantations and land developers have to follow. As a consequence, reporting of these actions is sporadic and there is scarce information on the incidence of mitigation actions, although necessary.

3.7.3 Main conclusions and recommendations

Results of indicator measurement

Oil palm plantations in the islands of Sumatra and Kalimantan have been estimated to overlap with about 52,527 and 26,488 ha respectively or 0.34 percent of combined nationally recognized areas of high biodiversity in the two islands and that the attribution to biodiesel feedstock can be calculated in absolute terms as 6,321 ha and in relative terms as 0.03 percent.

Areas of high biodiversity value, if considered in their most comprehensive term, thus not limited to instituted protected areas in Indonesia, are much larger than the nationally recognized protected areas. On this basis, plantations where feedstock used for biodiesel is cultivated overlap with High Conservation Value Areas for about 105,000 ha or 1.37 percent of the total oil palm planted area in 2010.

Indicator component 7.2 returned a value of 0 since oil palm (*Elaeis guineensis*) is not classified as an invasive species in Indonesia as of 2012.

Indicator component 7.3 was not measurable, although the importance of this indicator has been recognized during this project and confirmed by information retrieved in the literature; as of 2012, Indonesia does not have a recognized set of biodiversity conservation methods and therefore only sporadic evidence was found of their application. In addition, no monitoring of relevant conservation methods as suggested by FAO (2011) was found.

Future monitoring of indicator 7 in Indonesia

The measurement of indicator 7 in Indonesia has demonstrated the importance of assessing to what extent bioenergy feedstock is produced on areas where high biodiversity value or critical ecosystems are found. These areas may be in addition to those already recognized and protected by national, regional or local institutions and legislations. Therefore, for the future monitoring of Indicator 7 in Indonesia, a comprehensive approach which includes those areas that are of high relevance for biological diversity conservation (i.e. HCV 1.1, 1.2, 1.3, 1.4, 2, 2.1, 2.2, 2.3 and 3, as it was done in this study) is recommended.

Relevance, practicality and scientific basis of indicator 7

Biodiversity is an important factor in any kind of territorial development in Indonesia given the biological diversity possessed by the country. Most work on and discussion of biofuel feedstock expansion in the country refers to the need to limit the impact on biodiversity. Hence the indicator is considered very relevant in general terms. However, it should be noted that nationally recognized areas of high biodiversity value or critical ecosystems as they are defined by the GBEP Indicators, most frequently coincide with recognized protected areas in most countries. Land use and Land Use Change in these areas is usually prohibited by law and, when statistics are available, these report figures of conversion which approximate 0, because effectively land conversion does not take place (legally) or because it is not reported, although taking place (illegal land conversion). However, in order to assess properly the real impact on high biodiversity value or critical ecosystems, the indicator should include the full process of HCV status assignation (HCV, 2008). This process is currently not fully recognized in Indonesia but the real impacts of land conversion in areas not included in the protected-areas system in a country having the biodiversity of Indonesia exist. These are felt in large parts of the landscape containing critically endangered, protected, and vulnerable species. It is therefore recommended that the GBEP Sustainability Indicators for Bioenergy include the concept of high biodiversity value areas in its broadest sense and suggest to measure effects of land conversion well beyond the extent of nationally recognized (and therefore already-established) conservation areas or critical ecosystems.

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Remark Asia, 2014. Map rendered by Remark Asia, Bogor, Indonesia. Editing of maps and information from various ministries, government agencies, and dedicated literature.

3.8 INDICATOR 8: LAND USE AND LAND-USE CHANGE RELATED TO BIOENERGY FEEDSTOCK PRODUCTION

Description:

(8.1) Total area of land for bioenergy feedstock production, and as compared to total national surface and

(8.2) agricultural land and managed forest area

(8.3) Percentages of bioenergy from:

- (8.3a) yield increases,
- (8.3b) residues,
- (8.3c) wastes,
- (8.3d) degraded or contaminated land

(8.4) Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production, including the following (amongst others):

- arable land and permanent crops, permanent meadows and pastures, and managed forests
- natural forests and grasslands (including savannah, excluding natural permanent meadows and pastures), peatlands, and wetlands

Measurement unit(s):

(8.1-2) hectares and percentages

(8.3) percentages

(8.4) hectares per year

3.8.1 Testing of indicator 8 in Indonesia

For the testing of indicator 8 in Indonesia, data on the total area of land for bioenergy feedstock production and as compared to total national surface and agricultural land (i.e. indicator components 8.1 and 8.2), was retrieved from both national and international statistics.

Oil palm yields in Indonesia have remained substantially stable over the last two decades and have slightly decreased starting from 2005. At the same time, as of 2012, neither production of bioenergy from wastes nor feedstock production on degraded or contaminated land has taken place to a notable extent in the country. Biodiesel from yield increase, wastes, residues or cultivation on contaminated or degraded lands (indicator component 8.3) accounted for a negligible share of total production and was considered zero.

With regard to indicator component 8.4, a national scale experimental research has been carried out with the support of experts from the Indonesian Soil Research Institute in order to quantify net annual rates of conversion between land-use types caused directly by bioenergy feedstock production. Land use changes to oil palm plantations in Sumatra, Kalimantan and Papua, were analysed using Landsat TM images for 1990, 2000, 2005 and 2010. These three islands have consistently made up for more than 90 percent of the surface planted with oil palm in Indonesia over the study period. Satellite images were overlaid with the map of Indonesian soil types in order to assign land use changes taking place on peat versus mineral soils and generate the *activity data*[25]. The activity data were then used for the calculation of the net rates of conversion between land-use types caused directly by bioenergy feedstock production. The same activity data were used to estimate greenhouse gas emissions due to carbon stock changes in above ground biomass (on both soil types) and peat decomposition (on peat soils) employed in the assessment of Indicator 1 (Life Cycle Analysis of Greenhouse Gas emissions).

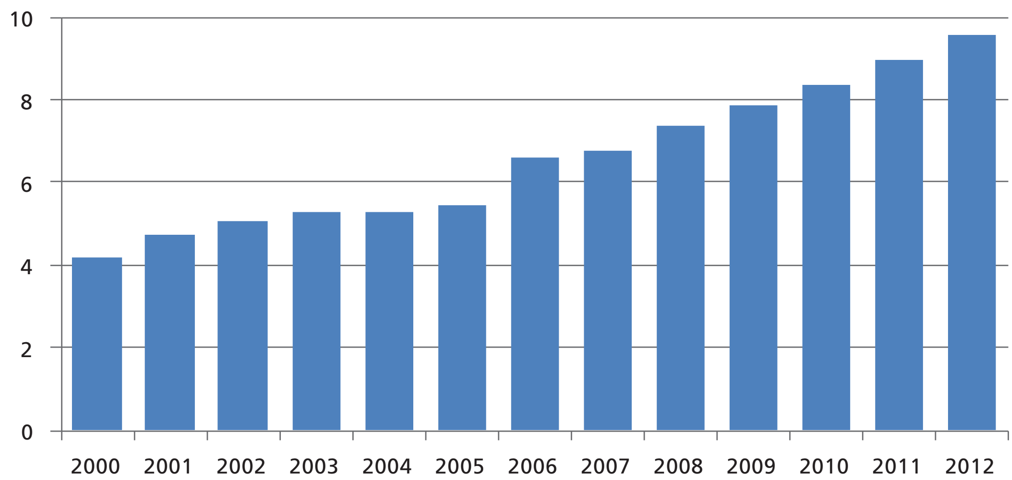
3.8.2 Key findings

8.1: Total area of land for bioenergy feedstock production, and as compared to total national surface and (8.2) agricultural land

Oil palm planted area in Indonesia has substantially increased between 1990 and 2012 (Ministry of Agriculture, 2013). From 2005 to 2012, however, oil palm planted area in Indonesia has almost doubled as the expansion has interested about 4 million hectares of land, from approximately 5.5 million hectares in 2005 to around 9.5 million hectares in 2012.

Figure 3.8.1

Planted area of oil palm in Indonesia (million ha), 2000 - 2012



Source: Ministry of Agriculture, 2013

25 Activity data are defined as data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time (UNFCCC, website).

In 2012, Indonesia produced 2.2 million liters of biodiesel which were processed starting from 2.08 million tonnes of CPO (Ministry of Energy, 2014). Given a total CPO production in 2012 of 26,015,518 tonnes (Ministry of Agriculture, 2013), the share used for biodiesel production accounted for approximately 8 percent of the total output.

As of 2012, no biodiesel-dedicated plantation existed in Indonesia and therefore the share of feedstock used for biodiesel production (8 percent of total) is considered for the attribution of the related land use and land use changes to the production of biofuel.

With this approach it could be inferred that 8 percent of the planted area with oil palm is destined, directly or indirectly, to the production of biodiesel feedstock. This means that about 765,000 ha of land as of 2012 have been planted with oil palm for the production of crude palm oil that ultimately was used to make biodiesel domestically.

Indonesia has a total national land surface of 186,071,969 ha of which 97,245,300 ha were covered by forests and 53,075,208 ha constituted the total national agricultural land in 2012 (Agus et al, 2014).

As shown in table 3.8.1, in 2012 the planted area of oil palm accounted for 5.14 percent of the total national surface and for 18.04 percent of agricultural land. Considering the share of palm oil used for biodiesel production in Indonesia, in 2012 the planted area of oil palm attributable to biodiesel production was equal to 0.41 percent of the total national surface (Indicator component 8.1) and to 1.44 percent of the agricultural land (Indicator component 8.2) (Ministry of Agriculture, 2013; Agus et al, 2014).

Table 3.8.1

Planted area of oil palm and share attributable to biodiesel production as compared to total national surface and agricultural land

	2012
Planted area of oil palm (ha)	9,572,715
Total national surface (ha)	186,071,969
Agricultural land (ha)	53,075,208
Planted area of oil palm area as compared to total national surface	5.14%
Planted area of oil palm attributable to biodiesel production as compared to national surface	0.41%
Planted area of oil palm as compared to total agricultural land	18.04%
Planted area of oil palm attributable to biodiesel production as compared to agricultural land	1.44%

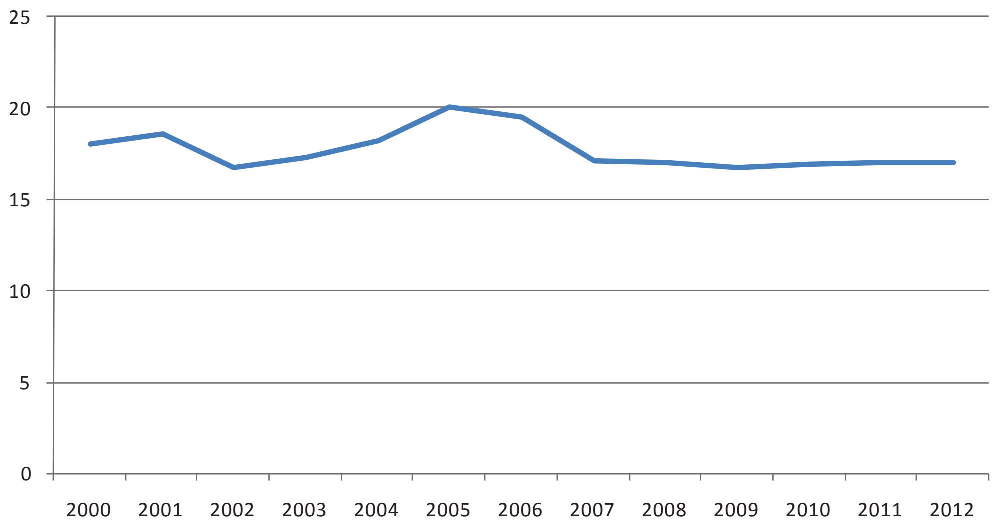
Source: Ministry of Agriculture, 2013; Agus et al, 2014

8.3: Percentages of bioenergy from: yield increases, residues, wastes, degraded or contaminated land

In Indonesia the additional demand for palm oil for biofuel production has been met through an increase in the harvested area of this crop. On the other hand, the productivity of oil palm has remained substantially stable between 1990 and 2012 and therefore no share of bioenergy can be attributed to yield increases.

Figure 3.8.2

Annual FFB yield (t/ha), 2000 - 2012



Source: FAOSTAT, 2014

In addition, as of 2012, neither production of biodiesel from wastes nor feedstock production on degraded or contaminated land has taken place to a notable extent in Indonesia and this value can be considered zero (indicator component 8.3).

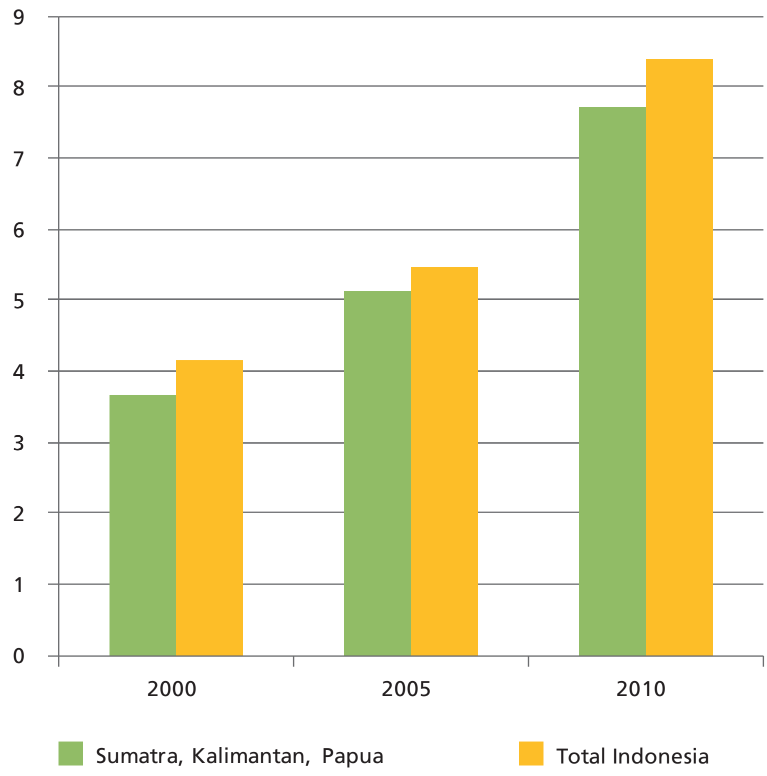
8.4: Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production

As shown in Figure 3.8.1, in Indonesia there has been a significant expansion in the planted area of oil palm up to 2012. Understanding where this expansion took place and what it displaced is essential in order to determine the conversion between land-use types caused directly by bioenergy feedstock production.

Several studies have been carried out with the scope to describe phenomenon of land use change which interested oil palm expansion in the archipelago to different extents. In 2013, Gunarso et al (2013) have first documented land cover and land use change to oil palm in Indonesia, Malaysia, and Papua New Guinea between 1990 and 2010 in order to identify patterns and trends in the development of oil palm plantations in these countries. For this project, FAO has partnered with the Indonesian Soil Research Institute and authors of the aforementioned study in order to i) build on their work and extract experimental data on land use change to oil palm cultivation for the specific case of Indonesia; and ii) to relate to bioenergy production the share of expansion. In addition, this analysis has set the basis for iii) the quantification of the greenhouse gas emissions related to the phenomenon of land use change by soil type and land cover category. This component of the study was performed in order to inform on the emission related to LUC and include them in the dedicated component in indicator 1 (Life Cycle Analysis of Greenhouse Gas emissions).

Figure 3.8.3

Oil palm planted area in Sumatera + Kalimantan + Papua vs total oil palm planted area in Indonesia (Million hectares)

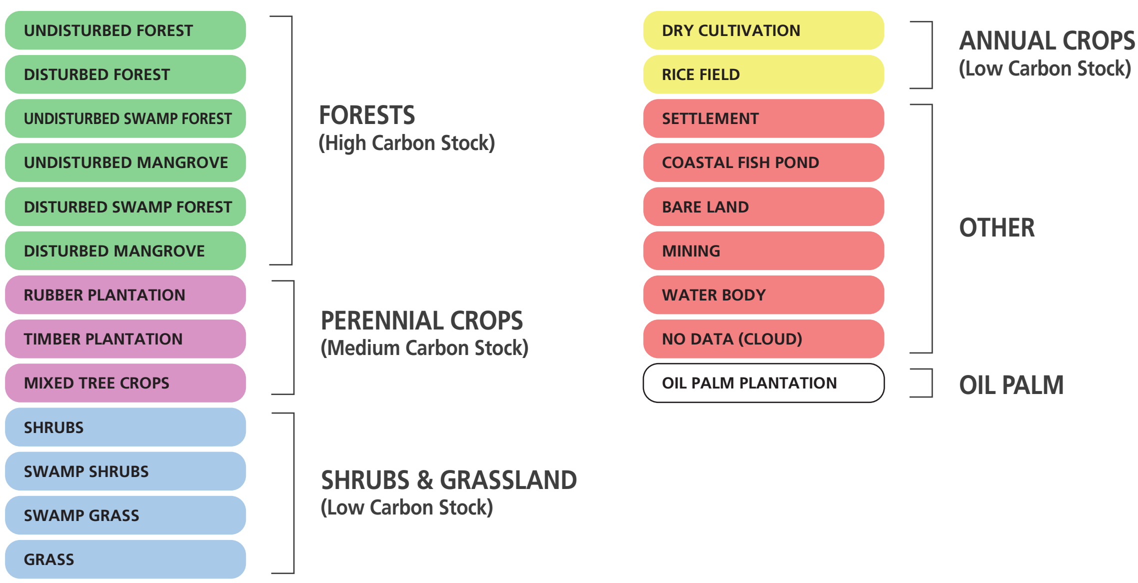


Source: Gunarso et al, 2013; Ministry of Agriculture, 2013

Land use changes to oil palm plantations in Sumatra, Kalimantan and Papua, were analysed using Landsat TM images for 1990, 2000, 2005 and 2010 obtained from the National Aeronautics and Space Administration (NASA). In 2010 in Indonesia about 8.4 million hectares were planted with oil palm; in the same year, the cumulative planted area of Sumatera, Kalimantan and Papua reached about 7.7 million ha or 91.6 percent of the total. As a matter of a fact, consistently from 2000 to 2010, these three islands have made up for more than 90 percent of the surface planted with oil palm in Indonesia, making this analysis highly representative of the national situation (figure 3.8.4).
Twenty two different land cover categories were adapted from criteria and definitions used by the Indonesian Ministry of Forestry and those used by the Ministry of Agriculture for land cover classification. The two classification systems were harmonized to create a set of 22 classes that reflect differences in above ground carbon stocks and include a specific category for oil palm plantations. Consequently, the 22 adapted land cover categories were grouped into six main groups of land cover types in order to align with the methodological approach suggested in the GBEP Sustainability Indicators for Bioenergy (FAO, 2011). The 22 land cover categories are shown in figure 3.8.4 and were considered for both mineral and peat soil types.

Figure 3.8.4

Land cover categories and grouping by main land cover type and related carbon stock levels



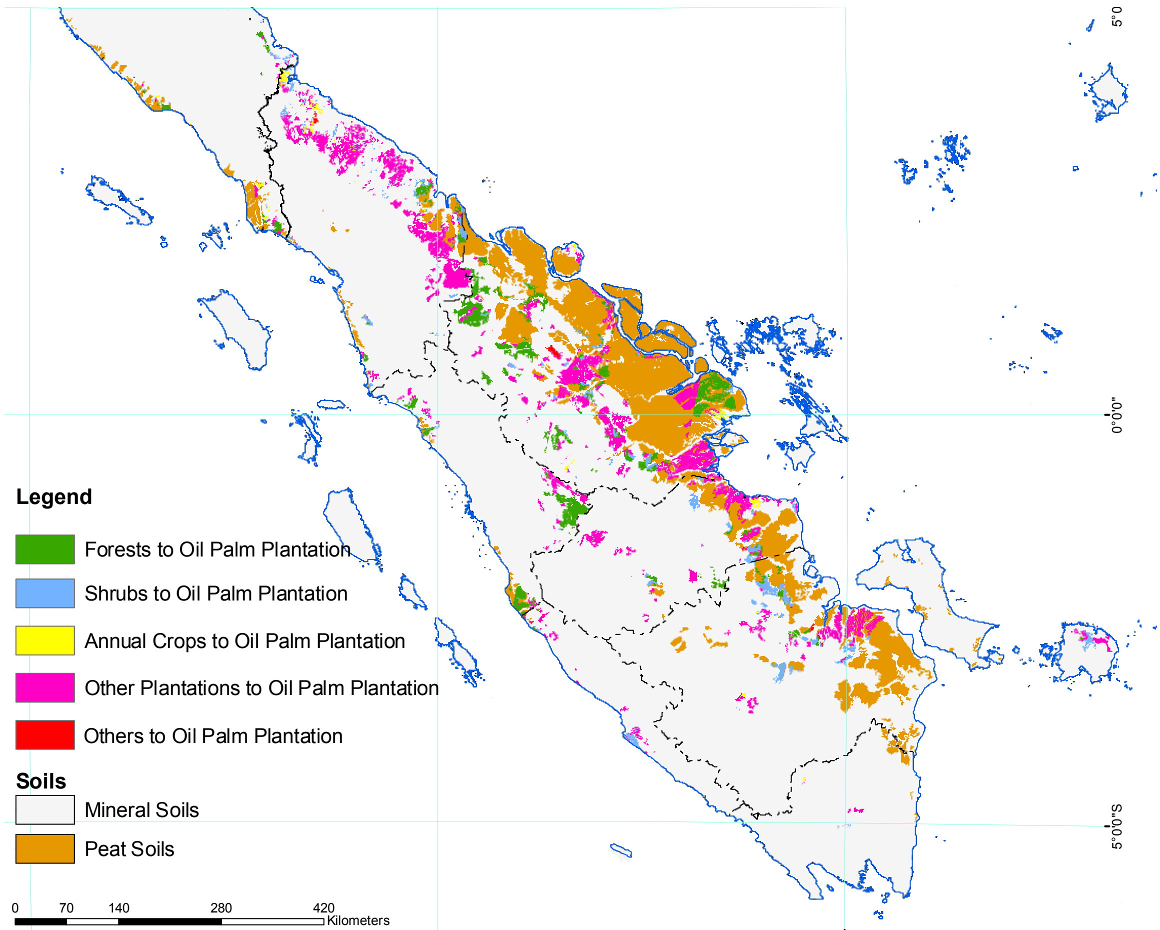
Source: adapted from Gunarso et al, 2013

The trajectories of land use change to oil palm (LUC to OP) have been studied starting from the Landsat images and the overlay of land cover maps for each of peatland and mineral soils of two different image acquisition years (e.g. 2000 and 2005) generated the information of the existence of land use changes into oil palm plantation. Other trajectories that do not involve oil palm plantations were not included in the study. The aforementioned land use and land use change data constitute the activity data for which, ultimately, emission factors were assigned.

Maps of the cumulative land use change trajectories to oil palm plantations between 1990 and 2010 are shown in figure 3.8.5, 3.8.6 and 3.8.7.

Figure 3.8.5

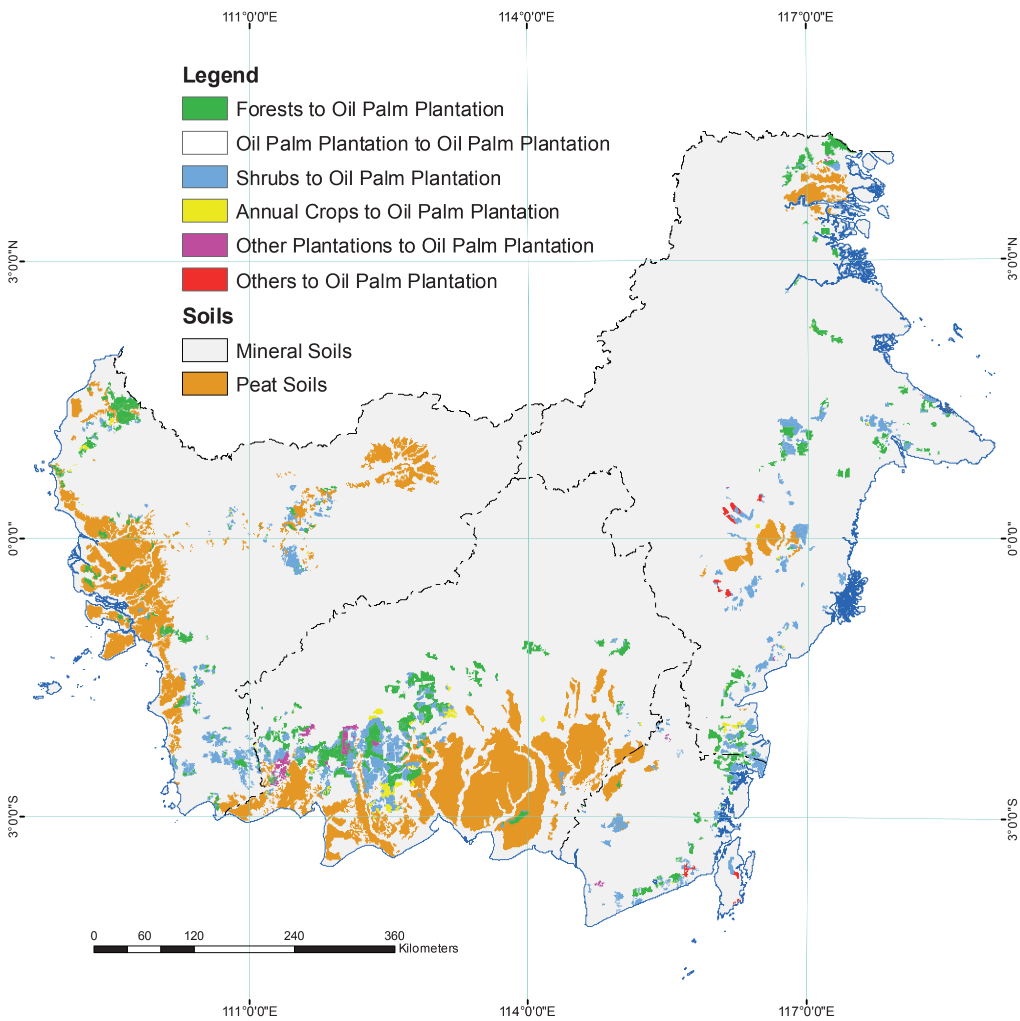
Cumulative land use change to oil palm in Sumatra between 1990 and 2010



Source: FAO elaboration based on Landsat images

Figure 3.8.6

Cumulative land use change to oil palm in Kalimantan (Borneo) between 1990 and 2010



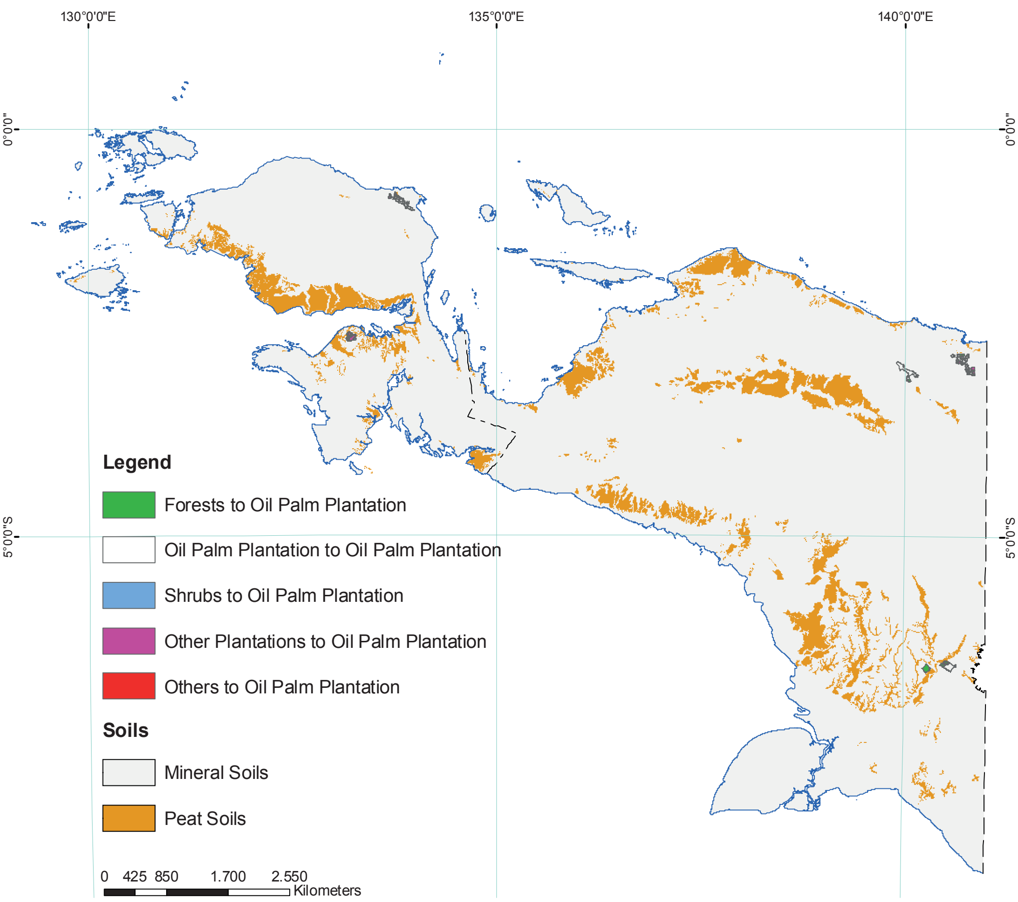
Source: FAO elaboration based on Landsat images

The quantitative analyses of the land use changes to oil palm plantation in Sumatra, Kalimantan and Papua revealed where land conversion has taken place and the summary of the area converted to oil palm in the three Indonesian islands between 1990 and 2010 and related yearly average conversion rates are shown in table 3.8.2.

As of 1990, oil palm covered 1.33 million ha whereas in 2010 total planted area reached 7.7 million ha. In other words, between 1990 and 2010, in Sumatra, Kalimantan and Papua about 6.35 million ha of land were converted to oil palm plantations. The majority of the conversion took place on mineral soils (5.1 Mha), however 1.25 million ha of peat land were drained and converted to oil palm cultivation from various previous land cover types.

Figure 3.8.7

Cumulative land use change to oil palm in Papua between 1990 and 2010



Source: FAO elaboration based on Landsat images

Table 3.8.2

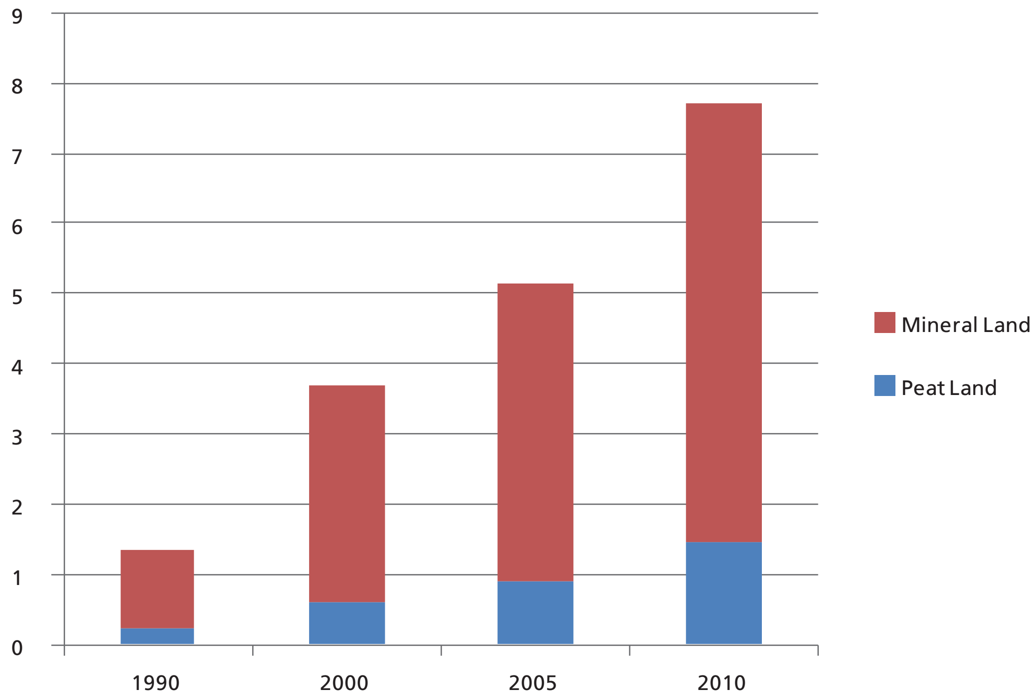
Total area where land use change to oil palm plantation has taken place in the period 1990 – 2000, 2000 – 2005, 2005 – 2010 and summary of changes from 1990 to 2010. Surfaces expressed in hectares (ha) unless otherwise specified

Initial land use	1990-2000	2000-2005	2005-2010	Summary 1990 - 2010
Forests	1,022,609	171,173	949,857	2,143,638
Shrubs	435,378	264,308	1,093,320	1,793,007
Oil palm (beginning year)	1,333,442	3,671,204	5,139,859	1,333,442
Other plantations	822,112	972,133	375,520	2,169,765
Annual crops	16,931	45,764	138,389	201,084
Others	40,253	15,277	12,619	68,150
Total OP (end year)	**3,671,204**	**5,139,859**	**7,709,564**	**7,709,564**
Net Conversion rate (ha/year)	**233,728**	**293,731**	**513,941**	**318,782**

Source: Gunarso et al (2013) modified by using Ritung et al. (2011) instead of Wahyunto et al. (2003, 2004, 2006) peatland maps

Figure 3.8.8

Cumulative oil palm planted area (Million hectares) in Sumatra, Kalimantan and Papua between 1990 and 2010 on mineral and peat soils



Source: own calculations based on Gunarso et al (2013)

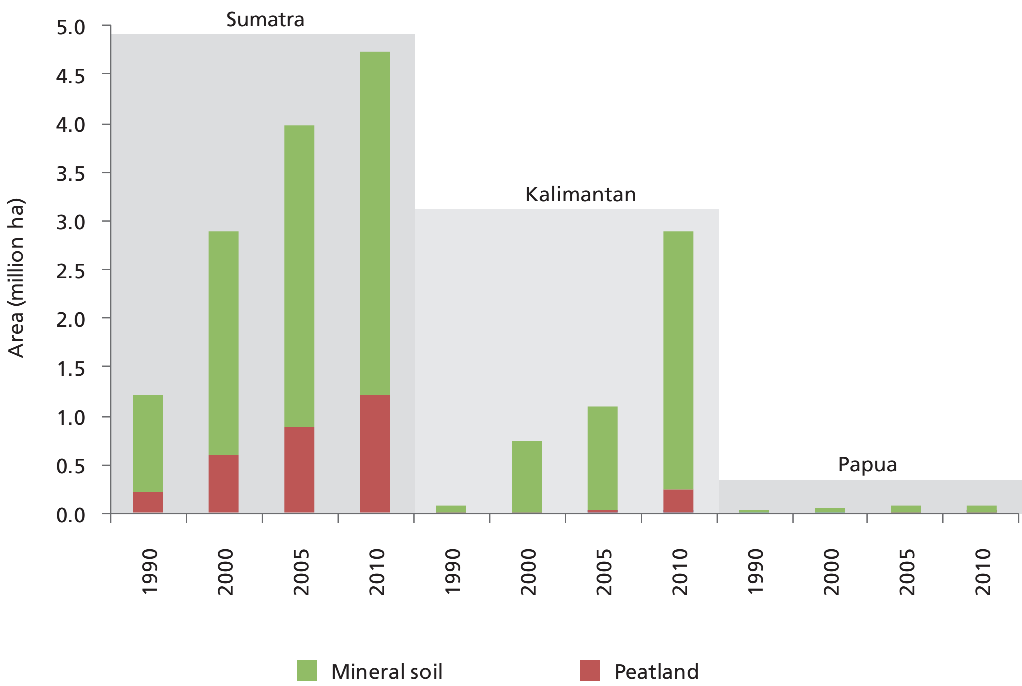
Most of the land use change to palm oil has taken place in Sumatra (figure 3.8.9) where, in addition, most of the conversion of peatland to oil palm cultivation was recorded. In Sumatra, land conversion rates have been consistent from 1990 to 2010 on both soil types. The Provinces where most of the oil palm area is planted are Riau, North Sumatra, Jambi and South Sumatra. Land cover types that were converted to oil palm plantations in Sumatra were mostly perennial crops (e.g. timber, rubber and other plantations for a total of about 2.06 million ha) followed by disturbed upland and swamp forests and other high carbon stock cover types (some 0.88 million ha). Annual crops (mainly rice) showed minimum conversion rate in the island (0.08 million ha).

In Kalimantan a noticeable increase in the rate of conversion to oil palm has taken place in recent times, starting from 2005. Prior to this date, limited amounts of peatland had been converted to oil palm cultivation, whereas in 2010 about 250,000 ha of peat have been drained and planted with oil palm and in excess of 1.6 million ha of mineral land have been converted between 2005 and 2010. Most of the land use change in Kalimantan in fact interested disturbed upland and swamp forests on mineral soils (roughly 1 million ha) and shrubland (about 1.3 million ha). In total, some 110,000 ha of land were converted from the cultivation of annual crops to oil palm in the study period.

The quantitative analyses of the land cover maps and related land use changes detected have indicated that Papua has been interested by the phenomenon only marginally (about 53,000 ha as of 2010) although almost 60 percent from former forest cover types.

Figure 3.8.9

Land use change to oil palm by island (1990 – 2010).



Source: own calculations based on Gunarso et al (2013)

The values and findings presented thus far concern the entire oil palm sector in the three islands studied (> 90 percent of total planted area of Indonesia); for the assessment of indicator component 8.4, the net rate of conversion to oil palm should be allocated and attributed to the production of feedstock for bioenergy purposes only. In particular, the GBEP methodological approach for the assessment of this indicator suggests the measurement of net annual rates of conversion between land use types caused *directly* by bioenergy feedstock production. On the basis of such definition, land use changes taking place prior to the year when commercial scale bioenergy production in Indonesia begun (year 2008) should be excluded from this analysis. Therefore, the net annual rates of conversion between land use types caused *directly* by bioenergy feedstock production were considered only for the period 2005 – 2010. The amount of land converted to oil palm between 2005 and 2010 was allocated to bioenergy on the basis of the actual share of feedstock used for domestic biodiesel production in the reference period (8 percent of total). This allocation is based on a necessary assumption linked to the definition of net annual rates of conversion *directly* due to bioenergy production. Such an assumption ceases to be applicable when GHG emissions related to LUC are concerned as emissions caused by land conversion to oil palm should be borne by the feedstock if this is used for bioenergy purposes regardless the planting year.

Table 3.8.3 shows the cumulative area of land converted to oil palm plantation that can be attributed directly to bioenergy feedstock production by land cover category. Between 2005 and 2010, about 76,000 ha of forests, about 87,500 ha of shrubs, some 30,000 ha of perennial cropland (e.g. rubber, timber plantation etc) and about 11,000 ha of land previously used for growing annual crops such as rice, grain and/or vegetables have been converted to oil palm estate. In the reference period, on average, a yearly conversion of 41,115 ha of land (from all land cover categories) can be attributed to the demand for biodiesel in Sumatra, Kalimantan and Papua for the production of biodiesel feedstock.

Table 3.8.3

Land use change by land use category and annual conversion rate directly attributable to bioenergy feedstock production in Sumatra, Kalimantan and Papua (> 90 percent of total CPO output of Indonesia)

Initial land use	1990-2000	2000-2005	2005-2010
Forests (ha)	0	0	75,989
Shrubs (ha)	0	0	87,466
Other plantations (ha)	0	0	30,042
Annual crops (ha)	0	0	11,071
Others (ha)	0	0	1,010
Sum (ha)	0	0	205,576
Conversion Rate (ha/year)	0	0	41,115

3.8.3 Main conclusions and recommendations

Results of indicator measurement

With regard to indicator components 8.1 and 8.2, Considering the share of palm oil used for biodiesel production in Indonesia (2.08 million tonnes of CPO or 8 percent of total CPO production), in 2012 the planted area of oil palm attributable to biodiesel production (0.764 million ha) was equal to 0.41 percent of the total national surface (Indicator component 8.1) and to 1.44 percent of the agricultural land (Indicator component 8.2) (Ministry of Agriculture, 2013; Agus et al, 2014, Gunarso et al, 2013).

Concerning indicator component 8.3, based on the information retrieved (FAOSTAT; BPS, 2013) in recent years there was no significant increase in the productivity of oil palm in Indonesia, and consequently no share of bioenergy produced until 2012 was attributed to yield increases. In addition, neither production of biodiesel from wastes nor biodiesel feedstock production on degraded or contaminated land took place to a notable extent in Indonesia up to 2012.

Finally, regarding indicator component 8.4, land use changes to oil palm plantations in Sumatra, Kalimantan and Papua, were analysed using Landsat TM images for 1990, 2000, 2005 and 2010. In 2010 in Indonesia about 8.4 million hectares were planted with oil palm; in the same year, the cumulative planted area of Sumatera, Kalimantan and Papua reached about 7.7 million ha or 91.6 percent of the total. Between 1990 and 2010, in Sumatra, Kalimantan and Papua about 6.35 million ha of land have been converted to oil palm plantation. The majority of the conversion took place on mineral soils (5.1 Mha) although 1.25 million ha of peat land have been drained and converted to oil palm cultivation from various previous land cover types. Most of the land use change to palm oil has taken place in Sumatra (figure 3.8.9), where also most of the conversion of the peatland to oil palm cultivation was recorded. In Kalimantan a noticeable increase in the rate of conversion to oil palm has taken place starting from 2005 largely at the expenses of high carbon stock cover types on peat soils. Papua has been interested by land use changes to oil palm cultivation only marginally (about 0.05 million ha as of 2010) although originally these were largely covered by forests.

Net annual rates of conversion between land use types caused *directly* by bioenergy feedstock production were considered only for the period 2005 – 2010 since commercial scale biodiesel production in Indonesia commenced in 2008. The amount of land converted to oil palm between 2005 and 2010 was allocated to bioenergy on the basis of the actual share of feedstock used for domestic biodiesel production in the reference period (8 percent of total). Between 2005 and 2010, about 76,000 ha of forests, about 87,500 ha of shrubs, some 30,000 ha of perennial cropland (e.g. rubber, timber plantation etc) and about 11,000 ha of land previously used for growing annual crops such as rice, grain or vegetables have been converted to oil palm estate. In the reference period, on average, a yearly conversion of 41,115 ha of land (from all land cover categories) can be attributed to the demand for biodiesel in Indonesia for the production of biodiesel feedstock.

Future monitoring of indicator 8 in Indonesia

As discussed above, in Indonesia the additional demand for palm oil for biodiesel production has been met through an increase in the harvested area of this crop, while yields have remained substantially stable. As the bioenergy sector continues to expand in Indonesia and higher biofuel blending mandates are considered, it is important to continue monitoring these trends, and to put in place measures to stimulate productivity increases, thus reducing the pressure on the land.

This project has revealed that there has been a significant expansion in the planted area of the main bioenergy feedstock in Indonesia. The areas where oil palm expansion has taken place have been mapped and a quantitative analysis of what it has displaced was carried out for more than 90 percent of the country. This has important implications for a range of environmental, social and economic sustainability issues addressed by the GBEP indicators, such as GHG emissions, biodiversity, land tenure and food security, in addition to land-use change itself (i.e. indicator 8). Therefore, in order to properly monitor the GBEP indicators and conduct a meaningful assessment of the sustainability of bioenergy production in Indonesia, it is crucial that future research and monitoring of land-use changes associated with the expansion of oil palm are based on the methodology employed in this project.

As the bioenergy sector continues to expand and higher biofuel mandates are considered, indicator 8 could also be used, in conjunction with other GBEP indicators and with FAO's BEFS Rapid Appraisal[26], as a tool to inform and guide participatory territorial planning to meet multiple land-use objectives.

Relevance, practicality and scientific basis of indicator 8

The testing in Indonesia confirmed the high relevance of the issues addressed by indicator 8. This indicator is data intensive and availability of adequate data for all components of this indicator (particularly indicator component 8.4) might be an issue in some developing countries. For the purpose of this project, Landsat images were retrieved and analysed with the support of senior experts from the Indonesian Soil Research Institute in order to assess the area of land converted to bioenergy feedstock production between 1990 and 2010. Without this precious contribution, the understanding of the dynamics of land use changes that interested oil palm cultivation in Indonesia could never be achieved. However, there exists the risk that countries may not dispose of adequate material, human, financial and/or institutional resources to carry out such a cutting-edge type of research.

With regard to the practicality of the methodological approach for the assessment of this GBEP indicator, a crucial aspect emerged during this pilot testing carried out by FAO. The indicator description expressly mentions the assessment of net annual conversion rates caused *directly* by bioenergy feedstock production. In the case of Indonesia (and likely the case of several other countries where first generation biofuels constitute the main bioenergy pathway), the allocation of land use changes to bioenergy demand, separated from the demand for other uses of the product, has proven difficult. In fact, crude palm oil demand has driven the expansion of oil palm plantations in Indonesia since 1990. Up until 2008 (when commercial scale biodiesel production begun in the Southeast Asian country) no direct land use change could be attributed to bioenergy. After 2008 only the share of feedstock used for bioenergy (in the case of Indonesia 8 percent of total CPO production) can be considered among the *drivers* for expansion of oil palm cultivation. This forced procedure is the consequence of the formulation of Indicator 8, however, as of 2012 bioenergy feedstock in Indonesia has likely been produced from oil palm estates planted well before 2008. This is due to the i) the specific physiology of oil palm (i.e. the trees enter production 3 – 5 years after planting and reach full productivity when 8 - 10 years of age) and ii) to the market dynamics which influence the choices of palm oil producers concerning the destination of the feedstock on the one hand but that, on the other hand, are hardly predictable with sufficient notice (minimum of 3 – 5 years). Summarizing, the attribution to bioenergy of the *direct* land use changes only might fail to capture the actual extent of the sustainability consequences due to land conversion for the production of bioenergy feedstock at the domestic level. It is therefore suggested to include in the methodological approach of the GBEP Indicator 8 further guidance on how to attribute

26 The BEFS Rapid Appraisal can be used to get a preliminary indication of the sustainable bioenergy potential at national and local level and identify the related opportunities and trade-offs. This tool is available here: http://www.fao.org/energy/befs/rapid-appraisal/en/

and treat the share of responsibility of land use changes to bioenergy when current surfaces used for feedstock production exceed the direct net annual rates of conversion assessed.

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SOCIAL PILLAR

3.9 INDICATOR 9: ALLOCATION AND TENURE OF LAND FOR NEW BIOENERGY PRODUCTION

Description:
Percentage of land – total and by land-use type – used for new bioenergy production where:
(9.1) a legal instrument or domestic authority establishes title and procedures for change of title; and
(9.2) the current domestic legal system and/or socially accepted practices provide due process and the established procedures are followed for determining legal title.

Measurement unit(s):
Percentages.

3.9.1 Testing of indicator 9 in Indonesia

Land tenure is a relatively complex and contentious issue in Indonesia. Therefore, getting hold of relevant data and information can be quite challenging. This is true, in particular, for areas that have been recently converted to the production of bioenergy feedstocks such as oil palm.

For this reason, it was not possible to carry out a quantitative assessment of indicator components 9.1 and 9.2. However, literature on land conflicts associated with oil palm concessions was reviewed and summarized. In addition, an overview of the legislative framework related to land tenure was presented in the sections below, together with information about two key aspects related to access to land, namely land ownership and business models.

3.9.2 Key findings

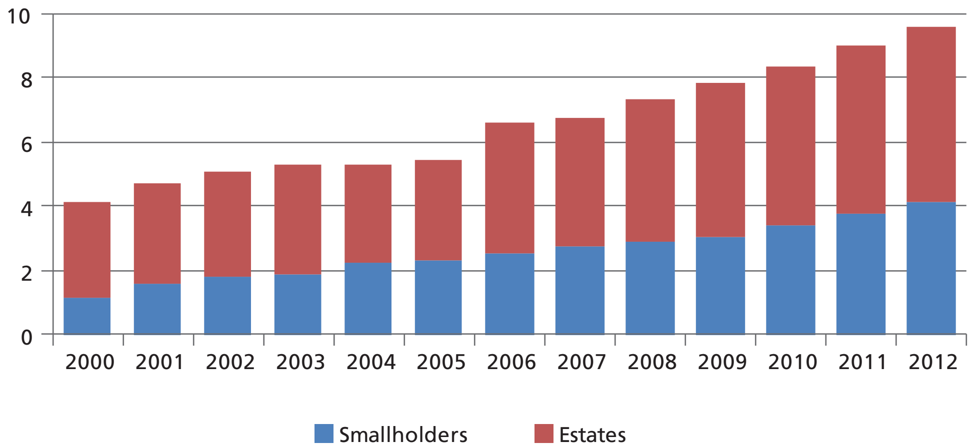
Land ownership and business models are two important aspects that influence access to land. There are three main ownership models under which Indonesian oil palm plantations are operated: privately owned estates, independent smallholder plots, and government owned plantations. Figure 3.9.1 shows the planted area of oil palm in Indonesia between 2000 and 2012, according to the Indonesian Central Bureau of Statistics (2013).

As of 2012, in Indonesia the planted area of oil palm amounted to around 9.5 million ha. Of this, estate plantations (government or privately owned) represented about 60 percent, whereas smallholders farmers represented about 40 percent of the planted area.

The 2003 Agricultural Census indicated that almost half of agricultural households cultivate less than 0.5 ha of land. Furthermore, there are high levels of inequality in the distribution of agricultural land ownership, with a GINI coefficient of around 0.6 (Winoto, 2010).

Figure 3.9.1

Estates Area for palm oil Indonesia (Million hectares)



Source: Badan Pusat Satistik, 2013

With regard to oil palm specifically, government owned plantations (*Perusahaan Terbatas Perkebunan Nasional - PTPN*) had an important role in the early development of the sector in Indonesia. Over time, however, private owned estates and smallholders have gained prominence in this sector. In 2011, there were 10 PTPN plantations, accounting for 11 percent of the planted area of oil palm and for 14 percent of palm oil production.

Many privately owned and government estates have been developed using a scheme known as Nucleus Estate Smallholder (NES) or *Perkebunan Inti Rakyat* (PIR). In this model, smallholder plots are developed in conjunction with the main estate (the nucleus or '*inti*') to form a system also known as plasma (Wright, 2011) where smallholders are satellites of the main nucleus estate (which often comprises a mill).

According to the Global-Bio-Pact report (Wright, 2011), the initial development of the NES model of production was heavily influenced by government policy. The system started in the 1970s as a way of providing income generating opportunities in rural communities and was part of the government's resettlement (*transmigrasi*) programme where companies were required to develop "plasma" areas in order to access land and subsidized capital.

As argued by Colchester et al. (2006), smallholders face a number of major technical and economic constraints that may contribute to a reduced autonomy than that of independent producers. Initial investments (for land preparation, purchase of oil palm seedlings, machineries for pest control and fertilization operations, etc) and the gap of profitability inherit in the physiology of oil palm trees (palms enter production three to five years after planting) make smallholders in the plasma scheme highly dependent upon the support of the mills to which they sell their FFBs. If on the one hand the support of the mills is the enabling factor for smallholders to enter business, then on the other such dependence is linked to a reduced ability to negotiate prices and/or manage the lands according to one's own inclinations (Colchester et al. 2006). Based on the information collected in the updated literature on the matter then, the term smallholders is not explicitly a synonym of independent grower in oil palm cultivation in Indonesia.

The national regulations changed and government support officially ended in 2001, but the NES system continues to play a central role in the Indonesian oil palm sector. For companies establishing plantations at present, implementing some forms of plasma model can help them access land while demonstrating corporate social responsibility. Since the cessation of government support, however, the trend has been towards a decline in the share of plasma areas (Wright, 2011).

Another tenure schemes developed by the government to integrate local landowners into new plantation developments is the KKPA (*Koperasi Kredit Primer Anggota*: Members Primary Credit Co-operative) (Wright, 2011). Under this scheme, land owners provide approximately one-third of their land to the plantation company's nucleus estate while the remaining two-thirds are planted with oil palm by the company and then are returned to the smallholders in the form of an oil palm smallholding. These smallholders are contractually bound to sell FFBs to the company (Winrock, 2009). The increasing numbers of smallholders entering the palm oil sector is also a result of the competitive financial returns offered by palm oil cultivation.

In addition to providing an overview of land ownership and business models in the palm oil sector, when analysing issues related to access to land in the context of bioenergy development it is important to briefly describe the relevant policy and legislative framework in the country.

Conflicts over land in Indonesia may results from two causes. First, the land ownership structure, largely a legacy of the Dutch colonial system along with later allocation processes, has proved inflexible in responding to social changes. Secondly, the lack of transparency, the complexity and lack of clarity of the legal framework governing land rights in Indonesia can complicate the relationships between the parties and result into land conflicts (Colchester et al, 2006).

The legal instrument that historically established land right titles in Indonesia is Act No. 5 of the Basic Agrarian Law of 1960 (BAL). BAL states that Indonesia's agrarian law is the *adat law*[27], or Indonesian customary law, as long as it does not conflict with national interests or other regulations set out in the BAL (USAID, 2013). An *Adat law* is essentially a communal approach to regulating land rights, including land rights exercised by individuals with the consent of the community; as a consequence, *adat laws* regulating the same resource (in this case land) can vary widely across the archipelago sometimes even over short distances.

In October 1992, the Indonesian parliament passed the Spatial Planning Law (Law No. 24; later amended by Law No. 26 of 2007) which defined spatial planning and provided related guidelines for decision-makers (USAID, 2013). In addition, as of 2013, a new forestry regulation statute aimed at reducing the current uncertainty and variability surrounding land rights was under review.

27 The term *adat* refers to customary laws, the unwritten traditional code regulating social, political, and economical as well as maritime laws.

An increasing number of conflicts over land have been witnessed in recent years; in 2007, there were 7,491 significant land disputes and conflicts recorded, interesting some 608,000 ha of land. Many such conflicts have resulted from the allocation of land for plantation estate development (Wakker, 2005).

Different authors (SawitWatch, 2012; Colchester et al, 2006) have reported the existence of conflicts, particularly with indigenous communities in Indonesia over the allocation of land for oil palm cultivation and documented the way Indonesian laws have allowed lands to be expropriated from local people without regard for their rights (Colchester et al, 2011).

According to Winoto (2010) and Marti (2008), in the case of land conflicts over palm oil concessions, the main problem is the lack of adequate legal recognition of customary rights to land. Access to land supporting the livelihoods of rural households, particularly forest dwellers, is regulated by customary law (Wakker, 2005) and few local farmers have titles to land. These rights are partially recognised by the Indonesian constitution, but are legally subordinated to the needs of national development and government agencies have discretionary power in deciding whether to respect them (Colchester et al, 2006 in Wright, 2011).

Although in theory recognition of indigenous rights has improved since 1998, even recent legislation gives businesses the right to take over land if plans are in accordance with state development plans (Marti, 2008). Wright (2011) reported differences between provinces where local governments recognised local communities' land right, despite operating within the same legal framework.

Despite these signs of change in the recognition of indigenous people's rights from the historic trend, some NGOs reported in 2012 the occurrence of land deals resulting in displacement of local communities. According to GRAIN (2013), various international companies have signed land deals in Indonesia for the production of palm oil for an aggregated surface of 213,500 ha until 2012 and, in these areas, the occurrence of local communities' displacement was reported. However, it should be noted that several of these deals have not been followed up on and it is not possible to know if they are still in place or not and, most importantly, an effective quantification of the occurrence of displacements was never reported nation-wide but only at case study level (see Colchester et al, 2006).

According to information available, then, the land used for bioenergy feedstock production takes place where a legal instrument (whether legally or customarily defined) is, at least in theory, in place. However, given the customary nature of the laws that govern land acquisition and tenure in several areas of the country, it was not possible to retrieve specific nation-wide data to support the measurement of indicator component 9.1.

Similarly, although for the majority of the territory where oil palm cultivation takes place legal or socially accepted practices that provide due process and established procedures are followed to determine legal title to the use of the land, the literature reports cases where these procedures have been violated. Due to the complexity of this issue and the variability of laws and scarcity of reporting across the country, it was not possible to quantify the actual incidence of this phenomenon for the measurement of indicator component 9.2.

3.9.3 Main conclusions and recommendations

Results of indicator measurement

The analysis of land ownership types and business schemes related to oil palm cultivation in Indonesia has produced interesting qualitative information; however a quantitative approach to assess allocation and tenure of land for bioenergy production could not be applied.

As of 2012, oil palm cultivation in Indonesia takes place on approximately 9.5 million hectares of which 60 percent directly controlled by large estate firms (private) or government companies (public) and about 40 percent owned by smallholders. The existence of the NES programme, a scheme entailing a strong technical and commercial relationship between farmers and mills, has helped many smallholders find the necessary support to begin oil palm cultivation by reducing technical inefficiencies and financial risks. In some documented cases, however, such scheme has resulted in a noteworthy share of the land owned by farmers linked to a specific mill for a long period of time, which has diminished the independence of the smallholders to manage their land and products.

In certain areas of the country, customary laws govern the resolution of disputes around the acquisition of land. The Indonesian Constitution respects the existence of customary law communities, acknowledges their right to be self-governing and recognizes their customary rights to land, however, specific pieces of regulation provide only weak recognition of customary rights and give broad discretion to government agencies when deciding whether those apply to the specific case or not. While laws recognize the rights of customary communities to their lands, it was reported that procedures for titling such lands can be absent, defective or not applied (Colchester et al, 2006, Colchester et al, 2011; Wakker, 2005, Wright, 2011).

Future monitoring of indicator 9 in Indonesia

Certain studies (Colchester et al, 2006, Colchester et al, 2011; Wakker, 2005, Wright, 2011) has noted that Indonesia has experienced cases of conflicts over the use of the land, many of which were related to oil palm cultivation and thus, to some extent, to feedstock used for biodiesel production. As oil palm plantations continue to expand and higher biofuel mandates are considered in Indonesia, it is important to assess the resulting land tenure implications and monitor, in particular, the extent to which on the land used for 'new' bioenergy production due process is provided and the established procedures for determining legal title are followed.

Relevance, practicality and scientific basis of indicator 9

The testing in Indonesia confirmed the relevance of theissues addressed under indicator 9. With regard to the practicality, getting hold of the data and information required for themeasurement of this indicator can be quite challenging, given the sensitive nature of part of such data and information, and the complexity of the issues at stake.

Indicator 9 deals with allocation and tenure of land for *new bioenergy production* specifically. Data might be particularly scarce in the case of areas recently converted to the production of bioenergy feedstocks. In addition, as confirmed by the testing in Indonesia, in most cases it is not possible to identify the exact areas used for the production of bioenergy feedstocks. This is true, in particular, for vegetable oils such as palm oil, which can be transported over long distances and traded before being processed into biodiesel. Further guidance should be provided on these important methodological issues.

A pragmatic approach that was implemented in Indonesia was to analyse key variables closely related to land allocation and tenure, namely the structure of land ownership, the size and distribution of farms, and the various types of business models found along the bioenergy supply chain. A similar approach could be replicated in other developing countries as well when a quantitative measurement of indicator 9 cannot be conducted.

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3.10. INDICATOR 10: PRICE AND SUPPLY OF A NATIONAL FOOD BASKET

Description:

Effects of bioenergy use and domestic production on the price and supply of a food basket, which is a nationally defined collection of representative foodstuffs, including main staple crops, measured at the national, regional, and/or household level, taking into consideration:

- changes in demand for foodstuffs for food, feed, and fibre;
- changes in the import and export of foodstuffs;
- changes in agricultural production due to weather conditions;
- changes in agricultural costs from petroleum and other energy prices; and
- the impact of price volatility and price inflation of foodstuffs on the national, regional, and/or household welfare level, as nationally determined.

Measurement unit(s):

Tonnes; USD; national currencies; and percentage

3.10.1 Testing of indicator 10 in Indonesia

For the testing in Indonesia, each of the steps and tiers that comprise indicator 10 were implemented.

Step 1 (i.e. 'Determine the relevant food basket(s) and its components') was carried out based on information and data from both national and international sources.

With regard to step 2 (i.e. 'Assessing the links between bioenergy use and domestic production and changes in the supply and/or prices of relevant components of the food basket(s)'), data from FAOSTAT was used to obtain the "Preliminary indication" described under tier I.

Concerning tier II, the "Causal descriptive assessment" was carried out based on expert judgment and using both national and international sources. Furthermore, the information used in the assessment and the related results were validated by the project working group during a workshop that was held in Jakarta in November 2013 and that brought together relevant Indonesian experts and stakeholders.

Last, but not least, the 'Quantitative assessment' under tier III of step 2 was carried out using the partial equilibrium model AGLINK-COSIMO, which was run by the dedicated team of FAO specialists for four scenarios, of which one historical and three forward-looking. Given the importance of this complex model and in light of the interest expressed by national stakeholders, training sessions on AGLINK-COSIMO were held in Jakarta in August and September 2014. The training was attended by government officials from the Ministry of Agriculture and Ministry of Energy, in addition to experts from the main agricultural university in the country.

28 Each of these foodstuffs contributes for a share of less than 2 percent to the total calorie supply.

3.10.2 Key findings

Step 1: Determine the relevant food basket(s) and its components

With decree No 115/MPP/Kep/2/1998, Indonesia defined its national food basket. The national food basket contains nine items deemed as "staple goods essential for covering minimal living needs" (see table 3.10.1). In addition to foodstuffs, the Indonesian food basket also includes kerosene (*minyak tanah*).

Table 3.10.1

National Indonesian Food Basket items list

1	Rice
2	Sugar
3	Cooking oil
4	Beef and chicken meat
5	Eggs
6	Milk
7	Maize
8	Kerosene
9	Salt

Source: Decree No 115/1998

According to FAOSTAT (2014), rice is the main staple food in Indonesia as it represents roughly 47.6 percent of the total caloric content of the average Indonesian diet, while maize and cooking oil (mainly palm oil) represent 9.8 percent and 8.2 percent respectively of the average calorie intake of an average Indonesian citizen (see table 3.10.2).

Table 3.10.2

Food balance sheet for Indonesia (2009) ranked by per capita calorie intake.

Total calorie supply: 2,646 Kcal/day

Rank	Food stuff	Kcal/day	Percentage of total
1	Rice	1,259	47.58
2	Maize	259	9.78
3	Vegetable Oils	221	8.35
4	Wheat	151	5.70
5	Cassava	126	4.76
6	Sugar	124	4.68
7	Fruits	87	3.28
8	Coconuts	76	2.87
9	Meat	62	2.34
10	Groundnuts	52	1.96
11-23	Others[28]	380	14.36

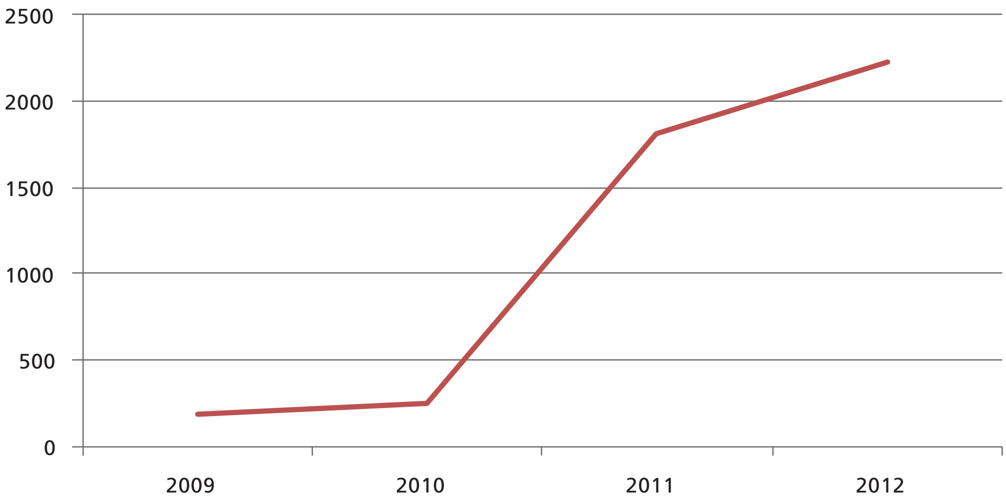
Source: FAOSTAT, 2014

Step 2: Assessing the links between bioenergy use and domestic production and changes in the supply and/or prices of relevant components of food basket(s).

In Indonesia, production of biodiesel from palm oil increased significantly in recent years (see figure 3.10.1). The analysis presented below under the three tiers that comprise this second step of indicator 10 aims to assess whether and how biodiesel use and domestic production (in combination with other factors) affected the supply and price of the food basket identified under step I.

Figure 3.10.1

Biodiesel production in Indonesia from 2009 to 2012 (in Million liters)



Source: Ministry of Energy, 2014

Step 2, Tier I: "Preliminary indication" of changes in the price and/or supply of the food basket(s) and/or of its components in the context of bioenergy developments

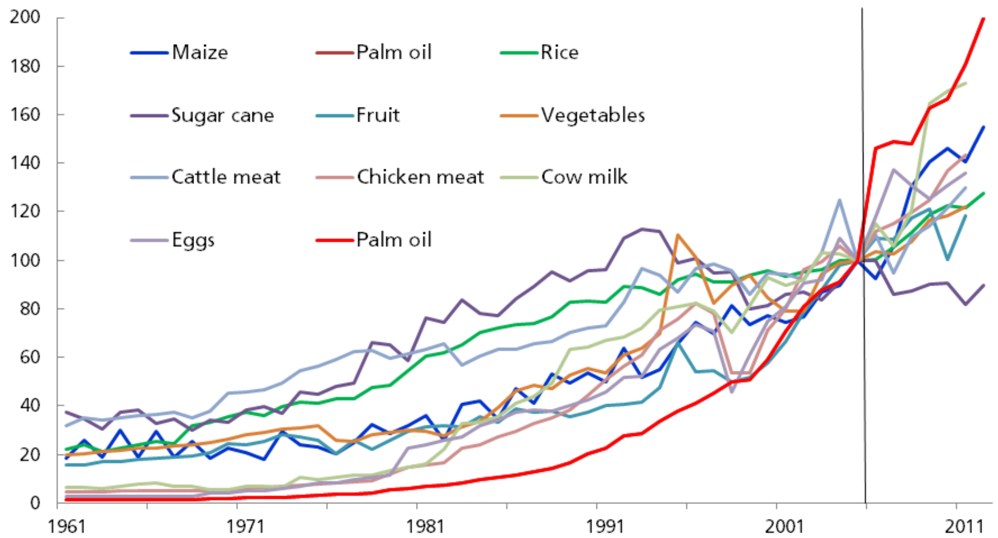
As shown in figure 3.10.2, production of the main food basket items shows an upward trend over the past few decades. This trend continued in recent years, in parallel with the increase in biodiesel production. The only exception is represented by sugarcane (Indonesia is a net importer of sugar), which showed a decreasing level of production.

Palm oil is the agricultural commodity that had the major relative upward change of all agricultural production from 2005 (index =100) to 2012 (index =199.5). Despite the increase in the demand for palm oil for biodiesel production, the supply of this vegetable oil for food (as cooking oil) increased during the past few years.

Finally, with regard to prices, between the second half of 2010 and the first half of 2013, rice and sugar showed an upward trend, while the price of cooking oil (mostly palm oil) jittered (see figure 10.3). Given the importance of rice in terms of its contribution to the average daily calorie in-take in Indonesia (i.e. 47.6 percent), the recorded increase in the price of this commodity warranted further investigation, which was conducted under tiers II and III of step 2.

Figure 3.10.2

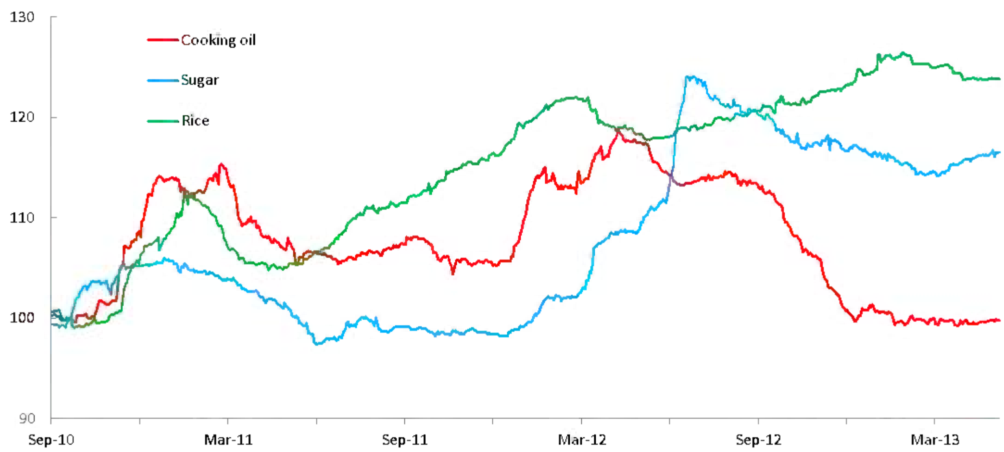
Indonesia: Agriculture Production, 1961-2012 (Index, 2005=100)



Source: FAOSTAT, 2014

Figure 3.10.3

Domestic prices of food basket items in Indonesia from Sept 2010 to May 2013



Source: FAOSTAT, 2014

Step 2, Tier II: "Causal Descriptive Assessment" of the role of bioenergy (in the context of other factors) in the observed changes in the price and/or supply

Tier II of step 2 consists of a *Causal Descriptive Assessment* (CDA) of the probability that the demand for modern bioenergy in a given country led to a downward pressure on supply – and an upward pressure on prices – of the relevant food basket(s) and/or of its components. The CDA is based on an analysis of the sources of bioenergy feedstock, which is performed based on expert judgment using historical data from both national and international sources. The feedstock employed for the production of modern bioenergy can be obtained through a combination of different pathways: imports, use of non-agricultural waste, residues from agriculture, forestry and fisheries, additional crop production (both in terms of increased yields and increased land surface) and diversion of crops from the food and/or feed markets.

As in the case of the other indicators, the analysis was conducted for biodiesel. In 2012, Indonesia produced about 2 million tonnes of this biodiesel from crude palm oil (CPO). The Causal Descriptive Assessment, which was conducted for the period 2011-2012 produced the following results:

A) Imports

According to the Ministry of Agriculture (2013) a negligible amount of CPO has been imported by Indonesia in 2012. Discussions with the Ministry of Energy (2014) confirmed that no imports of bioenergy feedstock took place over the study period.

B) Non-agricultural Wastes

Although small amounts of non-agricultural wastes, such as liquid manure and sludge, have been used to produce small amounts of biogas, as of 2012 no used cooking oil or other non-agricultural waste was used to make biodiesel in Indonesia.

C) Residues from agriculture, fisheries and forestry

As of 2012, there was no modern bioenergy production from residues from agriculture, fisheries and forestry in Indonesia.

D) Additional crop production

The share of CPO used for biodiesel production increased from 0.2 percent in 2008 to 8 percent in 2012. The growing demand for CPO was met through an increase in the production of this vegetable oil (as opposed to a diversion of it from the food market, i.e. pathway E), which was achieved through an increase in the land area (D1) rather than a yield increase (D2).

D1) Increased land area for crops

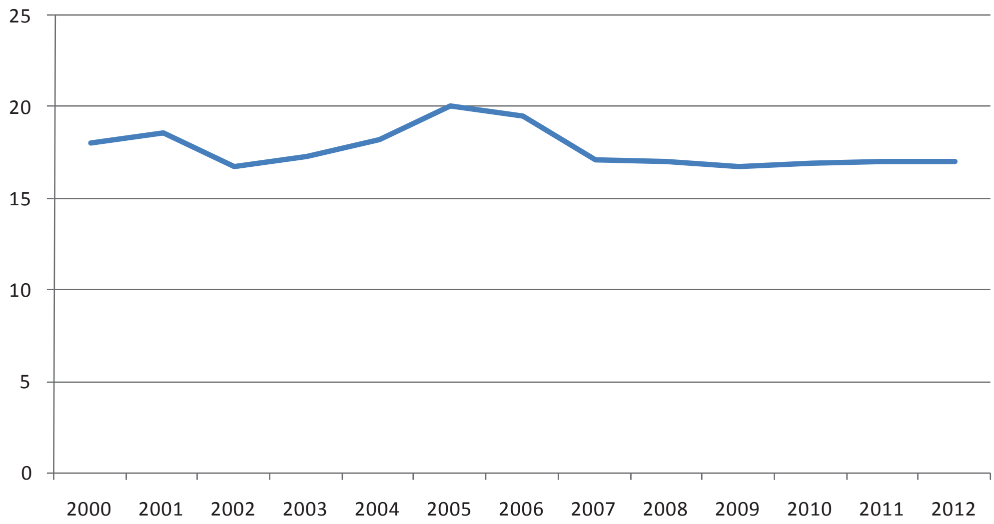
Land area for oil palm plantations increased from 4.1 million ha in 2001 to 7.3 million ha in 2008 and 9.5 million ha in 2012 (Ministry of Agriculture, 2013). As explained in indicator 8, according to Gunarso et al. (2013), 52.2 percent of oil palm expansion between 2001 and 2010 took place on non-agricultural land (i.e. all forest, shrub and grassland types), followed by agricultural land were non-FBC were cultivated (i.e. agroforestry, rubber and timber plantations) with 40.4 percent and agricultural land were FBC were cultivated (intensive agriculture, assumed to be rice) with 4.6 percent (Gunarso et al., 2013).

D2) Increased crop yield

As shown in figure 3.10.4, in Indonesia palm oil yields remained substantially stable between 2000 and 2012 (FAOSTAT, 2014).

Figure 3.10.4

FFB yields in Indonesia between 2000 and 2012 do not show an increasing trend



Source: FAOSTAT, 2014

According to the Ministry of Agriculture (2013) agricultural yields vary among locations, ownership type and size of the plantations. For instance, in 2012, the average yield in the island of Sumatra was 3.77 tonnes of CPO/ha, or about 17.1 tonnes of FFB per ha. In Java, average yield reach 2.5 tonnes of CPO per ha (about 11.4 tonnes of FFB/ha). The same variability is found among ownership types; for instance, government owned plantations report higher yields (i.e. about 20 $tonnes_{FFB}$/ha) compared to smallholders in the same area (i.e. 15.4 $tonnes_{FFB}$/ha) (Ministry of Agriculture, 2013).

While there seem to exist some efforts to improving technology and management practices in oil palm plantations (i.e. new oil palm varieties, introduction of modern soil management techniques, etc) these factors do not appear to have significantly affected the productivity of oil palm plantations in Indonesia over the reference period.

E) Diversion of crops from the food/feed market

As explained above, the increase in the demand for CPO for biodiesel production was met through additional palm oil production thanks to an increase in the dedicated land area, as opposed to a diversion of this vegetable oil from the food market (for cooking). This information is consistent with the data available in both national and international statistics. According to FAOSTAT, between 2008 (when production of biodiesel from CPO started) and 2012, in Indonesia the supply of CPO for food increased.

Summary of results

Causal descriptive assessment (step 2, tier II)

As explained above, the Causal descriptive assessment that was conducted in Indonesia based on expert judgment and using both national and international sources showed that the increase in the demand for palm oil for biodiesel production from 2008 onwards was met through an increase in the production of this vegetable oil. As revealed by the analysis of the available data, this increase was the result of an expansion of the planted area (and subsequently of the harvested area) of oil palm in the country. As described in detail in indicator 8, oil palm expansion took place mainly on non-agricultural land and only a very limited share of it displaced agricultural crops.

Given the supply response described above and the nature of the land use change associated with palm oil expansion in Indonesia, at least up to 2012 there was no diversion of palm oil from the food market to the biofuel market in the country. This is consistent with data available in national and international statistics. According to FAOSTAT, in Indonesia the supply of palm oil for food increased between 2008 (when biodiesel production started) and 2012. Therefore, the Causal descriptive assessment suggests that so far biodiesel production in Indonesia had no significant influence on the domestic food markets. Nonetheless, a quantitative assessment (i.e. step 2, tier III) was conducted as well in order to corroborate these results.

Step 2, Tier III: "Quantitative approaches – time-series techniques and computational modelling (e.g. CGE and PE)

In order to seek insights on the quantitative relationship between the demand for modern bioenergy and the price of food basket components in the case of Indonesia, a study based on the Tier III approach was also carried out, using the partial equilibrium model AGLINK-COSIMO. AGLINK-COSIMO is presently one of the most comprehensive models for global agriculture covering about 20 agricultural commodities and some 50 countries/regions. The model is one of the tools used in the generation of baseline projections underlying the OECD-FAO Agricultural Outlook. For many countries agricultural policies are specifically modelled within AGLINK-COSIMO. This makes the model a powerful tool for forward looking analysis of domestic and trade policies, comparing scenarios of alternative policy settings against the benchmark of the baseline projections (OECD-FAO Agricultural Outlook, website). AGLINK-COSIMO also includes explicit modelling of the biofuel sector, i.e. ethanol and biodiesel. Policies, such as blending mandates and taxes are explicitly incorporated. Other policy instruments such as border measures, tariff rate quotas, and production supports are also included to account for domestic policies.

In the case of Indonesia, three scenarios were analysed in terms of their impact on domestic food markets:

- Scenario 1: Biodiesel production from 2007 to 2012.
- Scenario 2: Biodiesel blending mandate increasing to 10 percent by 2022.
- Scenario 3: Biodiesel blending mandates increasing to 25 percent by 2022.

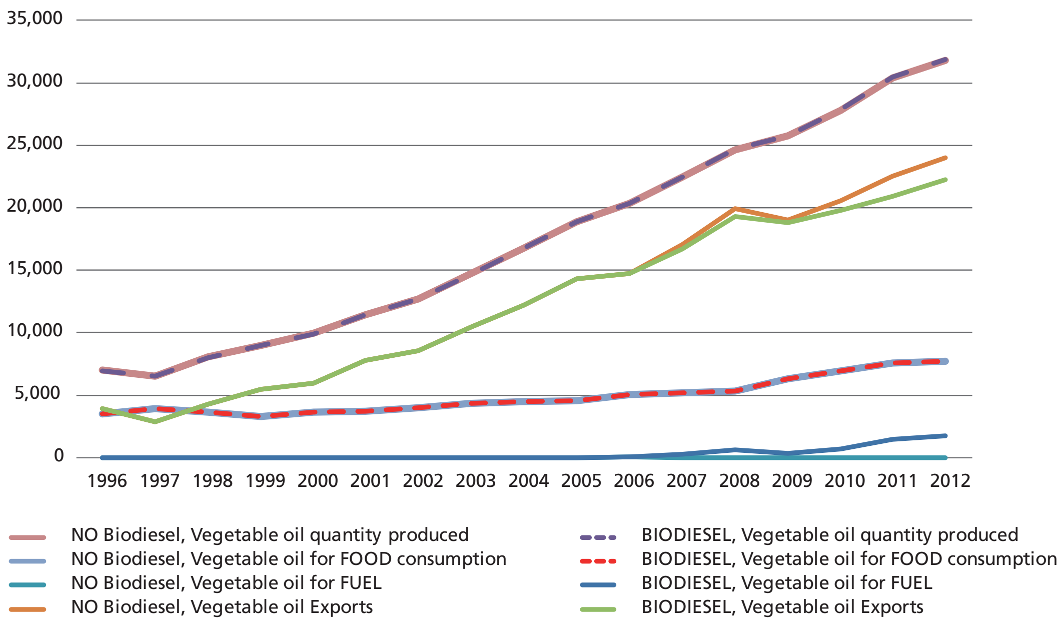
The approach used was to calibrate the 2013 version of the AGLINK-COSIMO model to replicate actual values for the period 2007 - 2012 and assess scenario 1 on that basis. For the forward looking scenario 2 and 3, the AGLINK-COSIMO model produced simulations for the period 2013-2022. Prior to the implementation of the scenarios a baseline model was developed against which the scenarios would be compared.

1. *Impact of biodiesel production on domestic prices of the main agricultural commodities from 2007 to 2012*

   This first scenario evaluates the impact of the biodiesel sector as a source of demand for vegetable oils, mainly palm oil, for the period of 2007-2012. This counterfactual scenario starts from a hypothetical baseline which describes food markets in Indonesia in the absence of biodiesel. It then analyses the deviation from this baseline caused by the use of vegetable oil to produce biodiesel. The use of palm oil for biodiesel came at the expense of exports which decreased by about 2 million tonnes (i.e. about 8 percent of total) in 2012 in comparison to the baseline. Because of this almost proportionate substitution, domestic prices of vegetable oils increased by approximately 1 percent which left domestic food consumption relatively unchanged. Overall results indicate that there have not been major changes affecting the food markets caused by biodiesel production. Domestic prices for rice, wheat, and coarse grains remained relatively unchanged in comparison to the baseline.

Figure 3.10.5

Impacts of biodiesel production on vegetable oil markets in Indonesia until 2012



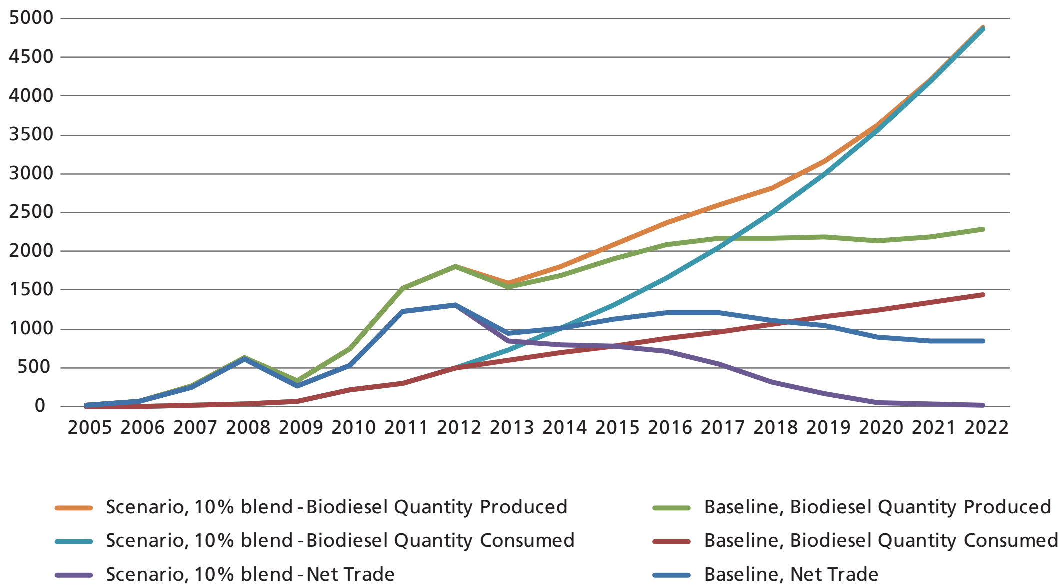
Note: IDN: Indonesia; VL: Vegetable oils; QP: production; FO: food use; EX: export; BF: biofuel use;
Source: FAO calculations

2. *Impact of increasing the biodiesel blending ratio to 10 percent by 2022*

The objective of this scenario exercise was to assess the implication of Indonesia achieving a 10 percent blending ratio for biodiesel by 2022. The baseline assumed that the realized blending in the country, despite a mandated blending rate of 7 percent, will only increase from 1.5 percent in 2012 to 3 percent in 2022. Under this baseline projection, Indonesia would use about 1.4 billion litres of biodiesel in 2022 and export around 800 million litres. Achieving the 10 percent mandate will require a consumption volume of almost 5 billion litres in 2022, this is realized by bringing production up to this level and driving biodiesel exports down to almost zero (figure 3.10.6). While these are tremendous expansions for the domestic biodiesel sector, they are small with respect to the Indonesian palm oil sector which is projected to produce close to 40 million tonnes of CPO in 2022. The additional feedstock demand for biodiesel will be satisfied through slightly reduced exports of CPO and a small production expansion of about 2 percent in 2022. Domestic price is projected to rise only slightly, such that food consumption will not be impacted negatively. With stable oil prices and no major land use shifts, the price structure of staple foods will not change and their consumption levels remain at baseline levels.

Figure 3.10.6

Indonesia biodiesel: level change between baseline and scenario 2



Note: IDN: Indonesia; VL: Vegetable oils; QP: production; QC: consumption; NT: Net trade; Output: scenario output; Baseline: baseline results
Source: FAO calculations

3. *Raising blending ratios to 25 percent for all sectors (i.e. transport, electricity generation, commerce, industrial)*

   The last scenario investigated the likely impact of raising gradually the blending ratio to 25 percent (for all sectors) by 2022. This value was chosen and tested because the newly enacted Indonesian National Energy Policy (KEN) has mandated that past year 2020, the blending of biodiesel into fossil diesel will have to reach at least 25 percent for all sectors, thus including but not limited to transport. In fact, all diesel used in the industrial, electricity generation and commerce sectors will also reach at least the 25 percent blend ratio past 2020. This operation would require about 10 billion tonnes[29] additional biodiesel consumption in 2022. To meet the extra demand in biodiesel, domestic vegetable oil production would increase by 6 percent (about 2 million tonnes), and such an increase is expected to be achieved mostly through area expansion by about 350 thousand hectares. Indonesian CPO exports would decline by at least 30 percent and domestic consumption of cooking oil would fall by an estimated 2 percent. As a result of the increased blending ratio in Indonesia, world vegetable prices could increase by at least 12 percent, while world biodiesel prices are expected to rise by 11 percent.

   Indonesia has been the largest exporter of vegetable oil in the world and a significant exporter of biodiesel. This scenario reduces the exports of both commodities significantly which induces a noticeable price shift in these markets. The reduction of palm oil exports by 7.7 million tonnes corresponds to about 9 percent of total trade. It results in an increase of at least 12 percent in the world vegetable oil price, because the compensation by other producers can only happen at higher marginal cost. The relative reduction in biodiesel trade is even more drastic, as Indonesia is projected to account for about 25 percent of global biodiesel exports. This shortfall would cause an 11 percent rise in the international biodiesel price by 2022.

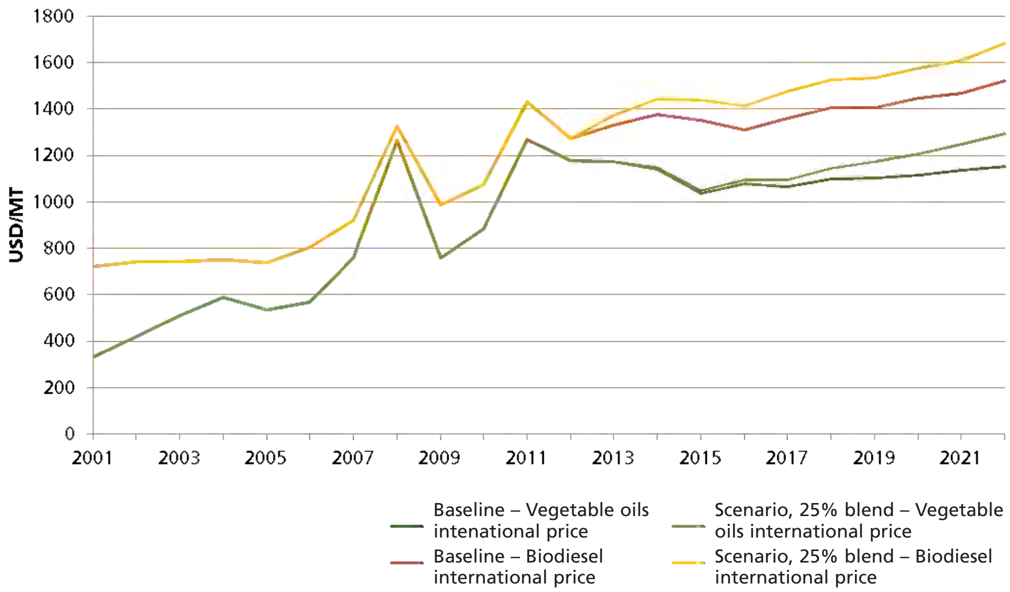
   As a result of the vegetable oil price increase, global consumption of this commodity for food may decrease by 2 percent (approximately 3.6 million tonnes), while global vegetable oil production would increase by 3 percent (approximately 5.2 Mt) in 2022. This price increase is expected to stimulate global competitors to produce an additional 3 million tonnes of vegetable oil. In this scenario, Malaysia would provide approximately one-third of this total, while the balance would be shared equally among Canada, China, the European Union and Brazil. The greatest decline in vegetable oil consumption as food would be observed in China, where consumption, in this scenario, is expected to decrease by approximately 1.4 million tonnes (-4 percent) in 2022.

   The reduction in biodiesel exports from Indonesia would be compensated by two adaptations: first, the expansion by Argentinean exports and second, the reduction of imports into the EU.

29 The value of 10 million tonnes is estimated on a volume basis. By taking into account the lower LHV of biodiesel, a larger share of CPO would be required to fill the energy gap. On an energy basis, in fact, a total of 11.3 million tonnes of CPO may be needed to meet the energy requirements of the substitution of 25 percent of all diesel consumed in Indonesia by 2022. This would amplify even further the effects on price and supply of vegetable oil and other food commodities both domestically and internationally.

Figure 3.10.7

Raising the blending ratio[30] to 25 percent, impact on world markets



Source: FAO calculations[30]

Uncertainties surrounding the scenarios

The medium term projections results are a conditional scenario of likely market developments based on assumptions about macroeconomic developments, domestic policies, trade policies and normal weather conditions. Should any of these assumptions change, the resulting set of projections and scenarios would also be different. For example, changes in domestic biodiesel policies in the EU or any other trading partners can alter the level of their trading pattern for vegetable oil.

3.10.3 Main conclusions and recommendations

Results of indicator measurement

The assessment of indicator 10 has provided several relevant findings. Although the Tier I approach has not offered a clear understanding of the existence of relationships between bioenergy production and price and availability of food basket components in Indonesia, the assessment of other components of the indicator (Tier II and III) have returned interesting results.

In Indonesia, as of 2012, modern bioenergy was almost entirely produced from palm oil. The country has not imported significant amount of any bioenergy feedstock nor has it used non-agricultural wastes or residues for the production of modern biofuels. The production

30 This is considered for all sectors: transport, industry, commerce and electricity generation.

and development pattern of the palm oil industry in Indonesia has followed an increasing trend independently upon the additional demand for biodiesel. The testing of various forward looking scenarios under the Tier III has confirmed that being such a large exporter of palm oil, Indonesia could supply biodiesel quantities such that a 10 percent mandate is met countrywide, without contributing significantly to decreasing the availability and/or increasing the price of foodstuffs included in its national basket. In the case of meeting the ambitious mandate proposed in the new National Energy Policy, for which additional 10 million liters of biodiesel would be required by 2022, the implications with food security would instead be evident at the domestic level, leading to a decrease in the consumption of cooking oil as consequence of increased price. This policy would indirectly affect also availability of vegetable oils on the global market as most of the feedstock for fulfilling the 25 percent blending target would be diverted from the export market. As a consequence of reduced availability of palm oil on the world market, international prices would rise and price transmission effects would interest the whole vegetable oil sector.

Future testing of indicator 10 in Indonesia

The testing of indicator 10 in Indonesia has produced important findings. The assessment of the Causal Descriptive Assessment (Tier II) for the reference year, has informed about the origin of the feedstock in use for biodiesel production and it has concluded that bioenergy implications with the availability and price of food basket items have not been significant as of 2012. The forward looking scenarios produced through the Tier III approach have offered insights on the likely consequences of future policies and actions on domestic and international food markets. In order to monitor the implications of bioenergy in the future, it is fundamental that the assessment of indicator 10 is carried out in Indonesia on a regular basis. In order to enable the country to self-assess the implications of bioenergy production and price and supply of the national food basket, FAO has organized capacity development activities aimed at familiarizing Indonesian experts with the tools used throughout this project. It is recommended that, for the future testing of the indicator 10 in Indonesia, scientists involved in the training continue the development of their capacity to use the tools in their day-to-day activity.

Relevance, practicality and scientific basis of indicator 10

A challenge to the investigation of the relationship between biodiesel production and the trend of cooking oil in Indonesia with the Tier I approach was the limited availability of observations on price data, due to the relatively recent development of the bioenergy sector in the country. In addition, in the Tier I approach, other factors which affect the cooking oil price, including possible external shocks, can hardly be considered. For the assessment of Tier II data availability and collection constituted a challenge that was overcome with great efforts, investing time and financial resources to collect the information required, cross check and validate the results. The existing data needed for the completion of the analysis of Tier II was not readily available as it was expected given the nature of the Causal Descriptive Assessment which requires information from the agriculture, forestry, trade and energy sector. The joint coordination of FAO and the Directorate for Bioenergy of the Ministry of Energy and Mineral Resources of Indonesia, together with the support of the members of the stakeholders group instituted around this project, allowed the research and collection of most of the cross-sectoral information needed for the assessment of Tier II. For the assessment of the quantitative implications of biodiesel production in Indonesia through the Tier III approach the support of FAO experts was fundamental. The human capacity to produce and run complex global commodities models such as the AGLINK-COSIMO was not in place at the beginning of this project. FAO has therefore organized and performed two workshops and training sessions on the use of the tool for the assessment of Tier III which was attended by government officials from the Ministry of Agriculture and Ministry of Energy, in addition to scientists from the major agricultural university in the country. Without the support of the international community the valuable outcomes of the assessment of indicator 10 could not have been achieved. This limitation to the practicality of the tool requires the continued support of agricultural economists and food security experts which may not be available in every country.

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3.11 INDICATOR 11: CHANGE IN INCOME

Description:
Contribution of the following to change in income due to bioenergy production:
(11.1) wages paid for employment in the bioenergy sector in relation to comparable sectors
(11.2) net income from the sale, barter and/or own-consumption of bioenergy products, including feedstocks, by self-employed households/individuals

Measurement unit(s):
(11.1) local currency units per household/individual per year, and percentages (for share or change in total income and comparison)
(11.2) local currency units per household/individual per year, and percentage (for share or change in total income)

3.11.1 Testing of indicator 11 in Indonesia

Disaggregated data on wages in bioenergy feedstock production and processing were found in literature and were cross-checked with up-to-date surveys performed in two locations in North Sumatra, one of the main bioenergy feedstock production areas in Indonesia. Information on the price paid to independent smallholders for the sale of FFBs to the palm oil mills was not found, consequently indicator component 11.2 could not be measured. Information on potential and actual wages paid to workers in the feedstock production and processing stages of the value chain were recorded and compared. The analysis of the primary and secondary data obtained during the project reinforced the quantitative assessment of component 11.1 of this indicator. Due to the variability of contracts and agreements that smallholders have with the buyers of their products, a broader survey was deemed necessary to assess representative average values for the calculation of indicator component 11.2.

3.11.2 Key findings

Values of average monthly wages for 2013 in Indonesia ranged from IDR 2,200,000 for Jakarta (metropolitan area) to around IDR 830,000 for Central Java Province (Wageindicator, 2013). In 2013, in Indonesia minimum wages increased on average by 18.32 percent when compared to 2012. However, depending upon the job category considered, minimum wages show marked variability throughout the country.
Data obtained through the annual National Labour Survey (BPS, 2013; BPS, 2013a, BPS 2013b, BPS, 2013c), was adapted to the ILO classification (ISCO-88) and presented in Table 3.11.1. The values shown refer to mean nominal monthly earnings by job category in Indonesia for the period 2009 - 2010.

Table 3.11.1

Mean Nominal Monthly Earnings of Employees by Occupation (IDR), Indonesia (2009/2010)

Occupation (ISCO-88)	2009	2010	Change between 2009-2010 (%)
1. Legislators, senior officials, managers	3,770,501	3,767,499	-0.08
2. Professionals	1,815,655	1,869,505	+2.97
3. Technicians and associate professionals	2,220,670	2,215,217	-0.25
4. Clerks	1,696,432	1,782,737	+5.09
5. Service workers and shop and market sales workers	982,352	1,013,965	+3.22
6. Skilled agricultural and fishery workers	819,583	825,282	+0.70
7. Craft and related trade workers	895,287	967,489	+8.06
8. Plant and machinery operator and assemblers	1,253,460	1,327,688	+5.92
9. Elementary occupations	813,385	878,850	+8.05
10. Armed forces	2,674,102	2,808,799	+5.04

Source: Wageindicator (2013), BPS, 2013 BPS, 2013a, BPS, 2013c and ILO, 2013a adapted to ILO (2013b)

The occupational categories most relevant to the assessment of this indicator are: skilled agricultural workers, plant and machinery operators and elementary (unskilled) occupations.

During the project, FAO has conducted field surveys in areas where modern bioenergy is produced in Indonesia and compared to the national figures the values obtained. Table 3.11.2 summarizes the results of the field survey concerning average monthly wages paid to the employees of two oil palm plantations in North Sumatra in 2012 in order to provide data to describe the agricultural stage of the bioenergy chain. Three types of employee in the feedstock production stage of the chain were found: 1) free daily labour that is not exclusively contracted by the company; 2) contractual employees who have a temporary contract with one company which usually provides an accommodation for them and their families inside the plantation area for the duration of their contract; and 3) formal employees; exclusively contracted by one company, they often have a higher education level, belong to the category of “skilled workers” and their tasks may include the management of other employees.

Wages in the feedstock production stage are usually calculated on a daily rate basis, as the majority of the workers employed in this stage of the chain are contracted as free daily labour. However, discrepancies in daily rate among different types of contract are not extreme; from the survey in the field it emerged that daily rates for workers in oil palm plantations in North Sumatra, are comprised between IDR 47,510/day (USD[31] 4.90/day) and IDR 59,990/day (USD 6.18/day). These values are slightly higher than the average national *nominal* wage for farm workers in Indonesia as according to BPS (2014) these in

31 At the average 2012 exchange rate of 1 USD = 9,695 IDR.

2012 ranged between IDR 39,727/day (USD 4.10/day) and IDR 40,877/day (USD 4.21/day) but almost double the *real* wage which was on average IDR 28,300/day (USD 2.91/day) in that year.

Table 3.11.2

Average wage for the main components of the feedstock production stage in IDR as of August 2012

Job type/division	Number of Employees	Average base monthly salary (IDR)	Average total* monthly salary (IDR)
Harvesting	184	1,205,854.8	1,558,761.2
EX	3	1,138,733.0	1,598,925.5
Grooming	2	1,089,220.0	1,370,504.5
Maintenance	247	1,139,322.0	1,210,806.9
OT	36	1,218,088.7	1,507,842.8
Transportation	69	1,167,273.5	1,590,523.2
WS	4	1,349,090.5	1,602,423.7
Total	545	--	--
Average	--	1,186,797.5	1,491,398.2

** Including overtime and extras*
Source: Survey at the operation site of a selected biodiesel company in north Sumatra, September 2012

Including overtime (worker have reported to be able to work up to 26 days per month in the survey area) and extras (including allowances for food and beverages) on average at feedstock production level, a worker in the survey location in North Sumatra is paid between IDR 1,210,806 and 1,602,423 (between USD 127.88 and 165.28) per month.

Unlike feedstock production jobs, almost all employees working in the palm oil mills (POM) are categorized as formal employees exclusively contracted by the company. Wages paid to mill operators are generally higher than average wages paid to workers employed in feedstock production. The average base monthly salary for these categories of workers is IDR 1,843,658 (USD 189.90), while the average total monthly salary, including overtime and extras, is IDR 3,230,655 (USD 332.76) (Table 3.11.3).

The average base monthly salary of most workers in the feedstock production stage is slightly below the official monthly wage of the Province for the year 2012 (average IDR 1,186,797.5 vs. IDR 1,375,000). However, the total monthly salary (including overtime and extras) of all workers in feedstock production is above the minimum wage threshold (table 3.11.3). Both average base and total monthly salary of feedstock production workers are higher than the index of minimum living needs for North Sumatra's province and higher than the mean nominal monthly earnings of employees in similar sectors (Table 3.11.4).

Table 3.11.3

Average wage for the main components of the palm oil milling operations in IDR as of August 2012

Department	Number of employees	Average base monthly salary (IDR)	Average total* monthly salary (IDR)
Administration	6	2,226,929.8	2,983,744.5
Mechanical	19	2,226,929.8	2,983,744.5
PGA	6	2,226,929.8	2,983,744.5
Process A	32	1,474,823.8	3,603,284.1
Process B	32	1,570,412.0	3,489,962.1
Quality Control	5	1,522,617.9	3,546,623.1
Security	30	1,546,514.9	3,518,292.6
WB	3	1,954,113.0	2,735,848.7
Total	133		
Average		**1,843,658.9**	**3,230,655.5**

** Including overtime and extras*
Source: Survey at the operation site of a selected biodiesel company in north Sumatra, September 2012

Table 3.11.4

Comparison of average wages per month in each sector of CPO-based bioenergy chain

Component	Value in IDR**
Average base monthly salary in feedstock production	1,186,797
Average total* monthly salary in feedstock production	1,491,398
Average fix wages per month in POM	1,843,659
Average total wages per month in POM	3,230,655
Official North Sumatra Province minimum wage	1,200,000
North Sumatra Province's index of minimum living needs	1,035,028

** Total monthly wage includes overtime and extras*
*** Average values*
Source: Survey at the operation site of a selected biodiesel company in north Sumatra, September 2012

The results of this study show that wages paid to employees in the early stages of the biodiesel value chain (feedstock production and processing) in North Sumatra have been around or above the minimum wage of the Province for comparable job categories (table 3.11.4). However, information concerning the number of hours worked daily, hourly wages and the incidence of overtime hours and days was not thoroughly and consistently reported by the participants during the survey.

3.11.3 Main conclusions and recommendations

Results of indicator measurement

As of 2012, biodiesel is still a relatively new commodity in Indonesia. Assessing the change in income due to the presence of this form of bioenergy in the country is therefore difficult. Moreover, throughout most part of the value chain, workers perform their activities without a clear attribution to the end use of the feedstock produced (agricultural phase) and processed (industrial phase). Data on wages paid to personnel in the biodiesel refinery plants were not collected during the survey. However, based on the literature and the cross-checking of secondary information, along with the results of a field survey in an area where bioenergy feedstock is produced, has delivered interesting results: monthly wages paid to workers in the feedstock production of the bioenergy value chain in North Sumatra have been around or above the minimum wage of the Province for comparable job categories with a differential of -2 percent (base salary) to +24 percent (including overtime and extras). Workers employed in feedstock processing have comparatively much higher minimum wage. Workers in this last category, in fact, reported wages that reach two fold the national average for plant and machinery operators.

Future monitoring of indicator 11 in Indonesia

The biodiesel case study is based on the operations of companies in North Sumatra that provided data on monthly wages for one month only. Therefore, this analysis should be used as a baseline for future comparisons and monitoring, however, a longer time series (at least 12 months) would provide more reliable information. It is therefore suggested to collect income data from workers directly involved in the bioenergy industry and people who live in surrounding areas of plantations and mills that might have indirect or induct income changes amenable to bioenergy. In addition to an extended timeframe, a future broader survey should comprise information on prices paid to local smallholders for the production of potential bioenergy feedstock by contract type, in order to allow for the quantitative assessment of indicator component 11.2.

Relevance, practicality and scientific basis of indicator 11

Due to lack of data it was not possible to complete the measurement of this indicator. However, no particular issues arose in relation to the indicator methodology.

The availability of - and access to - detailed data related to wages and prices might be an issue in a number of countries due, among other things, to the commercially sensitive nature of part of this information. In the particular case of Indonesia, where the well-established palm oil industry has recently seen the appearance of a further production pathway (i.e. biodiesel) for its main commodity, possible changes in income can hardly be attributed to modern bioenergy with statistical significance. The challenges posed by the correct attribution to one of the complementary products of a value chain (in this case biodiesel as part of the broader palm oil sector) are redundant for many indicators and require further guidance, particularly for monitoring purposes in developing countries.

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3.12 INDICATOR 12: JOBS IN THE BIOENERGY SECTOR

Description:

Net job creation as a result of bioenergy production and use, total (12.1) and disaggregated (if possible) as follows:

- (12.2) skilled/unskilled
- (12.3) indefinite/temporary.

(12.4) Total number of jobs in the bioenergy sector; and percentage adhering to nationally recognized labour standards consistent with the principles enumerated in the ILO Declaration on Fundamental Principles and Rights at Work, in relation to comparable sectors (12.5)

Measurement unit(s):

(12.1) number and number per MJ or MW
(12.2) number, number per MJ or MW, and percentage
(12.3) number, number per MJ or MW, and percentage
(12.4) number and as a percentage of (working-age) population
(12.5) percentages

3.12.1 Testing of indicator 12 in Indonesia

To date, no official data on employment in the bioenergy sector specifically is readily available for Indonesia and it is difficult to estimate with accuracy the actual size of the workforce involved in the sector. Official employment statistics for Indonesia classify sectors of the national economy in an aggregated form which may either subsume or cut across categories that all enumerate workers in the bioenergy sector. For instance, in the National Labour Survey, which is carried out annually and is also the key source of data on employment status and employment by sector, there is no standalone figure available for employment in agriculture. Employment data is presented as aggregate for agriculture, forestry, hunting and fishery. However, the work of different authors who have attempted estimating the workforce attributable to bioenergy alone was included in this study. In addition, a survey approach was taken also for the measurement of indicator 12; interviews with one selected large biodiesel operator in Indonesia were conducted and the results compared with information found in literature.

3.12.2 Key findings

According to the Indonesian Central Bureau of Statistics (BPS, 2014), some 41 million workers have been employed continuatively in agriculture from 2006 to 2012 (table 3.12.1). Other sectors (e.g. Industry, transport, etc) are likely to include workers whose occupation is also linked to activities taking place in the bioenergy sector although, admittedly, agriculture is likely the largest contributor to the number of workers employed in the bioenergy sector.

Table 3.12.1

Workers in Agriculture, Forestry, Hunting and Fishery, 2006-2012 , Indonesia (millions)

Year	2006	2007	2008	2009	2010	2011	2012
Workers	41,561,987	41,229,716	41,907,617	42,010,671	42,320,667	42,160,374	40,902,122

Source: Edited from BPS (2014)

Workforce size estimates in the palm oil sector in Indonesia vary considerably. Some authors estimated that in 2006 palm oil production in Indonesia, employed between 1.7 and 2 million people (Zen et al, 2006; Sheil et al, 2009) and in 2011 CIFOR (2013) reported about 3.2 million workers involved in palm oil production. CIFOR (2013) estimated that the palm oil sector in Indonesia employs 1 person every 2.5 hectares of land planted with the oil crop throughout the whole value chain. The palm oil value chain includes processing and other industrial processes as well as transport, trade and distribution. Although it is difficult to assess the share of jobs in the bioenergy sector alone without dedicated statistics, the strong link between the palm oil and the biodiesel value chains offers the possibility to use the former as a proxy of the latter.

The results of a survey carried out by FAO at the operation site of a selected large bioenergy producer in Riau Province, Sumatra, in 2012, are used as a case study to assess indicator component 12.1. In 2010, the surveyed company produced about 300 million liters of biodiesel or about 14 percent of the total national output for the same period (Indonesia produced some 2.2 billion liters of biodiesel according to the Ministry of Energy, 2012). In the palm oil plantation and mills there were 545 workers employed at the moment of the survey, 97 percent of which categorized as unskilled. Of these, 59 percent is hired as free daily labours (no formal contract, see indicator 11) while the rest are contractual labours. In the value chain of the selected palm oil and biodiesel operator in Sumatra, a representative example of large scale estate plantation for the production of biodiesel feedstock in Indonesia, only 3 percent of the employees in the agricultural stage of the chain are skilled workers. These are contracted as formal employees and occupy management positions.

The situation in the palm oil milling operation site near the plantation surveyed in north Sumatra is somewhat different: from a total of 133 workers registered, 27 percent are categorized as skilled workers and the rest is identified as unskilled workers. Similarly, in the bioediesel refinery located in the area of the survey, and part of the biodiesel value chain, a share of skilled workers comparable with that of POM was observed.

From the analysis of the palm oil biodiesel industry in Sumatra, the number of employees required for its operations and the output/input capacity in each stage of the chain, the labour intensity of the sector was estimated as an aggregated of the first (and most labour intensive) stages of the chain: A) feedstock production and B) feedstock processing into fuel. Based on information provided by the selected palm oil and biodiesel operator surveyed, it was estimated that the production of additional 11.7 tonnes of biodiesel would create 1 job in the bioenergy chain, which equals to 0.0000022492 jobs/MJ[32] in the case study conditions. Based on the primary information collected it was estimated that, in 2012, the production of 2 million tonnes of biodiesel has created an estimated 170,000 jobs of which about 80.4 percent in the feedstock production phase and the rest in the processing and transport phases. Likely, such an estimate is somewhat conservative as it is likely that the net job creation in smallholders' plantations is higher than in the average large estate plantation due to the lower level of mechanization found in the small farms in Indonesia.

The estimates of employment obtained through the survey at the selected palm oil and biodiesel operator studied can be compared with the estimates made by other authors (CIFOR, 2013) concerning the palm oil value chain. In 2012 it was estimated that about 8 percent of total CPO produced in Indonesia (26 million tonnes, according to the Ministry of Agriculture, 2013) was used for biodiesel production. This is equal to about 750,000 ha planted with oil palm and about 560,000 ha of area harvested. Throughout the whole value chain, CIFOR (2013) reported that every 2.5 ha planted with oil palm 1 worker is employed. This means that, the oil palm harvested area used to produce biodiesel in 2012 may have employed about 220,000 to 250,000 workers throughout the value chain. This value is comparable with the estimates provided by the selected palm oil and biodiesel operator for the specific case of the biodiesel production in Sumatra.

3.12.2 Main conclusions and recommendations

Results of indicator measurement

Modern bioenergy production and use in Indonesia is a relatively recent activity as it started on a commercial scale in 2008. Based on the total number of jobs in the palm oil sector and on insights on the quantity of jobs in specific stages of the bioenergy value chain (e.g. feedstock processing) obtained through field surveys, the number of direct jobs created as a result of biodiesel production in Indonesia was estimated at about 200,000 in 2012, i.e. 2.25 jobs x 10^{-6} for each MJ of biodiesel produced. Out of these 200,000 jobs, 80.4 were unskilled (97 percent at feedstock production level) and 19.6 percent were skilled (with high prevalence at the feedstock processing level). The majority of workers in the feedstock production stages (59 percent) are hired as free daily labours (temporary) whereas slightly more than 40 percent have a temporary contract and a closer relationship with the company and enjoy optional benefits (e.g. accommodation provided within the plantation borders, etc). In oil palm cultivation, and thus in the feedstock production stage of the bioenergy chain, only 3 percent of the workforce is considered skilled and is more likely to have indefinite duration contracts.

In the feedstock processing stages instead, about 27 percent of the workerforce is classified as skilled however, information about the formal recognition of indefinite duration of these contracts was not retrieved.

32 Considering the LHV of biodiesel 38 MJ/kg, 11.7 tonnes of FAME contain 444.6 GJ and would lead to the creation of 1 additional job. Therefore, the production of additional 1 MJ of FAME would create 0.0000022492 jobs.

Future monitoring of indicator 12 in Indonesia

As the bioenergy sector continues to expand and higher biofuel mandates are considered in Indonesia, it will be important to assess the resulting employment effects. The estimates that were made under this indicator are based on 2010 data and were inferred to 2012.

The estimates of employment in the biodiesel value chain in Indonesia are the result of the integration of field surveys and literature research. For the future monitoring of this indicator, the contribution of bioenergy producer associations (e.g. APROBI) is deemed fundamental to take into account regional and provincial differences and access a broader quantity of information. In fact, the case study of selected palm oil and biodiesel operator in Riau (northern Sumatra), although representative of one of the main biodiesel feedstock production areas in Indonesia, could not include the generation of employment in the later stages of the biodiesel value chain (e.g. transport, distribution, trade) which are often taking place away from production sites. It is therefore suggested that bioenergy producer associations are represented and contribute actively to the monitoring of this as well as other indicators in the future.

Relevance, practicality and scientific basis of indicator 12

The testing of indicator 12 in Indonesia confirmed the importance of measuring the employment effect of bioenergy production, both in terms of number of jobs created and in terms of employment quality and labour conditions.

As confirmed by the estimates made for Indonesia, the large majority of jobs linked to bioenergy are associated with feedstock production. Therefore, the results of the indicator depend mainly upon the methodology used for the attribution of the total number of jobs in the production of the crops/feedstocks for bioenergy. In light of this, further guidance would be needed on the complex issue of attribution.

Indicator 12 is supposed to measure net job creation. In the case of Indonesia, where modern bioenergy production has started relatively recently and where the main feedstock is palm oil, this was possible given the available information. However, the attribution to bioenergy only of the net job creation appears to be a rather ambitious goal, as in addition to the jobs attributable to biodiesel production, this indicator requires measuring those associated with the activities that have been displaced by biofuel production. While in theory this should be feasible in most cases, data availability might be a constraint, affecting the feasibility of measuring this indicator.

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3.13 INDICATOR 13: CHANGE IN UNPAID TIME SPENT BY WOMEN AND CHILDREN COLLECTING BIOMASS

Description:
Change in average unpaid time spent by women and children collecting biomass as a result of switching from traditional use of biomass to modern bioenergy services

Measurement unit(s):
Hours per week per household, percentage

3.13.1 Testing of indicator 13 in Indonesia

In most developing countries, firewood collection is a time- and energy-intensive activity, particularly in remote rural areas and in certain regions of the world, women and sometimes children are responsible for the collection of biomass for cooking and heating (FAO, 2011). Some studies note the pivotal role of women in collecting biomass for cooking in rural areas of Indonesia (Holmes, 2010) and other authors (Pattanayak et al., 2004) report that households that own stoves are likely to spend less time collecting fuelwood from forested areas in rural Indonesia, but do not break out the impact by age or gender. Koning et al (2000), report that in Indonesia women and children are involved in fetching wood, particularly for traditional ceremonial purposes, however more often this activity is carried out by men.

The available literature on this specific topic reviewed during this project, does not report a quantitative value of time spent collecting biomass, necessary for the measurement of this indicator. It was felt that the nature of indicator 13 required a specific survey to understand the share of traditional biomass used as energy source and the related time spent collecting the fuel. A representative sample of households was selected in rural and semi-rural areas in north Sumatra and the respondents indicated their preferences in terms of energy sources used for cooking and the related time required for its provision, particularly in the case of firewood.

3.13.2 Key findings

According to BPS-ILO (2009), in Indonesia some 4 million children aged 5-17 (6.9 percent of total population) were considered as working children in 2009, of which 43 percent would be classed as child labour (working below age). Other sources estimated that some 2.4 million boys and 1.6 million girls aged 10-17 were in child labour in Indonesia in 2009, with 28 percent of the boys and 34 percent of the girls actually working in hazardous situations involving over 40 hours per week (in van Klaveren et al, 2010). Nearly 58 percent of all economically active children aged 7-14 in 2009 were working in the agricultural sector (BPS-ILO, 2010; World Bank, 2013).

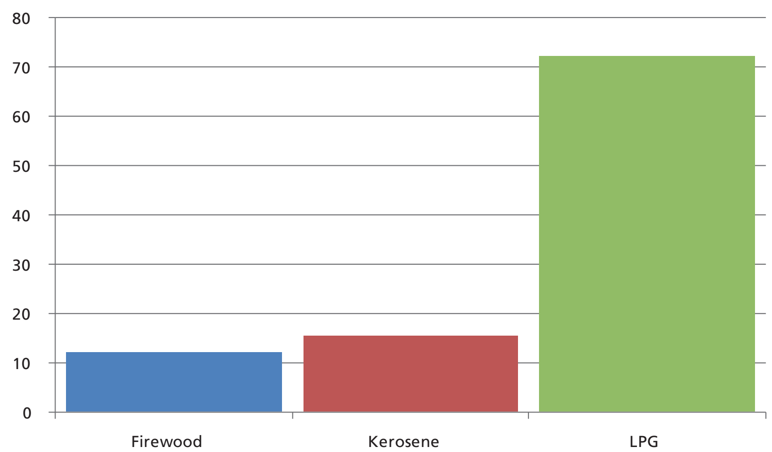
Information from literature on the amount of firewood used for cooking purposes in Indonesia is scarce and reliable sources reporting insights and studies on time spent collecting biomass were not found during the course of this project. Therefore, in order to measure this indicator, a specific field survey was carried out. In a rural area in north Sumatra, where the main economic activity is oil palm cultivation, 43 households found inside and in the surroundings of secondary forest areas, oil palm plantations, palm oil mills, and bioenergy refineries were surveyed. According to CIFOR (2003), only 6 percent of the woodfuel in Indonesia is collected from the forest, whereas the vast majority comes from non-forest areas (e.g. plantations, agroforestry land, and other types of farmland) like those surveyed during this project. Household members were asked to report about the energy sources commonly used for cooking, whether they used traditional biomass (or have used firewood in the past), or whether they rely on modern bioenergy sources or other forms of energy. For those households that do collect firewood or used to collect firewood in the near past, further questions related to the logistics and organization of the firewood collection activity were asked, including questions concerning what members of the household usually collect biomass and the amount of time they typically spend performing this activity.

Additional questions related to the intention to move from traditional use of biomass to modern bioenergy uses were also posed to the respondents.

The three most popular energy sources for cooking in Indonesia are kerosene, LPG and firewood, followed by charcoal and electricity. Starting from 2007, the Indonesian Government initiated a conversion program for household energy consumption to reduce dependence on kerosene in favour of LPG by giving every household a gas stove and 3 kg gas tubes to roughly 50 million households. This massive project provided an improved household cooking technology with its associated health and environmental benefits and reduced the Government's huge subsidy for kerosene. To date, LPG is the dominant cooking energy source in Indonesia as more than 50 percent of the households in the country use LPG as main energy source for cooking (Budya and Arofat, 2011; Pertamina & WLPGA, 2011).

Figure 3.13.1

Percentage of households relying on firewood, kerosene or LPG as their main energy source for cooking in the survey area



Source: Survey in north Sumatra, September 2012

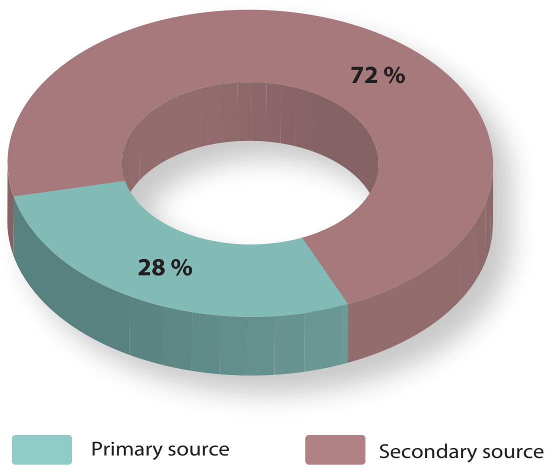
Out of the surveyed sample, 67.2 percent use a single energy source for cooking, while the remaining 32.6 percent relies on multiple energy sources and, for most, the secondary energy source employed for cooking is firewood. As of 2012, in the survey area, about 72.1 percent of the sampled households used LPG as their primary energy source for cooking. Kerosene is utilized by 15.7 percent of the sample and firewood is used by 12.2 percent of the households as main source of energy for cooking.

According to the Central Bureau of Statistics (BPS, 2014), 32.98 percent of the households in North Sumatra Province and 26.69 percent of the households in Riau Province use firewood as either primary or secondary energy source for cooking. In the area of the study, 42 percent of the sampled households utilize firewood for cooking as primary or, more commonly, secondary source and it cannot be excluded that the national LPG programme may have contributed to shaping such a scenario. About 14 percent of the households sampled used to rely on firewood as their main energy source for cooking purposes, however, they have moved on to other sources of energy, namely LPG, because of the technical advantages (ease of use) and higher accessibility to this fuel.

When asked about their intention to stop using firewood as a source of energy for cooking, 66.7 percent of the households that still utilize firewood responded with the intention to do so. When asked about the reasons that could lead them to consider alternative energy sources to traditional biomass the majority of the households surveyed summarized the disadvantages of traditional biomass with the difficulty of access to the resource.

Figure 3.13.2

Firewood utilization as primary and secondary source of energy for cooking in north Sumatran survey sites



Source: Survey in north Sumatra, September 2012

Interestingly enough, from the survey in north Sumatra it emerged that in 88.9 percent of the households that employ firewood for cooking, the household member responsible for biomass collection is the adult male (father). This is in line with what found by some authors (Koning et al, 2000). In 11.1 percent of the households surveyed, women and children are the main responsible for firewood collection. Men usually collect firewood in the surroundings of their work place (plantation or forest) after the end of their formal job shift.

Almost three quarters of the households that utilize firewood for cooking in the surveyed location collect biomass weekly. On average, 0.8 – 1 m^3 of firewood is collected per household per month.

Table 3.13.1

Woodfuel collection frequency

Daily	5.56 %
Weekly	72.22 %
Monthly	22.22 %

Source: Survey in north Sumatra, September 2012

In the survey area, the average time spent collecting firewood is 1.25 hours per week per household. In order to reduce the amount of time spent collecting biomass, the individuals in the survey location usually use motorcycles to transport the firewood home. The time spent for collecting firewood is categorize as unpaid, however, the woodfuel is collected at no charge resulting often in a monetary saving for the household. On average, in the survey locations, men employ 1.25 hours per week or about 65 hours per year of their time collecting the fuel for cooking, which is the equivalent of 8 working days dedicated to such an activity, although, in the survey area as well as commonly throughout Indonesia, firewood is collected in after regular working hours and it is likely that there is no effect on the primary occupation of the family member who collects the firewood.

3.13.2 Main conclusions and recommendations

Results of indicator measurement

It is inferred from this study that result of the indicator is affected by local environment, socio-economic condition, and cultural factors. Households in north Sumatra rely on LPG and kerosene as the main energy sources for cooking and to a lesser extent on firewood. In addition, those household that use biomass as an energy source spend approximately 1.25 hours per week or about 65 hours per year (the equivalent of 8 working days) collecting the fuel. This value is not substantial and it is deemed acceptable by the household members in the area of the survey. In fact, the low relevance of firewood as an energy source in

Indonesia as of 2012 and the high availability of alternative energy solutions employed for cooking (possibly favored by the presence of a national programme for the diffusion of LPG stoves instead of the once-widely spread kerosene stoves) relegate traditional biomass a secondary role in the energy matrix, although not marginal (see indicator 22). With this project, a possible baseline value for indicator 13 was produced whereas it was not possible to estimate changes in time spent collecting biomass due to lack of comparable information in different moments in time. In addition, the main substitute fuel for cooking in Indonesia was found to be kerosene or, more often, LPG and no modern bioenergy technologies for cooking have been implemented.

Future monitoring of indicator 13 in Indonesia

With this project, a possible baseline value for indicator 13 was produced whereas it was not possible to estimate changes in time spent collecting biomass due to lack of comparable information in different moments in time. In addition, the main substitute fuel for cooking in Indonesia was found to be kerosene or, more often, LPG and no modern bioenergy technologies for cooking have been implemented. For the future, similar surveys and a desk reviews should be performed in order to increase the pool of information surrounding the assessment of unpaid time spent collecting biomass. Due to the high costs and time requirements of the surveys for Indicator 13, unless future policies increase the penetration of modern bioenergy technologies for cooking in Indonesia, the indicator would not be applicable as a change due to modern bioenergy cannot be recorded.

Relevance, practicality and scientific basis of indicator 13

This indicator is relevant for Indonesia as well as for several other countries. Firewood is collected and traded (often on informal markets) in almost any country in the world. Due to its current formulation, however, this indicator may not capture important aspects of the collection and use of biomass for cooking and its social implications. Firstly, it clearly aims at assessing the change in unpaid time spent collecting biomass as a result of the switching to modern bioenergy sources. In this project, the indicator was measured in order to establish a baseline value to check against in future monitoring, however, if modern bioenergy forms do not substitute traditional collection of biomass in Indonesia, this indicator as it stands would not be applicable. Secondly, based on the results of this field survey (men collect wood in 88.9% of households, only in 11.1 percent women or children collect biomass), and by following the description of the indicator "*time spent by women and children collecting biomass*" the outcome of the assessment would ignore the amount of time spent by men performing this operation and therefore subtracted to any other activity.

It is therefore suggested that the indicator is made gender neutral (e.g. "*time spent collecting biomass per household*") in order to better describe the Indonesian context.

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3.14 BIOENERGY USED TO EXPAND ACCESS TO MODERN ENERGY SERVICES

Description:

(14.1) Total amount and percentage of increased access to modern energy services gained through modern bioenergy (disaggregated by bioenergy type), measured in terms of (14.1a) energy and (14.1b) numbers of households and businesses

(14.2) Total number and percentage of households and businesses using bioenergy, disaggregated into modern bioenergy and traditional use of biomass

Measurement unit(s):

(14.1a) Modern energy services can take the form of liquid fuels, gaseous fuels, solid fuels, heating, cooling and electricity. A change in access to each of these forms of modern energy can be measured in MJ per year and this is preferable in order to allow comparison of different forms of energy service, but each may also be measured in appropriate units of volume or mass per year, which may sometimes be more convenient, leading to the following possible units for this indicator component:

- liquid fuels: litres/year or MJ/year and percentage
- gaseous fuels: cubic metres/year or MJ/year and percentage
- solid fuels: tonnes/year or MJ/year and percentage
- heating and cooling: MJ/year and percentage
- electricity: MWh/year or MJ/year (for electricity used), MW/year (if only electricity generation capacity to which new access is deemed to have been gained can be measured), hours/year (for the time either for which electricity is used or for which there is access to a functioning electricity supply) and percentage

(14.1b) number and percentage

(14.2) number and percentage

3.14.1 Testing of indicator 14 in Indonesia

During the past decade, access to modern energy services increased in Indonesia. Between 2000 and 2012, electricity consumption has more than doubled (BPS, 2014). As a proxy for access to modern energy sources, the number of customers established by the National Energy Company (PLN), the state-owned electricity provider of Indonesia (World Bank, 2013; PLN, 2014), for electricity may be used as a proxy to understand the recent trend. In 2000, some 28 million customers were connected to the national grid whereas in 2012 almost 50 million customers had access to electricity (BPS, 2014). The major primary energy sources for electricity generation in Indonesia are coal, oil, hydroelectric and natural gas, whereas diesel fuelled power plants produce a minor portion of the total electricity in Indonesia.

Modern bioenergy did not have any role in the increase in access to modern energy services that was recorded in Indonesia during the past decade. As of 2014 there was no significant use of modern bioenergy for heating and cooking and off-grid electricity generation in the country. With regard to the electricity generated from biodiesel, it was found that this is minimal component of the current energy mix (USDA, 2013). During this project FAO screened the national grid and off-grid power generation networks and found that, apart from operator level applications[33], the contribution of standalone biomass power generators to increased access to energy at the national level in Indonesia is negligible. Finally, in the transport sector all the biodiesel produced in the country is blended with fossil fuels. Hence, this indicator is not relevant for the current Indonesian context[34].

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33 FAO carried out a survey in the Bangka Belitung Province, where 5,133 households (46% of total) receive electricity from biomass fuelled power plant of the company PT Listrindo, a cement factory located in Bangka Island that produces a total of 14,732,710 KWh per year.

34 As explicitly stated in the methodology sheet, indicator 14 "is not intended to include new use of bioenergy by a household or business for modern energy services that were previously accessed through use of other energy sources, such as fossil fuels" (GBEP, 2011, p. 156).

3.15 INDICATOR 15: CHANGE IN MORTALITY AND BURDEN OF DISEASE ATTRIBUTABLE TO INDOOR SMOKE

Description:
(15.1) Change in mortality and burden of disease attributable to indoor smoke from solid fuel use (15.2) Changes in these as a result of the increased deployment of modern bioenergy services, including improved biomass-based cookstoves

Measurement unit(s):
Percentages

3.15.1 Testing of indicator 15 in Indonesia

For the measurement of indicator 15 in Indonesia, information from the limited national as well as international reports on the matter has been reviewed. A field survey was also carried out during this project in order to complement the information obtained from the literature. Forty three households in a semi-rural area in north Sumatra (a representative sample area for the purpose of this study) were involved in the survey and respondents were asked to describe cooking conditions in their houses.

3.15.2 Key findings

Indonesian consumption of woodfuel has been continually decreasing since the 1960s (see indicator 3). It could be inferred that, due to the reduced use of firewood employed for cooking purposes in Indonesia (see indicator 13), chronic obstructive pulmonary diseases (COPDs) which are directly linked to indoor smoke and particularly the burning of biomass (Kurmi et al, 2010), would decrease. Instead, according to IHME (2010), from 1990 to 2010, COPDs have increased by some 40 percent in Indonesia and are responsible for 1.5 percent of the Years of Life Lost (YLLs) in Indonesia in 2010.

On the other hand, of the 25 most important causes of burden, as measured by disability-adjusted life years (DALYs), lower respiratory infections showed the largest decrease, falling by 81 percent from 1990 to 2010. Household air pollution was estimated to be the fourth highest risk factor for disease burden in Indonesia in 2010 (IHME, 2010) with a share of 6 percent of the Indonesian DALYs lost.

A field survey was also carried out during this project in order to complement the information obtained from the literature. Forty three households in a semi-rural area in north Sumatra were involved in the survey and respondents were asked to describe cooking conditions in their houses. The assessment of the kitchen conditions relied on a four-score scale ranging from very bad, bad, moderate, and good for both ventilation and lighting conditions. Households that rely on firewood as the energy source for cooking, were asked about the location of woodstove (whether located inside the house or outside/separated from the indoor environment) and information about household members that usually use the cooking facility was also collected.

Respondents were also asked about the incidence of illness and/or the occurrence of fatalities that may be related to indoor smoke (upper respiratory tract infection/URI, lung inflammations, COPDs, etc.) in their households. Moreover, data on the occurrance of respiratory diseases were collected from the nearest health facilities in different contexts in the location of the survey.

As stated in indicator 14, roughly one tenth of the sampled households use firewood as the main energy source for cooking. Overall, 42 percent of the sampled households use firewood as primary or secondary source for cooking. Of these, some 83 percent put the woodstove outside the house while the remaining 17 percent of the households have the woodstove located inside the house.

More than 60 percent of the sample believes their kitchen to have moderate ventilation and lighting. The majority of the respondents considered the lighting conditions to be sufficient (table 3.15.1).

In all households included in the survey, the adult woman (mother) and their daughter(s) are the family members responsible for cooking activities. The average amount of time spent cooking by the Indonesian women in the survey area is approximately 2 hours per day.

Table 3.15.1

Kitchen's ventilation and lighting condition

Condition	Ventilation	Lighting
	%	%
Good	25.6	23.3
Moderate	60.5	62.8
Bad	13.9	11.6
Very bad	0	2.3
Total	100.0	100.0

Source: Survey in north Sumatra, September 2012

Seven percent of sampled households reported the presence of a household member who experienced upper respiratory tract infections (URI) during the previous three months. They were in most cases men. Additional information related with the incidence of indoor smoke related illnesses in the survey area was gathered from health centers and clinics (*puskesmas* and *poliklinik*) within the vicinity of the research location. Staff of the health facilities in the survey area, correlate the exposure to indoor smoke mainly with disturbs such as URI.

Table 3.15.2

Data of URI incidence from health facility around research location

Location of health facility	Incident of URI					
	June 2012		July 2012		August 2012	
	n	% *	n	% *	n	% *
Health Centre (Puskesmas) in the semi-rural area of the survey	n.a	n.a	n.a	n.a	12	13.2
Clinic within the oil palm plantation	15	12.7	5	4.8	11	10.9
Clinic within the POM	n.a	n.a	53	38.4	75	46.0

**) % calculated out of the total cases of disease reported to the health facility in that month*
Source: Survey in north Sumatra, September 2012

The survey results (table 3.15.2) highlight the high incidence of URIs among the workers of the palm oil mill (POM). In July and in August 2012 respectively, 38 percent and 46 percent of all cases treated in the clinic located within the POM has been diagnosed with URI. This outcome may lead to seek the cause of respiratory infections among outdoor factors; it was hypothesized by local doctors both within and outside the oil palm plantation and mill area that the exposure to dust and fine suspended particles consequence of poor infrastructure conditions (i.e. dirt roads) and high truck traffic may be the primary cause of URI in workers of the palm oil mill facilities.

3.6.3 Main conclusions and recommendations

Results of indicator measurement

As explained in indicator 3, firewood consumption has been decreasing in Indonesia. This appears to be linked mainly to the increased access to alternative energy sources more practical than firewood such as kerosene which, starting from 2007, has been substituted by LPG (see indicator 13), while modern bioenergy technologies have not played a significant role in displacing traditional uses of biomass and in providing access to modern energy services.

On the contrary, according to IHME (2010), from 1990 to 2010, COPDs have increased by some 40 percent and in 2010 they were responsible for 1.5 percent of the Years of Life Lost (YLLs) in Indonesia.

This value cannot be described as wholly reflective of indicator component 15.1, as one facet of the argument attributes the major share of COPDs to the burning of biomass (Kurmi et al, 2010), while on the other hand cigarette smoking in Indonesia is a highly prevalent habit, which is reported as the third risk factor for DALYs in 2010.

Overall, the three risk factors that account for the most disease burden in Indonesia are dietary risks, high blood pressure, and tobacco smoking (IHME, 2010). A survey carried out in north Sumatra during the course of this project has also shown that air pollution (not necessarily indoor air quality) may be an important cause of upper respiratory infections and other respiratory diseases in Indonesia. In light of the results of this research, the attribution to indoor smoke from solid fuel use of the change in burden of disease could not be performed (indicator component 15.1). As no modern bioenergy services for indoor applications have been recorded in Indonesia as of 2012, when the main energy source for cooking is still LPG, no change in burden of disease was possible to attribute to modern bioenergy deployment (indicator component 15.2).

Future testing of indicator 15 in Indonesia

In order to measure this indicator in the future, surveys and epidemiological studies on woodfuel use and the incidence of COPDs should be conducted along the lines with the examples found in the literature (e.g. IHME, 2010). These should last for the minimum number of years which allows the detection of changes in mortality and burden of diseases attributable to indoor smoke among a sample of households in different regions of the country.

Relevance, practicality and scientific basis of indicator 15

With regard to the practicality of the indicator this project has shown that, where nationwide statistics of burden of disease attributable to indoor smoke are found (e.g. IHME, 2010), it is still difficult, in a complex scenario of possible causes, to attribute to the use of solid biomass for cooking its share of responsibility in creating such a burden. In the case study of Indonesia, woodfuel use has decreased steadily over the past decades, yet the incidence of COPDs has increased. Investigating the causes of this behaviour would require resource intensive studies for which high level expertise in the medical sciences and a long timeframe are required.

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3.16 INDICATOR 16: INCIDENCE OF OCCUPATIONAL INJURY, ILLNESS AND FATALITIES

Description:
Incidences of occupational injury, illness and fatalities in the production of bioenergy in relation to comparable sectors

Measurement unit(s):
Number/ha (for comparison with other agricultural activities) or number/MJ or MW (for comparison with alternative energy sources)

3.16.1 Testing of indicator 16 in Indonesia

Very limited information could be retrieved on the incidence of occupational injury, illness and fatalities in the domestic bioenergy sector in Indonesia. This may be due to a number of factors such as the scarcity of official reports, the lack of mandatory reporting schemes, the presence of a high incidence of informal labour – particularly in the agricultural stages – and ultimately the absence of disaggregated statistics for bioenergy specific occupations. The oil palm plantation, mills, and biodiesel refineries in north Sumatra that were surveyed for this project did not register any accident, injury nor death occurring in 2012, but only the occurrence of illnesses. However, the aforementioned results could not be inferred at the national level. Therefore, a review of the limited research available on this aspect is presented from which preliminary lessons and recommendations can be drawn.

3.16.2 Key findings

There is little if any official data concerning occupational injury, illness and fatalities that relate directly to the bioenergy sector in Indonesia, as any relevant data is not disaggregated from other sectors. Wright (2011) notes that occupational safety and health is an issue across most sectors in Indonesia, with limited enforcement of the law, a problem that is particularly pronounced in rural areas.

Anecdotal evidence from case-studies about palm oil production in Indonesia highlights important issues regarding occupational safety and health risks, policies and practices (Teoh, undated). Key risks in palm oil cultivation are associated with agrochemical use and accidents, which are more likely during harvesting, whereas in palm oil mills, key risks are industrial accidents associated with the use of heavy machinery (Marti, 2008; Wright, 2011).

In palm oil plantation, occupational health risks have a very clear dimension. Women are mostly employed to undertake field jobs such as planting and weeding, as well as applying agrochemicals (e.g. pesticides, herbicides and fertilisers), as they are seen to do the job with greater accuracy. Often they receive no training on handling hazardous or toxic substances and in most cases they are illiterate, which prevents them from accessing information on pesticides' warning labels. Authors (Marti, 2008, Wright, 2011) reported the scarce diffusion and use of safety equipments or protective clothing during pest control operations. The spraying of certain chemicals (e.g. *Paraquat* and those containing organophosphate active ingredients) have caused health problems, such as vomiting, breathing difficulties, skin irritation, eye injury, and nosebleeds. Exposure to them whilst pregnant or breastfeeding will further increase health risks and problems to both the mother and the baby (Marti, 2008, Wright, 2011).

As Wright reports (2011), in Indonesia official data on accidents and injuries that relate to work is reported in aggregate only, with no discrete figures for the bioenergy sector. Some 426 such accidents, involving 7,394 people were reported in 2009. However, one case-study performed by a union of workers in palm oil plantations in five estates in North Sumatra reported that 47 occupational accidents occurred in 2008, comprising two deaths, 32 light injuries and 11 cases of blindness caused by latex and resin (Situmorang, 2010). Unfortunately lack of official data on this matter constitute the main constraints to the assessment of baseline values for this indicator and further, long term studies are encouraged.

3.16.3 Main results and recommendations

Results of indicator measurement

As material available in literature on this indicator was scarce, only a preliminary assessment could be performed. In addition, the survey in North Sumatra was not capable of capturing the incidence of illnesses, injuries and fatalities over a representative time window for this sensitive topic, but only a three-month record was kept by the operation management. However, the study of this indicator has highlighted the key risk factors existing in the biodiesel value chain. Key risks in palm oil cultivation are associated with agrochemical use (mostly involving women) and accidents are more likely during harvesting (mostly involving men), whereas in palm oil mills, key risks are associated with the use of heavy machinery. From the results of Indicator 15, it was possible to derive the relevance of illness incidence particularly in workers employed in the feedstock processing (palm oil mills).

Future monitoring of indicator 16 in Indonesia

Given the scarcity of official data on the matter, it is recommended to establish a nation-wide long term monitoring programme concerning illnesses, occupational injuries and fatalities disaggregated for the bioenergy sector. The programme should retrieve historic information, where available, and collect data on injuries, illnesses and fatalities for future monitoring for a duration of at least 10 years. In fact, infrequent and rare events (e.g. fatalities) and their causes, may not be correctly described through yearly surveys. Bioenergy policy should include a clear mention to the mandatory character of reporting illnesses, injuries and fatalities occurring while working in the bioenergy value chain. Inter-ministerial dialogue on this issue, particularly among the three most relevant ministries (i.e.

Ministry of Energy, Ministry of Agriculture, and Ministry of Health) is fundamental for devising a strategy for the correct monitoring of the health implication of the bioenergy value chain in Indonesia.

Relevance, practicality and scientific basis of indicator 16

As in the case of many other indicators, data on the issue of occupational injury, illness and fatalities is not abundant in the literature. Moreover, the complexity of this analysis was increased by the lack of disaggregated values for attribution to bioenergy. In fact, the little evidence available covers the whole agricultural and/or industrial sectors, without a disaggregation by feedstock type in the first case nor by industrial pathway (food or fuel) in the second case. The methodological approach of the GBEP Sustainability Indicators for Bioenergy should take into account these hurdles and offer further guidance on how to effectively avoid these issues.

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ECONOMIC PILLAR

3.17 PRODUCTIVITY

Description:
(17.1) Productivity of bioenergy feedstocks by feedstock or by farm/plantation
(17.2) Processing efficiencies by technology and feedstock
(17.3) Amount of bioenergy end product by mass, volume or energy content per hectare per year
(17.4) Production cost per unit of bioenergy

Measurement unit(s):
(17.1) Tonnes ha per year
(17.2) MJ/tonne
(17.3) Tonnes/ha per year, m^3/ha per year or MJ/ha per year
(17.4) USD/MJ

3.17.1 Testing of indicator 17 in Indonesia

Data for the assessment of indicator 17 was obtained from international statistics (FAOSTAT, 2014), national reports (Ministry of Agriculture, 2013) and from primary collection campaigns in one of the largest Indonesian biodiesel companies as of 2012. The information collected allowed to measure all components of the indicator and returned interesting results on the productivity of bioenergy in the Southeast Asian country, as well as on the production cost of biodiesel. These results provide a sound baseline for future monitoring of indicator 17 in this country.

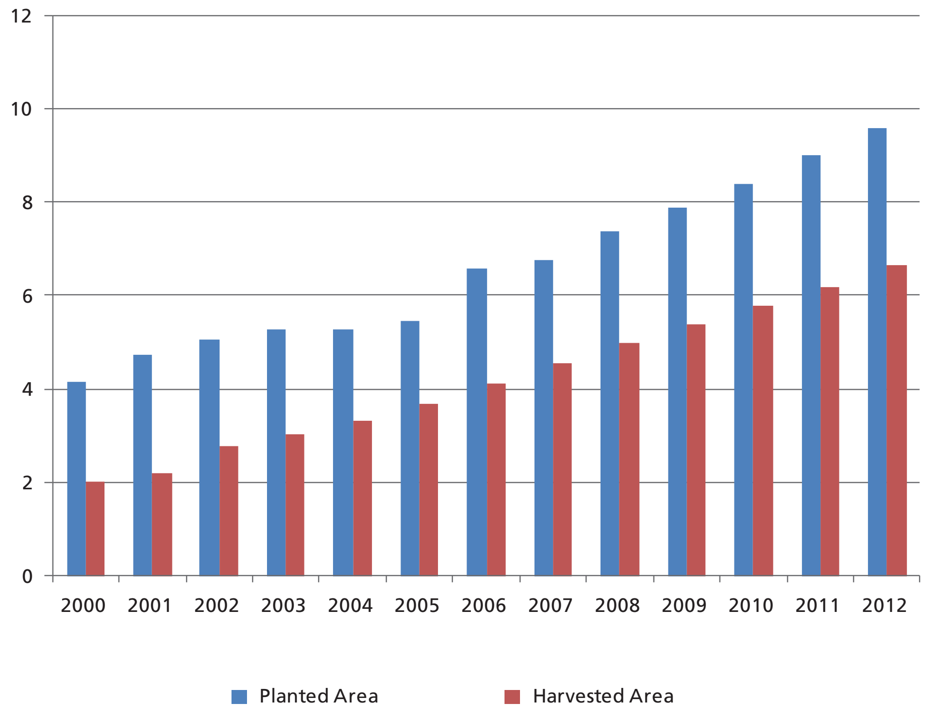
3.17.2 Key findings

17.1: Productivity of bioenergy feedstocks by feedstock or by farm/plantation
Data on bioenergy feedstock production, planted and harvested area was used in order to determine the productivity of oil palm in Indonesia (FAOSTAT, 2014; Ministry of Agriculture, 2013). During the period considered (i.e. 2002-2012), there was a significant increase in the harvested area of oil palm, consequence of the strong growth of the planted area which began in the 1990s and continued in recent years (see Indicator 8), and as shown by the gap between production area and harvested area (figure 3.17.1). Between 2002 and 2012, the average crude palm oil (CPO) yield was 3.62 t/ha (FAOSTAT, 2014; Ministry of Agriculture, 2013).

17.2: Processing efficiencies by technology and feedstock
In order to determine the efficiency of the processing of crude palm oil into biodiesel, data on the volume of CPO used for biodiesel and on the actual volume produced of this biofuel in a selected representative biodiesel plant in north Sumatra was used. This

Figure 3.17.1

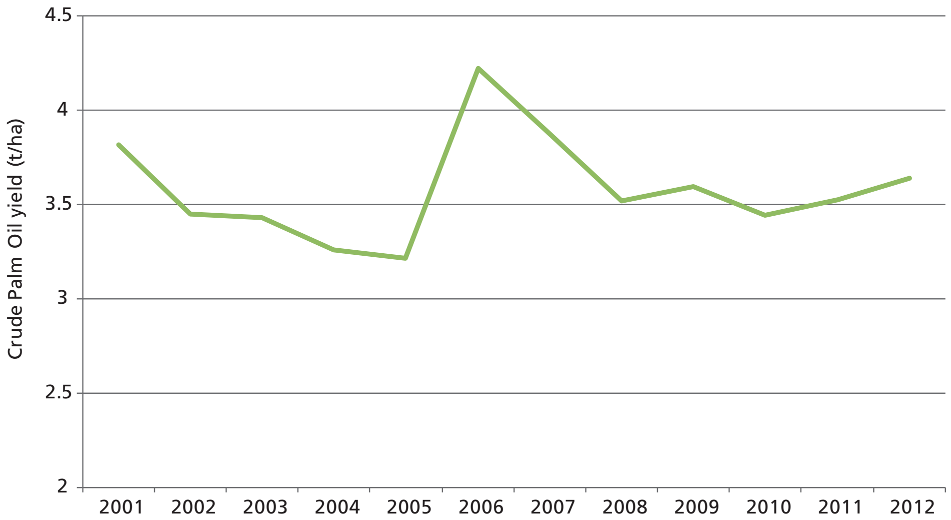
Planted area and harvested area of oil palm (Mha), in Indonesia, 2000-2012



Source: Ministry of Agriculture, 2013

Figure 3.17.2

Annual Crude Palm Oil (CPO) yield (t/ha) in Indonesia, 2001-2012



Source: FAOSTAT, 2014; Ministry of Agriculture, 2013

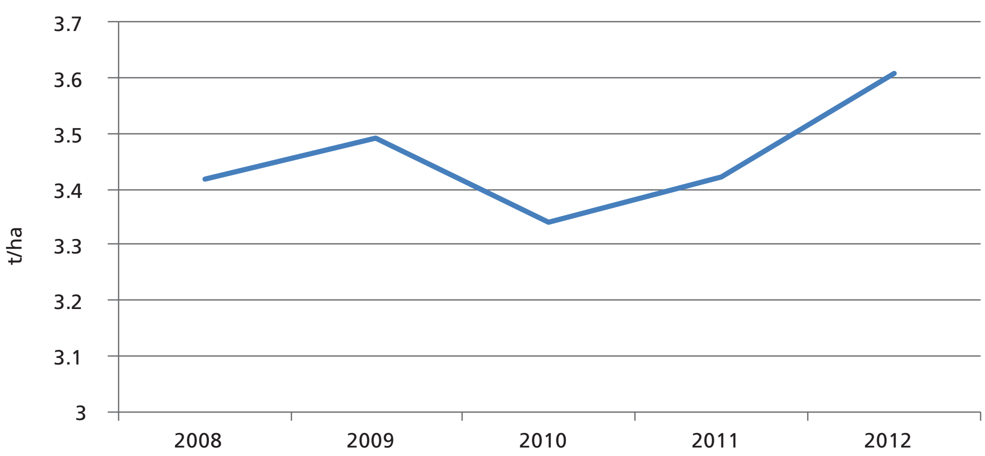
biodiesel plant, as others in the islands of Sumatra, processes the CPO from a number of mills. The processing in biodiesel plants is standardized and the analysis of the selected biodiesel company, which in 2012 produced roughly 1/7th of total national biodiesel, was considered representative of the national average.
The average biodiesel yield per tonne of palm oil processed between 2009 and 2012 was 38,350 MJ/tonne of CPO.

17.3: Amount of bioenergy end product by mass, volume or energy content per hectare per year

Data on biodiesel production and on the harvested area of oil palm was used in order to determine the amount of palm oil-based biodiesel produced per hectare per year in Indonesia. Also in this case, the period considered was 2009-2012. The average annual biodiesel yield was around 3.61 t/ha. Given the highly standardized processing system and the relatively short time horizon of the analysis (prior to 2009 Indonesia produced negligible amounts of biodiesel) the productivity of the biofuel is mainly influenced by the productivity of the feedstock.

Figure 3.17.3

Annual palm oil-based biodiesel yield (t/ha) in Indonesia, 2008-2012



Source: FAOSTAT, 2014; Ministry of Agriculture, 2013

17.4: Production cost per unit of bioenergy

The assessment of the production cost of biodiesel in Indonesia as of 2012 was performed on the basis of analysis of the operation costs in a selected biodiesel company in north Sumatra.
Based on the survey in the biodiesel plant, total biodiesel production cost in 2012 was 1,030 USD/tonne. Such cost does not include transport, distribution and blending and it does not account for revenues. Assuming a LHV of palm oil biodiesel of 37.2 GJ/tonne,

the average production cost of palm oil-based biodiesel in Indonesia in 2012 was estimated at 0.02768 USD/MJ.

3.17.3 Main conclusions and recommendations

Results of indicator measurement

With regard to indicator component 17.1, the productivity of oil palm remained substantially stable between 2002 and 2012, with an average annual CPO yield of 3.62 t/ha between 2002 and 2012 (Ministry of Agriculture, 2013), with a slight tendency to increase until 2006 and an equally light tendency to decrease from 2006 until 2012. The aforementioned tendencies however, should not be considered as diagnostic of a relevant trend other than the presence of an increasing number of immature plants as part of the total harvested area.

Concerning indicator components 17.2 and 17.3, the average biodiesel yield per tonne of palm oil processed between 2009 and 2012 was 38,350 MJ/tonne of CPO and 3.61 t/ha between 2009 and 2012.

With regard to indicator component 17.4, production costs were calculated on the basis of real production values in one of the largest biodiesel companies operating in Indonesia at 1,030 USD/tonne. This value does not include transport, distribution and fuel blending costs. Assuming a LHV of palm oil biodiesel of 37.2 GJ/tonne, the average production cost of palm oil-based biodiesel in Indonesia in 2012 was estimated at 0.02768 USD/MJ (indicator component 17.4).

Future testing of indicator 17 in Indonesia

Data was available for all components of indicator 17. Testing of this indicator yielded interesting results on the productivity of oil palm and of the related processing technologies in Indonesia and these results provide a sound baseline for future monitoring of indicator 17 in this country.

As shown in the figures 3.17.3, productivity of bioenergy feedstock and processing technologies have not changed significantly in recent years in Indonesia. The additional demand for palm oil for biofuel production has been met through an expansion in the area harvested although strongly driven by factors other than biodiesel demand (see also Indicator 10). As the bioenergy sector continues to expand in Indonesia, however, monitoring productivity is important in order to assess the efficiency of the industry and the extent to which a yield increase is triggered by the growth in demand. According to Platts (2013), although production costs are decreasing in Indonesia, in 2013 the new biodiesel price formula introduced by Pertamina (the national Indonesian fuel corporation) has not met the minimum production cost of biodiesel which is 0.02580 USD/MJ. The accurate monitoring of production costs would be important in order to assess the competitiveness of domestically produced biodiesel both on the domestic market (i.e. with domestic fossil fuel prices) and on the international market (i.e. with the international price biodiesel). To this end, the monitoring of Indicator 17 could inform the development and revision of biofuel support policies and incentives.

Relevance, practicality and scientific basis of indicator 17

The testing of indicator 17 in Indonesia confirmed the importance of monitoring productivity both at feedstock level and at processing level and of producing estimates of biofuel production costs. As explained above, monitoring these variables is essential in order to assess the efficiency and competiveness of the bioenergy industry over time.

In the methodology sheet of indicator 17, the importance of taking into account co-products and by-products is recognized. However, further guidance on how to account for them under the various components of this indicator would be useful.

With regard to the practicality, getting hold of the information required for indicator component 17.4 might be challenging, in light of the commercially sensitive nature of production cost data. If primary data cannot be obtained, as it was done for the testing of indicator 17 in Indonesia, estimates should be made. More guidance on this should be provided in the methodology sheet of the indicator.

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3.18 INDICATOR 18: NET ENERGY BALANCE

Description:

Energy ratio of the bioenergy value chain with comparison with other energy sources, including energy ratios of

(18.1) feedstock production,

(18.2) processing of feedstock into bioenergy,

(18.3) bioenergy use; and/or

(18.4) lifecycle analysis

Measurement unit(s):

(18.1) ratio

(18.2) ratio

(18.3) ratio

(18.4) ratio

3.18.1 Testing of indicator 18 in Indonesia

For the testing of indicator 18 in Indonesia, part of the information retrieved for indicator 1 was used, together with other relevant data and information from a number of sources. The study was carried out at the operation facilities of a major Indonesian biodiesel producer, accredited of about 15 percent of the total national biodiesel output in 2012. During the stakeholders meetings carried out throughout the project, it was agreed to measure only indicator component 18.4 (by treating the sampling facility as a black box) since for the components 18.1, 18.2 and 18.3 disaggregated values were not available. The selected company comprises all stages of the biodiesel value chain, from feedstock production to biodiesel refining. The characteristics of the mill and biodiesel plant are highly standardized throughout Indonesia, however, feedstock productivity in the surveyed operator was significantly higher than the national average, and therefore two scenarios have been calculated.

3.18.2 Key findings

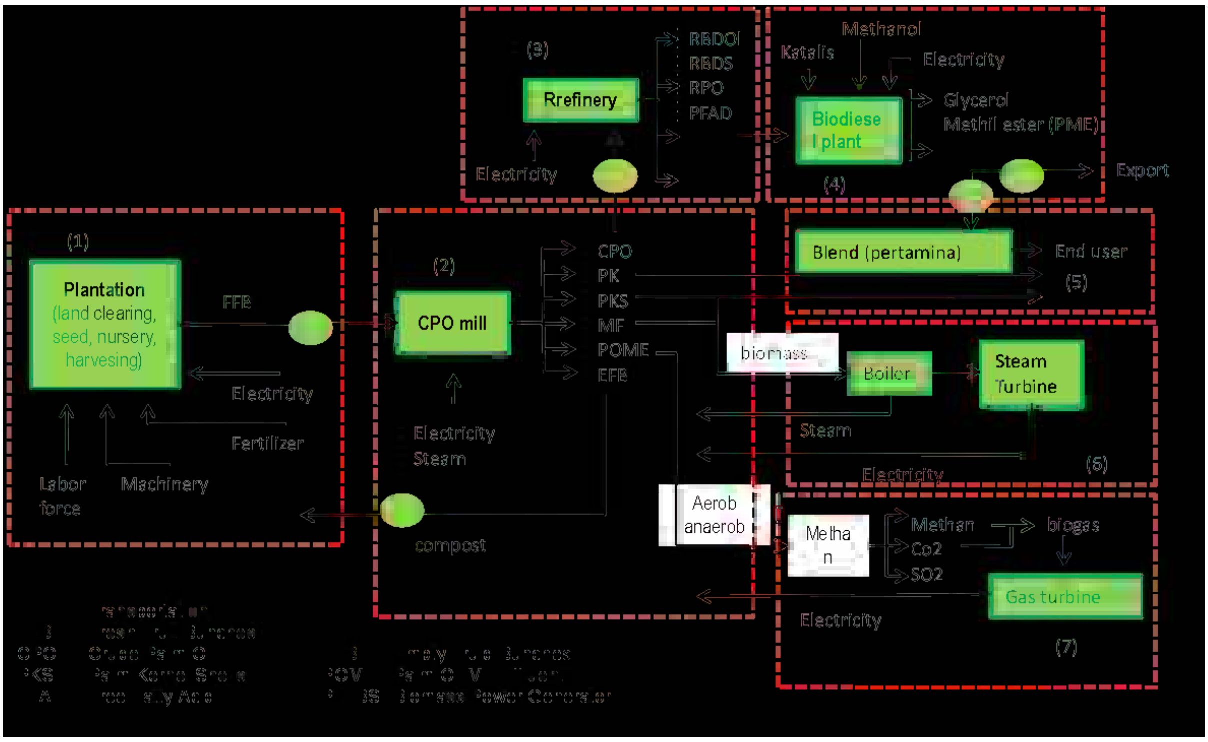
Figure 3.18.1 shows the system boundaries as they were considered in this study. The plantation is located in north Sumatra, in the Riau Province and it covers an area of 2,909 hectares of which 2,406 are cultivated with oil palm. There are a total of 327,049 palm trees in the estate, averaging 136 trees per hectare. Oil palm seedlings are obtained from a separated company and are planted after a quarantine period. For this purpose, about 3 hectares of the plantation are set aside as a nursery for the newly arrived seedlings. The plantation relies on different complex fertilizers: NPK super K[35] (57 percent), followed by MOP (16 percent) and Urea (12 percent). The production capacity of the plantation object of the study is 22.54 tonnes of fresh fruit bunches per ha (t_{FFB}/ha). On average, in 2012,

35 For more info see also indicator 2.

feedstock productivity was 17 t_{FFB}/ha in Indonesia (FAOSTAT). The FFBs harvested are sent to the palm oil mill (POM) via truck and, on average, are transported for a distance of about 10 km. Co-products such as palm leaves and midribs are used as green mulching and organic fertilizer and are left in the field, around the base of the trees.

Figure 3.18.1

Biodiesel value chain



Source: Wilmar International, 2011

The POM surveyed can process up to 60 t_{FFB} per hour and it is located in an area where there are a number of oil palm plantations. Within a radius of 100 km from the POM there are 251 potential FFB suppliers. In 2011, the surveyed POM received some 277,000 tonnes of FFB which yielded some 58,991 tonnes of CPO. In 2011, productivity was 0.21 tonne of CPO per tonne of FFB, or 4.8 tonnes of CPO per ha. According to the Ministry of Agriculture (2013), the average Indonesian yield in 2012 was 3.7 tonnes of CPO per ha. The CPO is sent to the biodiesel refinery located some 200 km away, also via truck.

The main co-product of the palm oil mills is the Empty Fruit Bunch (EFB), which constitutes about 22 percent of the original amount of FFB. In addition to EFB, also kernel, shells, and fibers are produced at a rate of 5.2 percent, 6.46 percent and 14.4 percent of the amount of FFB respectively. EFB are reemployed in the fields and used as fertilizer. The kernel is usually sold to palm kernel oil (PKO) refineries, whereas the shells and fibers are used as fuel to produce steam and power in the boilers within the palm oil mill.

Palm oil mill effluents (POME) generated from the mill are applied as liquid fertilizer in the plantations around the mill and, in the surveyed mill equipped with methane capture system, these are used for the production of biogas.
The palm oil refinery object of this survey receives CPO from some 90 mills in the area. CPO is processed into refined palm oil (RPO) which is consequently used as feedstock for biodiesel or further processed into olein (RPBDOI), stearin (RPBDS) and palm fatty acid distillate (PFAD).
The fraction of RPO which becomes biodiesel is sent to the refinery plant which, in the case of the survey, is located near the palm oil refinery. In fact, the RPO can be pumped directly to the biodiesel plant where it will undergo the process of transesterification to become palm methyl ester – PME, commonly referred to as biodiesel.
The biodiesel plant has a productivity of 0.97 tonnes of PME per tonne of CPO. The electricity employed in the biodiesel plant is supplied by an annexed coal fired power plants.
Table 3.18.1 shows the calculation of the value of energy input per unit of biodiesel produced in the facilities of the selected bioenergy company. The total energy consumption for the production of 1 tonne of PME was calculated to be 10.17 MJ. The production stage that required the highest energy input was found to be the transesterification process, which alone accounts for about 70 percent of the total energy consumption.
Methanol production in fact, takes up to 33.73 percent of the total energy needed for the biodiesel production process, followed by electricity (28.96 percent), and the use of Urea (9.71 percent) of the total energy used.

Table 3.18.1

Energy input and Energy output

Item	Per tonne PME	MJ/kg PME
Input		
(a) Feedstock production		1.96
(b) CPO Mill		0.120
(c) Refining plant		1.09
(d) Biodiesel production		7.00
Total Input (a + b + c + d)		10.17
Output		
Palm methyl ester (PME) (kg)	1,000	39.60
Glycerol (kg)	0.33	0.69
Fibre (kg)	701.45	8.14
Shell (kg)	152.61	1.77
Palm Kernel (kg)	252.92	4.30
Total Output		54.50

Source: Survey in a selected biodiesel producer in north Sumatra, September 2012

In the case study biodiesel chain, 10.17 MJ are employed for the production of 1 kg of biodiesel, whereas, including all co- and by-products produced and employed in the extended bioenergy value chain, the total energy output per kg of PME is 54.50 MJ. This gives a net energy balance ratio over the full lifecycle of the biofuel of 5.36.
The average NER of Indonesian palm oil was calculated on the basis of the standardized processes in the POM and biodiesel plant but accounted for the average yield of 3.7 tonnes of CPO per hectare and amount of agricultural inputs used on average estate plantations in Indonesia and was estimated to be 4.13.

3.18.3 Main conclusions and recommendations

Results of indicator measurement
With regard to indicator components 18.4 for palm oil-based bioenergy, the Net Energy Ratio (NER) was found to be 5.36 in the surveyed biodiesel operator and the average national value estimated to be 4.13.
The life-cycle analysis that was carried out under indicator component 18.4 showed that the energy efficiency of the Indonesian palm oil-based biodiesel supply chain is mostly affected by the energy intensity of the biodiesel refinery process, which alone accounts for about 70 percent of the total energy consumption. The assessment of indicator 18 has offered interesting information concerning the existence of room for improvement in the efficiency of the processing stages, from the operations in the palm oil mill to, especially, the operations in the biodiesel refinery.

Future monitoring of indicator 18 in Indonesia
As the bioenergy sector continues to expand in Indonesia, monitoring its efficiency from an energy perspective will be of crucial importance. The results of the testing of indicator 18 in Indonesia described above provide the basis for future monitoring of this indicator in the country.
Furthermore, in order to strengthen the robustness of the results, primary data based on direct observations and lab tests should be used as well.
From the comparison between the NER obtained with high yields (4.8 t_{CPO}/ha) versus the average Indonesian yield (3.7 t_{CPO}/ha) it is clear how this agronomical parameter, together with the enhancement of the processing operation's efficiency, are extremely significant for the overall energy balance of biodiesel production in Indonesia.

Relevance, practicality and scientific basis of indicator 18
The testing in Indonesia confirmed the relevance of the issues addressed by indicator 18, which provides valuable information regarding the energy efficiency of the main stages of the palm oil-based biodiesel supply chains.
With regard to the practicality, indicator 18 is rather data intensive. The indicator was treated as a black box (full LCA applied as opposed to calculating the net energy ration for each intermediate output value in the chain) and this was found to be an expeditious and

practical adaptation of the suggested methodological approach which still offered reliable findings.

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3.19 INDICATOR 19: GROSS VALUE ADDED

Description:
Gross value added per unit of bioenergy produced and as a percentage of gross domestic product

Measurement unit(s):
US$/MJ and percentage

3.19.1 Testing of indicator 19 in Indonesia

In Indonesia bioenergy is a relatively new sector and consequently comprehensive economic data on gross value added by these energy sources are scarce. For the measurement of this indicator a case study approach was taken in order to provide experimental data gathered from a major biodiesel company located in north Sumatra in 2012.

3.19.2 Key findings

In 2012 the surveyed biodiesel company produced some 312 million litres of biodiesel or 14.06 percent of total Indonesian production that year. The primary data campaign carried out at this company's operations has offered valuable information concerning biodiesel production cost and consumer prices. The company produces biodiesel (Palm Methyl Ester - PME) starting from crude palm oil (CPO). The gross value added was calculated using the following formula:

GVA = Total output value – Intermediate inputs

The total output value was considered to be the price of biodiesel per MJ (0.03008 USD/MJ_{PME}) calculated on the basis of real market conditions at the moment of the survey (August 2012). The biodiesel plant purchased intermediate inputs such as CPO at the equivalent price of 0.2638 USD/MJ_{PME} and methanol at an equivalent price of 0.00122 USD/MJ_{PME}. Other inputs (e.g. electricity, heat, labour, etc.) were not included in this estimate.

Table 3.19.1

Input and output prices at the surveyed biodiesel company

Item	Price USD/ MJPME
Biodiesel (PME)	0.03008
CPO	0.02638
Methanol	0.00122
Gross Value Added	0.00248

Source: Survey in a selected biodiesel operator's facilities in north Sumatra, September 2012

Given the limited data available, the GVA of biodiesel was estimated to be USD 0.00248 per MJ.

According to the Central Bureau of Statistics (BPS, 2014) in 2012 the Indonesian GDP reached USD 706 billion. In the same year, Indonesia produced a total of 2.2 billion liters of biodiesel (ESDM, 2014). This amount, coupled with the estimated GVA per MJ of biodiesel produced in Indonesia, may allow for an estimate of the percentage of GDP due to the GVA of biodiesel. However, it should be noted that the following estimation presents some limitations due to the case study approach taken for the collection of primary data and their representativeness.

Therefore, in 2012 the value added generated by biodiesel production was estimated at USD 180 million, accounting for 0.026 percent of Indonesian GDP. On a per unit of energy basis, the value added generated by biodiesel production in Indonesia in 2012 was equal to USD 0.00248 per MJ.

3.19.3 Main conclusions and recommendations

Results of indicator measurement

The analysis carried out was based on primary information collected in a private biodiesel company responsible for about 14 percent of total biodiesel production in Indonesia. In 2012 the value added generated by biodiesel production was estimated at USD 180 million, accounting for 0.026 percent of Indonesian GDP. On a per unit of energy basis, the value added generated by biodiesel production in Indonesia in 2012 was equal to USD 0.00248 per MJ.

Future monitoring of indicator 19 in Indonesia

As explained above, scarce information could be found in literature on the gross value added generated through the production of palm oil based biodiesel, hence the gross profit of a representative biodiesel plant was used as a proxy. Given the recent expansion in the production of biodiesel and the growing importance of the bioenergy sector in Indonesia, collecting up to date information on the gross value added in the production of palm oil based biodiesel would be extremely important. If this data was collected on a regular basis, it would be possible to get an indication of the relative weight of the bioenergy sector within the domestic economy over time.

Relevance, practicality and scientific basis of indicator 19

During the testing of the GBEP sustainability indicators for bioenergy in Indonesia, the importance of measuring the gross value added generated by bioenergy production and its contribution to the GDP was confirmed.

However, the measurement of the indicator was affected by both the quantity and the quality of the available data. The availability of sufficiently detailed and up to date information might be an issue in other developing countries as well.

In the lack of information regarding the gross value added generated by biodiesel production in Indonesia, the estimated gross profit per unit of energy of a representative plant was used as a proxy. The validity of this proxy and the potential replicability of this approach in other countries should be further explored.

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3.20. INDICATOR 20: CHANGE IN CONSUMPTION OF FOSSIL FUELS AND TRADITIONAL USE OF BIOMASS

Description:
(20.1) Substitution of fossil fuels with domestic bioenergy measured by energy content (20.1a) and in annual savings of convertible currency from reduced purchases of fossil fuels (20.1b)
(20.2) Substitution of traditional use of biomass with modern domestic bioenergy measured by energy content.

Measurement unit(s):
(20.1a) MJ per year and/or MW per year
(20.1b) USD per year
(20.2) MJ per year and/or MW per year

3.20.1 Testing of indicator 20 in Indonesia

For the testing of indicator component 20.1, the required data was obtained from both national and international statistics, as well as from indicator 18. Research was not necessary for indicator component 20.2, as it was not found to be relevant in the current Indonesian context. Despite reports of a decrease in woodfuel consumption over the past decade in Indonesia, this appears to be primarily linked to the increase in access to kerosene and then consequently to LPG, whereas modern bioenergy technologies have not played a significant role in displacing traditional uses of biomass nor in providing access to modern energy services.

3.20.2 Key findings

20.1: Substitution of fossil fuels with domestic bioenergy measured by energy content (20.1a) and in annual savings of convertible currency from reduced purchases of fossil fuels (20.1b)

Annual biodiesel production in Indonesia between 2009 and 2012 is reported in table 3.20.1, expressed in liters per year. In 2012, about three quarters of the biodiesel produced in Indonesia were exported.

Table 3.20.1

Annual biodiesel production, exports and domestic use in Indonesia between 2009 and 2012; values in litres

Year	Total production	Export	Domestic use
2009	190,000,000	70,000,000	120,000,000
2010	243,000,000	20,000,000	223,000,000
2011	1,812,000,000	1,453,000,000	359,000,000
2012	2,221,000,000	1,552,000,000	669,000,000

Source: ESDM, 2014

For the measurement of indicator component 20.1a, the use of the following formula is suggested for each imported type of fossil energy (i):

$$E_{fossilsub\_i} = E_{bioenergydom} \times (1 - 1/NER_{dom\_i}),$$

where:

$E_{fossilsub\_i}$ is the amount of fossil fuel energy, disaggregated by fossil fuel type, substituted by modern domestic bioenergy in the country;

$E_{bioenergydom}$ is the amount of domestically produced modern bioenergy consumed in the country; and

NER_{dom_i} is the net energy ratio for domestically produced modern bioenergy consumed in the country disaggregated by fossil fuel type and calculated according to the methodology sheet for Indicator 18, Net energy balance, and using only fossil fuel inputs for the energy input term (net energy ratio = energy output/energy input).

The results of the application of the aforementioned methodology to the case of biodiesel in Indonesia are shown in table 3.20.2. The net energy ratio that was calculated for biodiesel in indicator 18 (i.e. 5.36 MJ Biodiesel / MJ fossil fuel) was used in the formula. As shown below, in 2012 biodiesel substituted about 18 billion MJ of fossil fuel on the domestic market in Indonesia (Indicator component 20.1a).

Table 3.20.2

Fossil fuel substituted by biodiesel (total), 2009 – 2012

Year	MJ/year
2009	3,221,194,030
2010	5,986,052,239
2011	9,636,738,806
2012	17,958,156,716

Source: FAO calculations based on ESDM, 2014

Since 2009, Indonesia has imported considerable amounts of crude oil and refined products to meet the internal demand (EIA, 2014). The production of biodiesel has resulted in annual savings from reduced purchase of fossil fuels from 2009 to 2012 and in increased exports of biodiesel. With regard to the annual savings of convertible currency from reduced purchases of fossil fuels, the domestic use of biodiesel in Indonesia in 2012 has accounted for roughly 282 million USD. As shown in table 3.20.3, in 2012 the sum of savings and revenues from biodiesel exports accounted for nearly 939 million USD (Indicator component 20.1b). Table 3.20.4 shows the breakdown of the total amount of savings from reduced purchases of fossil fuels and the revenues from biodiesel exports[36].

36 As in the case of the substitution effect, this was calculated on the basis of the international price of crude oil which is assumed to substitute rather than based on the international price of biodiesel.

Table 3.20.3

Substitution of fossil fuel with domestic biodiesel in USD/year, 2009 – 2012

	20.1a			20.1b
Year	$E_{bioenergydom}$ MJ	$E_{fossilsub\_i}$ MJ	Price $bbl_{fossilsub\_OIL}$ USD	USD per year
2009	6,270,000,000	3,221,194,030	61.95	33,413,368
2010	8,019,000,000	5,986,052,239	79.48	79,663,690
2011	59,796,000,000	9,636,738,806	94.88	153,097,050
2012	73,293,000,000	17,958,156,716	94.05	282,802,091

Source: FAO calculations based on ESDM, 2014

Table 3.20.4

Substitution of fossil fuel with domestic biodiesel and revenues form biodiesel exports in USD/year, 2009 – 2012

Breakdown of indicator component 20.1b		
Savings from oil imports (USD)	Revenue from biodiesel export (USD)	Total Savings + Revenues (USD)
33,413,368	19,491,131	52,904,499
79,663,690	7,144,726	86,808,416
153,097,050	619,637,921	772,734,971
282,802,091	656,067,032	938,869,123

Source: FAO calculations based on ESDM, 2014

20.2: Substitution of traditional use of biomass with modern domestic bioenergy measured by energy content

As explained in section 3.20.1, indicator component 20.2 was not deemed relevant in Indonesia. Though a decrease in woodfuel consumption has been recorded in the country during the past decade, this predominantly appears to be the result of increased access to natural gas. On other hand, in Indonesia modern bioenergy technologies have not played a significant role yet in displacing traditional uses of biomass and in providing access to modern energy services.

3.20.3 Main conclusions and recommendations

Results of indicator measurement

In 2012, around 73 billion MJ of biodiesel were produced in Indonesia of which around 70 percent was exported and the rest consumed domestically. As calculated under indicator component 20.1a based on the NER of biodiesel estimated in indicator 18, in 2012 biodiesel from palm oil substituted 17.95 billion MJ of fossil fuel in Indonesia. This procured estimated savings from avoided oil imports for about 282 million USD. The quantity of biodiesel exported generated further revenues quantified in about 657 million USD.

As of 2012, biodiesel was employed entirely in the transport sector in Indonesia. Consequently, indicator component 20.2 was not measurable as it was found that modern bioenergy has not contributed to reducing or substituting traditional use of biomass in the Southeast Asian country.

Future monitoring of indicator 20 in Indonesia

As the domestic bioenergy sector continues to expand and higher biofuel mandates are considered, it will be important to continue monitoring indicator 20 in Indonesia and assess the displacement of fossil fuel with biodiesel and the resulting economic benefits, e.g. in terms of savings from imports of oil products.

Indicator component 20.2 should be monitored as well in the future, should modern bioenergy technologies start playing an important role in displacing traditional uses of biomass and in providing access to modern energy services in Indonesia.

Relevance, practicality and scientific basis of indicator 20

The testing in Indonesia showed the importance of assessing the substitution of fossil fuels with biofuels and the resulting economic benefits, thus confirming the relevance of indicator component 20.1. However, the wording of indicator component 20.1b appears to be tailored mainly to oil importing countries. In the case of oil or bioenergy exporting countries, it is more appropriate to assess the increase in exports rather than the import savings associated with the substitution of fossil fuels with biofuels. Therefore, a more neutral wording of indicator component 20.1b would be desirable in order to capture the full spectrum of substitutions and annual savings/revenues due to modern bioenergy trade.

As explained above, indicator component 20.2 was not deemed relevant in the current Indonesian context. However, this might change in the future.

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3.21 INDICATOR 21: TRAINING AND REQUALIFICATION OF THE WORKFORCE

Description:
(21.1) Share of trained workers in the bioenergy sector out of total bioenergy workforce, and (21.2) share of re-qualified workers out of the total number of jobs lost in the bioenergy sector

Measurement unit(s):
Percentage (per year)

3.21.1 Testing of indicator 21 in Indonesia

During the testing of indicator 21 in Indonesia, information related to skills, training and qualifications of workers could not be found in the literature for the palm oil supply chain. Disaggregated figures were not available for the portion of the supply chain dedicated to the production of biodiesel. A field survey in a representative palm oil plantation and in a large palm oil mill was carried out in order to inform about the aspects dealt with in indicator 21. The survey has offered some insights on the level of qualification of the workers in these two stages of the bioenergy value chain. These insights however, are not deemed sufficient to describe the national situation with adequate representativeness but only give a first overview of the situation in the sector.
Indicator component 21.2, which aims to measure the percentage of re-qualified workers out of the total number of jobs lost in the bioenergy sector, was not found to be relevant in the current Indonesian context. This indicator component does not apply to configuration of the palm oil biodiesel sector as of 2012 since there was no distinguishable displacement of workers in the palm oil sector as a result of increased mechanization or other factors and consequent re-qualification of the workers.

3.21.2 Key findings

Due to the scarcity of secondary data concerning the conditions of the bioenergy workforce, surveys and interviews were undertaken in one large scale Indonesian bioenergy operator in north Sumatra. Interviews involved the workforce employed in the oil palm plantation and workers employed in the palm oil mill. From the survey it emerged that skilled workers in the oil palm plantation are roughly 3 percent of the total (545 workers), while the remaining 97 percent of the workers is classified as unskilled. Free daily labour accounts for about 59 percent of the unskilled workers and the rest is contractual labour. Skilled workers in the palm oil mill are about one third of the total workforce: out of 133 workers, those classified as skilled are 27.07 percent, whereas unskilled workers accounted for 72.93 percent of the total.

Figure 3.21.1

Workers in Oil Palm Plantation

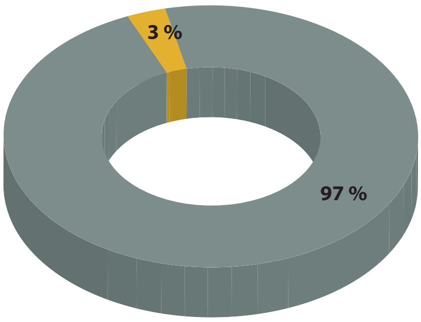
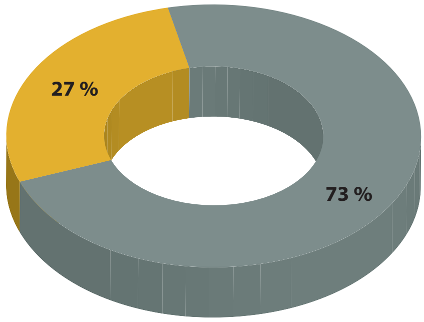


Figure 3.21.2

Workers in Palm Oil Mill



Skilled Unskilled

Source: Survey in a selected biodiesel producer in north Sumatra, September 2012

The outcome of the survey in one sampling location cannot be considered as representative of the national situation however, some interesting information can be gained from this exercise. In general, the workforce employed in the plantation is unskilled and the majority of them are on free daily contract regime. This is the consequence of the type of tasks that those workers are asked to perform: agricultural operations that do not rely on complex mechanical equipment and that do not imply the understanding of complex procedures. Newly hired workers have reported to receive very basic instructions from their supervisors and/or senior workmates although a proper training is not offered to those employed in the agricultural phase of the value chain. In the palm oil mills (and likely in the biodiesel refineries), a much higher percentage of workers receives training and is hired on the basis of acquired skills. As in the case of the workers in the plantations, this is directly due to the type of tasks consigned to them. These often include the use of heavy and complex machineries that have specific use procedures.

3.21.3 Main results and recommendations

Results of indicator measurement

Secondary information available on the topic of training and re-qualification of the workforce in Indonesia is particularly scarce. In addition, the indicator component 21.2 entails the existence of a displacement of the workforce from the bioenergy sector to other sectors. However, based on information available, this has not happened in Indonesia and therefore this component of the indicator was not applicable to the context of the Southeast Asian country. Surveys and interviews were carried out in north Sumatra (a major palm oil and palm oil-based biodiesel production area in Indonesia) in order to seek some insights on the conditions of the workers employed in the bioenergy value chain (limited to the feedstock production and processing stages). The surveys have revealed that nearly all workers employed in the agricultural phases of the biodiesel chain are unskilled workers and that only about 3 percent of the workers hired in the palm oil plantations are skilled. This is the consequence of the type of tasks that those workers are asked to perform, agricultural operations that do not rely on mechanical equipment and that do not require the understanding of complex procedures. Newly hired workers have reported to receive very basic instructions from their supervisors and/or senior workmates although a proper training is not offered to those employed in the agricultural phase of the value chain. In the palm oil mills (and likely in the biodiesel refineries), a considerably higher percentage of workers receives training and is hired on the basis of possessed or acquired skills. As in the case of the workers in the plantations, this is directly due to the type of tasks consigned to them. These often include the use of heavy and complex machineries that have specific use procedures.

Future monitoring of indicator 21 in Indonesia

With regard to indicator component 21.1, training of the workforce in the bioenergy supply chain appears to be a relevant issue in Indonesia. Data on the existence of programs to monitor and support farmers and estate companies receiving and delivering training to the workforce have not been documented in Indonesia. However, training courses are available and offered by private providers. These programmes target mainly managers and professionals, and it seems that the courses rarely focus on the enhancement of the capabilities of unskilled workers (IPNI, 2014; Cargill, 2013).

Approaches such as the FAO Farmer Field Schools (FFS) are seen as a valuable instrument to share experiences among farmers and learn from neighbouring farmers on how to cope with the challenges and respond to the difficulties encountered during a farming cycle. FAO and other development organizations have been promoting farmer field schools to improve land and water management in many areas of the world. Unlike traditional approaches to agricultural extension, which rely on extension workers providing advice to farmers, farmer field schools enable groups of farmers to find out the answers for themselves (FAO, undated). The specific case of Indonesia, however, would require a variant approach with respect to the standard FFS. Transferring knowledge from the well-established government-owned plantation management to the numerous smallholders is a first fundamental step in order to enable independent farmers to benefit from the enhancement of their technical and managerial skills. A second stage of the proposed programme would include a more classic FFS approach. However, only once effective skills have been transferred from the government plantation professionals to a first group of farmers, these latter should be capable of sharing with other farmers their newly gained knowledge and find common solutions.

Relevance, practicality and scientific basis of indicator 21

With regard to indicator component 21.1, training of the workforce in the bioenergy supply chain appears to be a relevant issue in Indonesia. Conversely, indicator component 21.2 was not found to be relevant in the current Indonesian context. This second component of indicator 21 appears to have a narrower scope if compared to indicator component 21.1, as it seems to be applicable mainly to requalification programmes for workers who lost their jobs as a result of a switch to mechanized operations. In Indonesia this has not happened and, moreover, the vast majority of those workers are employed on a free daily basis, thus without a direct and indefinite allegation with the employer.

Concerning the practicality of indicator 21, while the methodology per se is very straightforward, data availability might be an issue, especially with regard to the feedstock production side, where most jobs tend to be informal in developing countries.

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3.22 INDICATOR 22: ENERGY DIVERSITY

Description:
Change in diversity of total primary energy supply due to bioenergy

Measurement unit(s):
Index (in the range 0-1) MJ bioenergy per year in the Total Primary Energy Supply (TPES)

3.22.1 Testing of indicator 22 in Indonesia

For the testing of indicator 22 in Indonesia, the data required for the calculation of the Herfindahl Index and of the amount of MJ of bioenergy per year in the Total Primary Energy Supply (TPES) was retrieved from both national and international statistics.

3.22.2 Key findings

In Indonesia, the Total Primary Energy Supply (TPES) was equal to 1,514,639,000 boe (barrel of oil equivalent) in 2012 (ESDM, 2013). As shown in figure 3.22.1, in 2012 oil was the main energy source in Indonesia, accounting for 38.86 percent of the total primary energy supply, followed by coal with 22.44 percent, biomass (mostly solid) with 18.36 percent and natural gas with 16.87 percent. Apart from solid biomass, renewable sources such as hydropower, geothermal, and biofuels represent small shares of the TPES with 2.10, 1.08 and 0.29 percent respectively. With the term biofuels the Handbook of Energy & Economic Statistics of Indonesia (ESDM, 2013) includes both ethanol and biodiesel. Because no bioethanol has been sold on the domestic market for energy purposes since 2010, the share of the TPES attributed to the generic group named biofuels should be allocated to biodiesel only. However, based on realization data[37] provided by the Ministry of Energy to FAO (ESDM, 2014), biodiesel, if considered alone, supplied about 0.19 percent of the TPES in 2012, or 17,958,156,716 MJ (see also Indicator 20). The composition of the Indonesian TPES was adapted in order to reflect the updated information based on biodiesel production and domestic use (figure 3.22.1).

Based on the data from Figure 3.22.1, the Herfindahl Index was calculated for two scenarios: i) including modern bioenergy supply in the country and ii) excluding modern bioenergy supply from the total primary energy supply of the country. In the case of scenario ii), the share of TPES belonging to biodiesel was attributed to oil which was assumed to be the most direct substitute for liquid fuels used for transport.

Given the lack of sufficient information regarding the use of solid biomass in Indonesia (e.g. average efficiency and performances of the stoves, incidence of presence of chimneys, etc), this energy source was not accounted for as 'modern bioenergy[38]'. Therefore, biodiesel

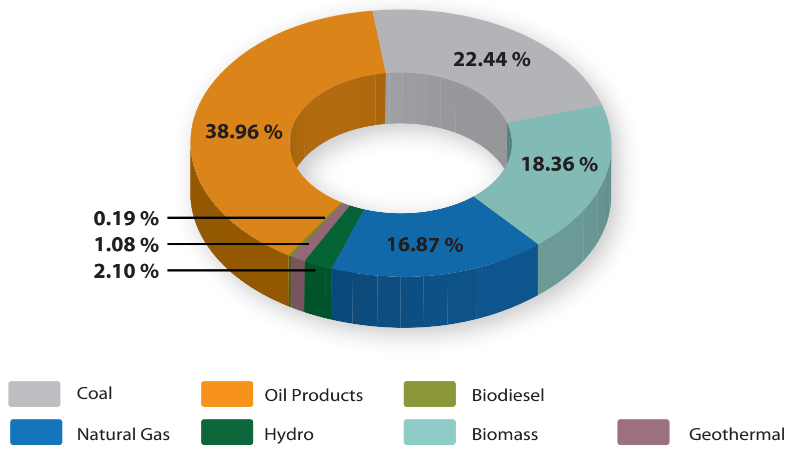
37 Actual quantity produced in a past reference year

38 Modern bioenergy has been defined by the Global Bioenergy Partnership in the Report on the Sustainability Indicators for Bioenergy at page 209 as follows: Modern bioenergy is used to describe energy which delivers modern bioenergy services. The concept of modern bioenergy services includes energy delivered by efficient conversion technologies for heating, cooling, electricity generation, transport etc employing biomass as their primary sources. The concept does not include biomass used for cooking or heating purposes in open stoves or fires with no chimney or hood or any other energy systems that release flue gases indoors or release high concentrations of air pollutants, irrespective of the feedstock or biofuel employed.

was the only modern bioenergy form considered. The two aforementioned scenarios and the associated Herfindahl Indexes are shown in table 3.22.1.

Figure 3.22.1

Share of energy sources in Total Primary Energy Supply (TPES), 2012



Source: Edited from ESDM, 2013 and ESDM, 2014

Table 3.22.1

Share of energy sources in total primary energy supply (TPES) with and without modern bioenergy, 2012

TPES	Share with modern bioenergy	Share without modern bioenergy
Oil	38.96 %	39.15%
Coal	22.44 %	22.44%
Biomass	18.36 %	18.36%
Natural Gas	16.87 %	16.87%
Hydropower	2.10 %	2.10%
Geothermal	1.08 %	1.08%
Biodiesel	0.19 %	0.00%
Herfindahl Index	0.265	0.266

Source: Edited from Edited from ESDM, 2013 and ESDM, 2014

In the 'current' scenario (i.e. with modern bioenergy), a Herfindahl Index of 0.265 was calculated, while in the scenario without modern bioenergy, this Index was found to be only slightly higher at 0.266. This shows a minor contribution of biodiesel to the diversity and security of the energy supply in Indonesia as of 2012.

As per the suggested methodological approach of indicator 22, the amount of energy (MJ) supplied by the considered modern bioenergy source in the TPES is reported in table 3.22.2.

Table 3.22.2

MJ of modern bioenergy per year in TPES, 2012

Modern bioenergy in TPES	MJ/year in TPES
Biodiesel	17,958,156,716

Source: Edited from Edited from ESDM, 2014

Proven oil reserves of the country are already shaping energy policy in Indonesia. In 2012, the country produced 314 million barrels of oil, from their proven reserves approximately 3.74 billion barrel. At the rate of extraction recorded in 2012, Indonesia has proven oil reserves for roughly 12 years (ESDM, 2013). Partially as a consequence of the finite proven oil reserves of the country, ambitious targets for the substitution of considerable amounts of energy have been proposed in the newly drafted National Energy Policy (KEN) which should be signed into law by the end of 2014. The policy aims at ensuring "energy independence and security" through, among other things, enhancing energy conservation and diversification (ESDM, 2014a). Biodiesel (not limited to palm oil-based FAME) is expected to represent a large share of the total primary energy supply of Indonesia by 2030 and the monitoring of indicator 22 is deemed important to assess the effectiveness of the actions included in the National Energy Policy 2014.

3.22.3 Main conclusions and recommendations

Results of indicator measurement

The Herfindahl Index was calculated for two scenarios: one with modern bioenergy as part of the TPES (i.e. the current Indonesian scenario) and one without. In the 'current' scenario, a Herfindahl Index of 0.265 was calculated, while in the scenario without modern bioenergy this Index was found to only slightly higher (0.266). This shows a modest contribution of biodiesel to the diversity and security of the energy supply of Indonesia. The use of the index adds little information to the picture of the Indonesian energy system: a system dominated by large quantities of fossil fuels (oil, coal, natural gas) and solid biomass as part of a mix that includes a modest amount of modern bioenergy (0.19 percent of TPES in 2012).

The amount of energy (MJ) supplied by the considered modern bioenergy source (biodiesel) in the TPES in 2012 was 17.95 x 10^9 MJ.

Future monitoring of indicator 22 in Indonesia

As the bioenergy sector continues to expand and higher biofuel mandates are considered, it will be important to monitor indicator 22 and assess how modern bioenergy affects energy diversity and security.

As explained above, given the lack of sufficient information regarding the use of solid biomass for heating and cooking in Indonesia, this energy source was not accounted for as ‘modern bioenergy’. Therefore, only biodiesel was considered under the latter for the calculation of the Herfindahl Index for the scenario which included modern bioenergy. Further research should be done in order to identify, and then monitor over time, the share of woodfuel that is used to deliver modern bioenergy services (as per GBEP definition) and in order to monitor changes in the supply of oil. Biodiesel (not only palm oil-based FAME) is expected to represent a large share of the total primary energy supply by 2030 (see indicator 10, Tier III for further details) and the monitoring of indicator 22 is deemed important to assess the effectiveness of the actions included in the newly developed National Energy Policy.

Relevance, practicality and scientific basis of indicator 22

The importance of assessing the contribution of modern bioenergy to the diversity and security of the energy supply was confirmed during the testing of indicator 22 in Indonesia. The Herfindahl Index appears to be a rapid and practical approach to assess this contribution however, when the share of TPES represented by modern bioenergy is smaller than 1 percent, as in the case of Indonesia, the results of scenarios which include and which exclude modern bioenergy from the TPES may not be captured by the Index.

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3.23 INDICATOR 23: INFRASTRUCTURE AND LOGISTICS FOR DISTRIBUTION OF BIOENERGY

Description:
(23.1) Number and (23.2) capacity of routes for critical distribution systems, along with (23.3) an assessment of the proportion of the bioenergy associated with each

Measurement unit(s):
(23.1) number
(23.2) MJ, m^3, or tonnes per year; or MW for heat and power capacity
(23.3) percentages

3.23.1 Testing of indicator 23 in Indonesia

For the testing of indicator 23 in Indonesia, relevant information was gathered and edited with the support of the Indonesian Geospatial Information Agency (Badan Informasi Geospasial – B.I.G.), through official reports and literature regarding infrastructure and logistics for the distribution of biofuels in the country.
However, due to the lack of sufficiently detailed data to conduct a quantitative assessment of the three components that it comprises, only estimates are proposed and intended to represent a baseline for future monitoring and refining of the assessment.

3.23.2 Key findings

Feedstock production
As shown in table 3.23.1, in 2012, over 97 percent of crude palm oil (CPO) production in Indonesia was concentrated in the islands of Sumatra and Kalimantan (Ministry of Agriculture, 2013).

Table 3.23.1

Crude Palm Oil (CPO) production in Indonesia by island

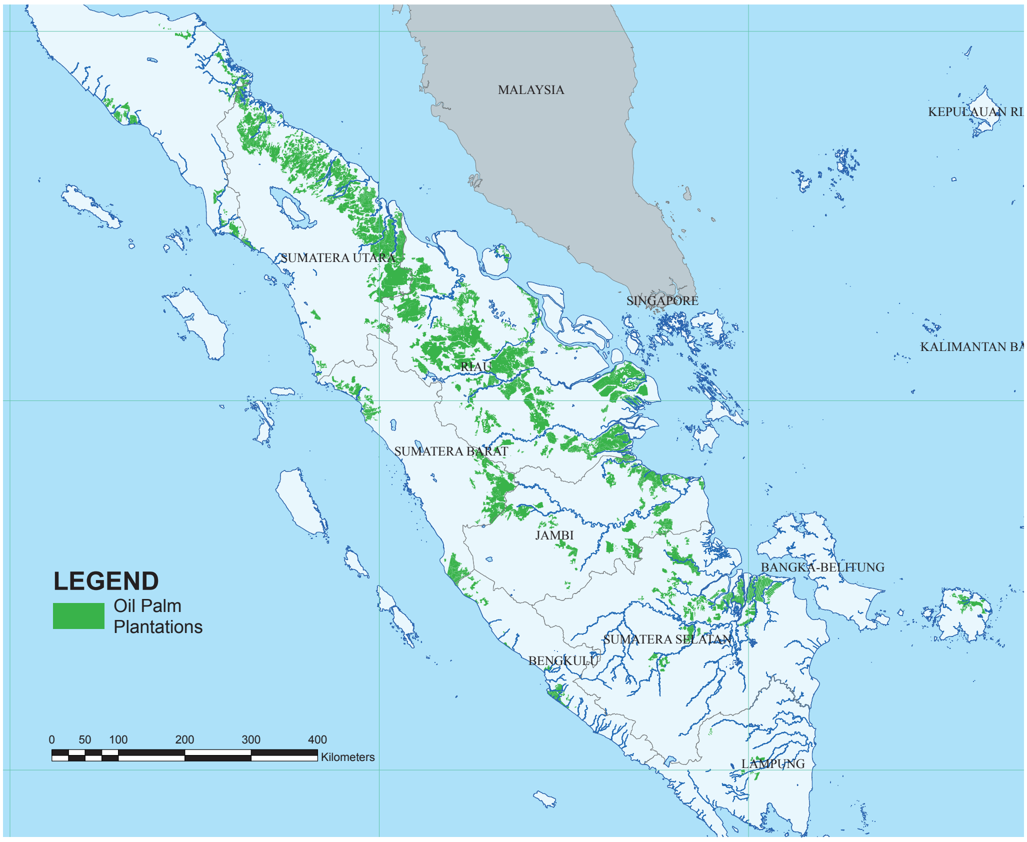
2012 CPO production		Share of total	
Sumatra	18,611,685 t	71.54%	97.02%
Kalimantan	6,629,623 t	25.48%	
Sulawesi	582,469 t	2.24%	
Java	49,431 t	0.19%	
Maluku & Papua	142,310 t	0.55%	
Total	**26,015,518 t**	100.00%	

Source (Ministry of Agriculture, 2013)

The main biodiesel feedstock production sites in Sumatra are illustrated in figure 3.23.1 (green areas represent oil palm plantations) for the year 2010 (edited from Gunarso et al, 2013). The provinces of Sumatra that produce the largest amount of CPO are Riau (6.4 million tonnes in 2012), North Sumatra (4.1 Mt), South Sumatra (2.6 Mt), Jambi (1.9 Mt) and West Sumatra (0.9 Mt).

Figure 3.23.1

Oil palm plantations, Sumatra Islands, 2010



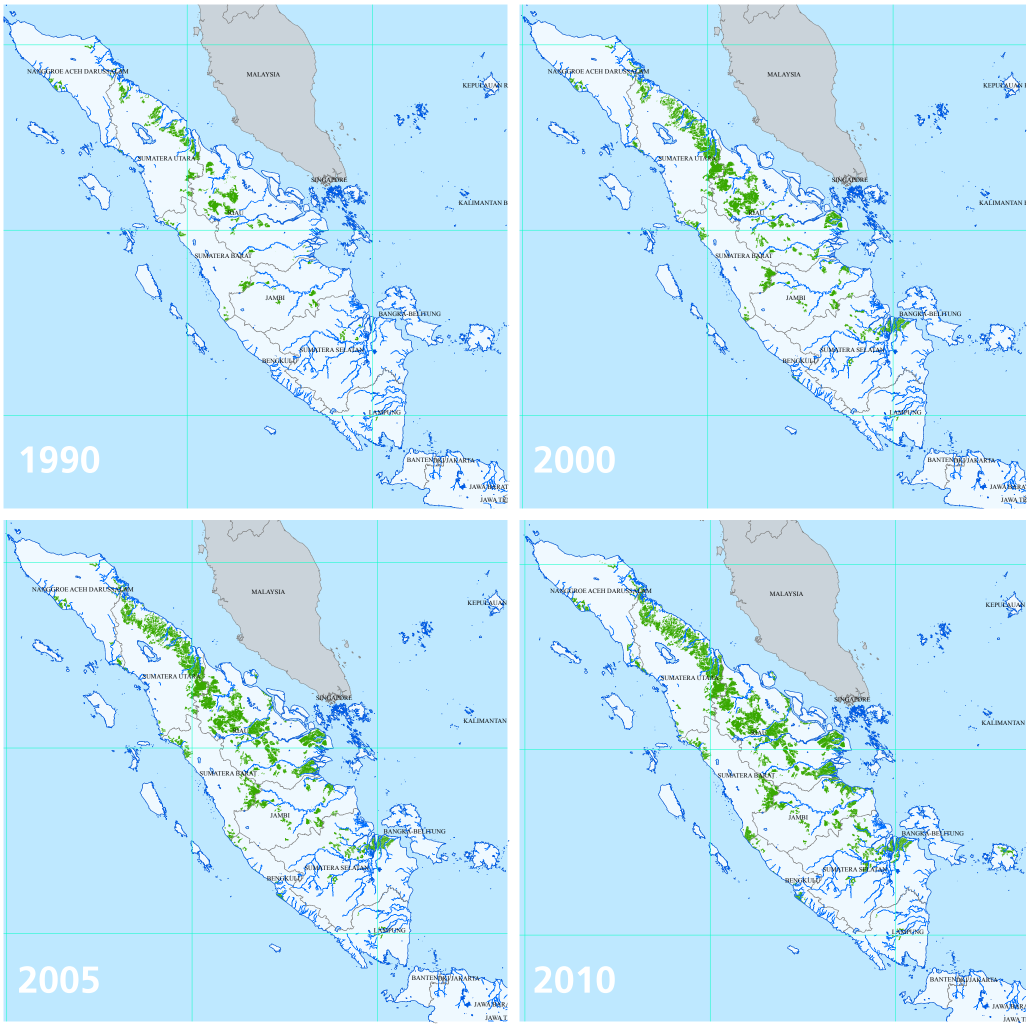
Source: Edited from Gunarso et al, 2013

In Sumatra, 47.5 percent of the harvested area in 2012 was owned by smallholders[39], 44.3 percent by private estate companies and the rest (8.2 percent) was represented by government-owned plantations. Often, large private estates have access to capitals and materials for the creation and maintenance of roads and transport routes, whereas smallholders have to rely on already existing infrastructures for the movement of their products (i.e. the fresh fruit bunches).

39 The Central Bureau of Statistics of Indonesia (BPS) defines palm oil smallholdings those farms having a surface of up to 4 (four) hectares.

Figure 3.23.2

Oil palm plantation development in Sumatra between 1990 and 2010



Source: Edited from Gunarso et al, 2013

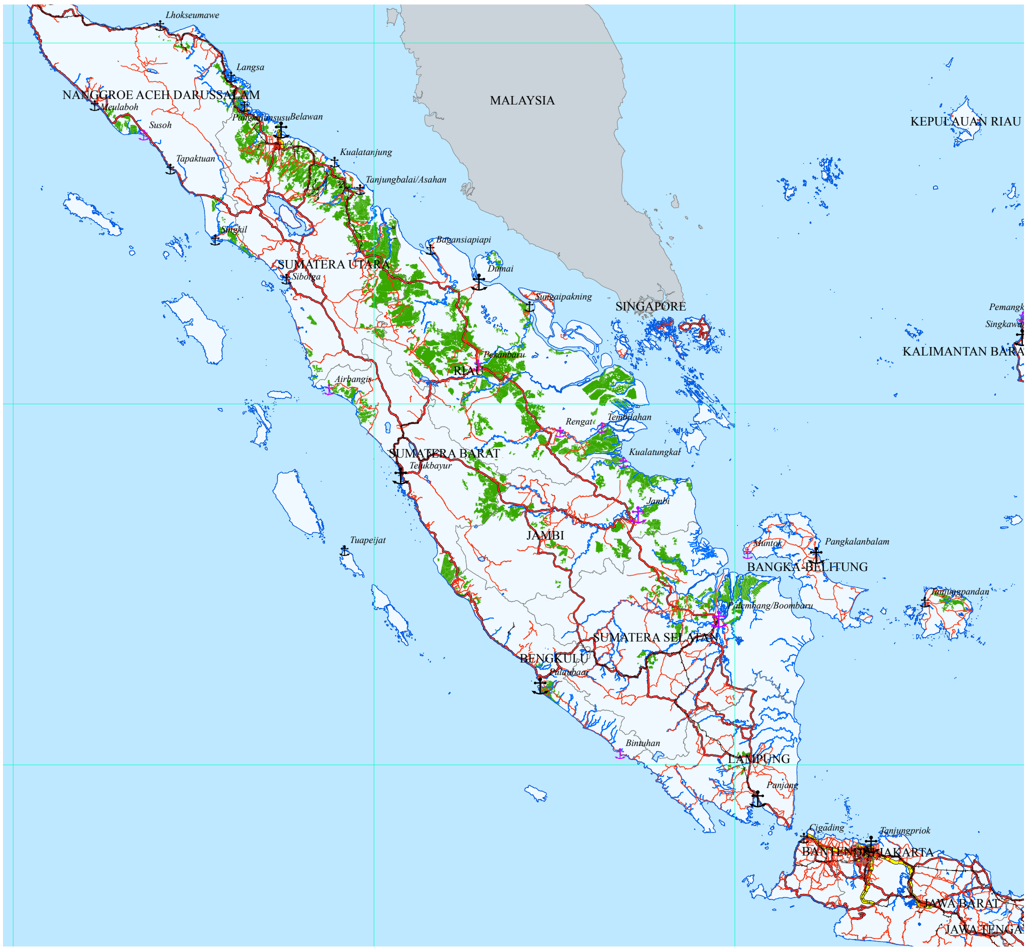
The historic development of oil palm plantations in Sumatra between 1990 and 2010 followed a pathway of expansion along the vast plains east of the Great Sumatran Fault, originating from the Barisan Mountains (figure 3.23.2).

In Sumatra, FFB are transported from plantations to the palm oil mills by truck or in some cases by boat. The map in figure 3.23.3 shows the main transport routes in Sumatra (roads and navigable waterways) and main reception infrastructures such as sea ports and river harbors. The land transportation network on the island of Sumatra is the *Jalan Lintas Sumatra* (JLS), dominated by interprovincial arterial roads. The JLS runs along a north-south axis through the island of Sumatra, from Banda Aceh to Bandar Lampung. Over the past few decades, its roads have become the most important land transportation network in Sumatra. The importance of the JLS is also due to the scarcity of alternative routes to connect the northern and southern ends of the island, as railroads only exist in the provinces of North Sumatra, South Sumatra and Lampung, which are mostly single track lines. Sumatra is markedly far from having an adequate rail system. Conversely, the JLS is divided into three main traits which are defined by sub-networks of arteries, collectors and local roads in the geographical area where these are located: the E-JLS is the Eastern network, the W-JLS is the Western network and, nested between the E-JLS and the W-JLS, there is a further sub-network of roads known as the Central JLS (C-JLS).

The E-JLS is currently the main transportation network in Sumatra by volume of traffic extending along the east coast of Sumatra. This road links the province of Bandar Lampung to Banda Aceh via Palembang, Jambi (eastern side), Pekanbaru and Medan provinces. Most of these roads run through the vast eastern Sumatran plains and are mostly flat, paved sections of road with few corners and have average width of 6-7 meters. In the provinces of South Sumatra and Lampung however, many components of the E-JLS network are severely damaged, particularly the smaller local roads.

Figure 3.23.3

Map of Oil Palm Plantations and Transportation Routes in Sumatra

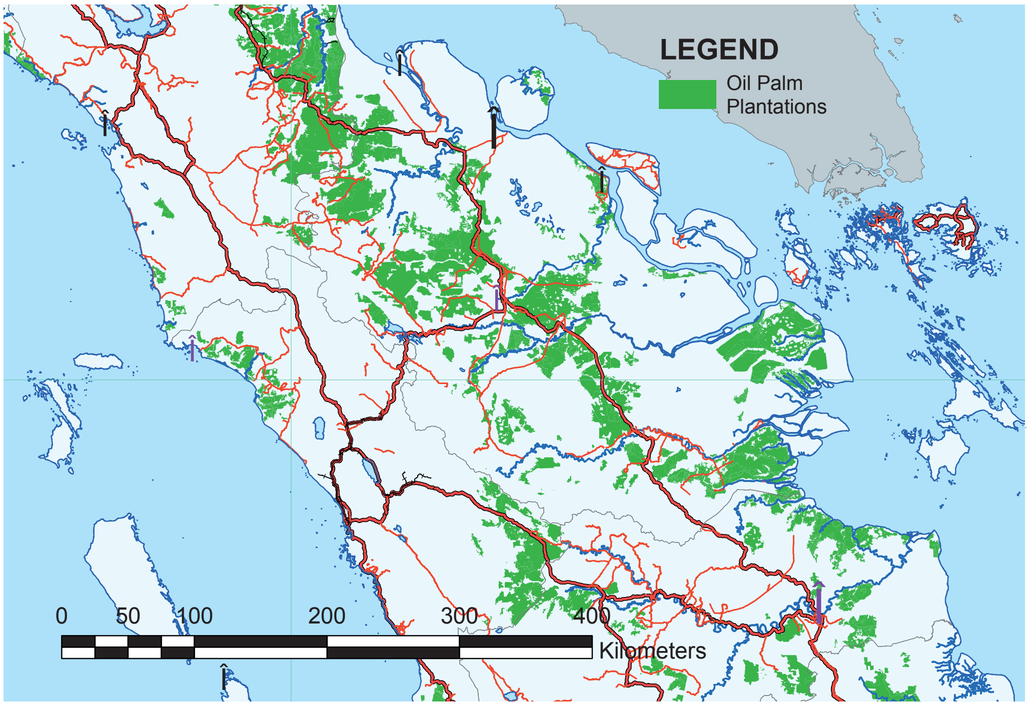


Source: Indonesian Geospatial Agency, 2014

The W-JLS connects the three provinces of Lampung, Bengkulu and West Sumatra, along the west coast of Sumatra. The majority of the roads composing this sub-network are narrow (less than 6 meters), winding and suffer from poor maintenance conditions. Road segments in the region of North Bengkulu, Muko-Muko and West Lampung have been reported to be prone to landslides due to heavy rainfall events and coastal erosion.
The Central JLS network extends from the provinces of Medan to Bandar Lampung through the provinces of Lampung, South Sumatra, Jambi, West Sumatra and North Sumatra. As in the case of the W-JLS network, also in the C-JLS the road conditions are often poor. After the 1990s, the role of this network became secondary due to the increasing volume of traffic and importance gained by the E-JLS.
The main ports in Sumatra are the Port of Panjang in Lampung, Dumai in the Province of Riau, Sekupang in Batam, Belawan in Medan, Malahayati and Sabang in Aceh, Telubayur in Padang and Pulau Baai in Bengkulu. In addition to the main sea ports listed above, Sumatra has three major river harbours: Jambi in the province of Jambi, Boombaru in Palembang, Pekanbaru in Riau.

Figure 3.23.4

Main roads and ports network in the principal oil palm-producing provinces in Sumatra



Source: Indonesian Geospatial Agency, 2014

As shown in figure 3.23.3 and 3.23.4, feedstock production areas in Sumatra are all well connected to the major transport routes of the island. The system of roads, particularly the E-JLS, and internal waterways with their harbours and infrastructures, are well aligned with the developments of oil palm plantations in Sumatra.

Figure 3.23.3 shows oil palm plantations in Kalimantan as of 2010. Central Kalimantan produced about 2.8 million tonnes of CPO in 2012, the largest amount among all provinces of the island, followed by North Kalimantan (1.6 Mt), South Kalimantan and East Kalimantan with approximately 1.1 Mt each. The main transportation network in Kalimantan is known as the Trans Kalimantan Road network or *Jalan Trans Kalimantan* (JTK). This network stretches from West Kalimantan to North Kalimantan, connecting important cities which often host a harbor such as Pontianak, Palangkaraya, Banjarmasin, Balikpapan, Samarinda to Tanjung Selor. Although most arterial roads in the JTK network are paved, some segments of the main roads as well as several local roads are not paved. Along the JTK two important bridges (the Tayan bridge and the Pulau Balang bridge) are still under construction and necessary detours cause difficulties with the transport of goods.

Most of the minor roads in the trans-Kalimantan network are not paved, particularly in the region of North Kalimantan. Once passed Bontang, the roads going to the northern side of North Kalimantan province are severely damaged and in overall poor conditions. In some areas, especially in East Kutai, dirt roads are commonly wiped away by the heavy rainfall events occurring during the wet season and puddles as deep as 2 to 4 meters are often formed. Based on interviews with local farmers of Sangatta (East Kutai), a transfer from the oil palm plantation areas in East Kalimantan to the port of Bontang, which would normally take 8 hours, may take a full week if heavy rains destroy the precarious dirt roads common in this area. In addition, according to respondents of the survey, among the causes of damage to local roads, is the traffic of heavy vehicles owned by the palm oil companies operating in Kalimantan. In the island, large estate companies own about 75 percent of the oil palm planted area.

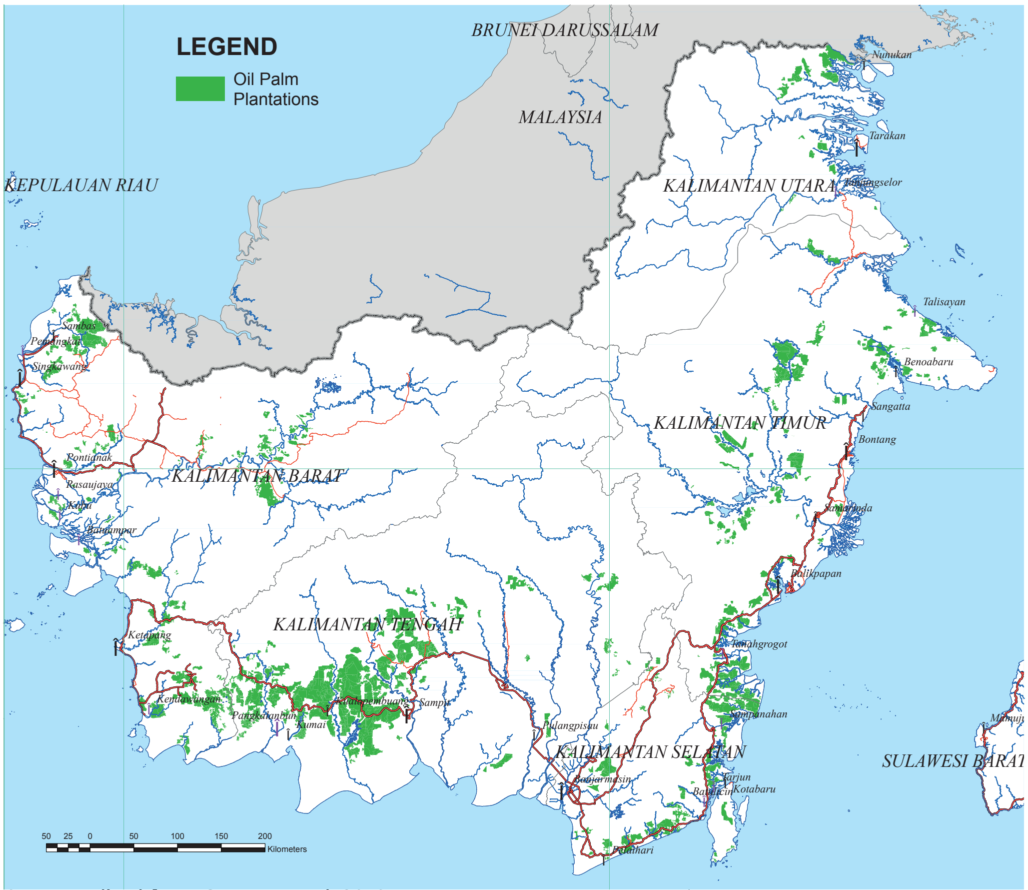
Similar conditions are found throughout the island such as in West Kalimantan where even the main arterial road is not paved for a trait of about 66.4 Km. In this Province there are road segments not connected by bridges, such as between Pontianak and Palangkaraya. These factors make the movement of goods, particularly oil palm FFB and CPO from the rural areas to the processing facilities, difficult.

Central Kalimantan experiences a higher level of infrastructures and overall better road conditions than the rest of the island. As mentioned above, the majority of the oil palm plantations of Borneo are in the Central Kalimantan province (figure 3.23.5).

The main ports on the island of Borneo are the port of Pontianak and Ketapang in West Kalimantan, Sampit in Central Kalimantan, Banjarmasin in South Kalimantan, Balikpapan and Samarinda at East Kalimantan and Tarakan in North Kalimantan. Several of these ports are located along the course or at the estuary of rivers.

Figure 3.23.5

Oil Palm Plantations in Kalimantan in 2010



Source: Edited from Gunarso et al, 2013

Logistics for the transport of biodiesel feedstock and distribution of final product

The major Sumatran seaports from which Indonesian palm oil is traded both domestically and internationally are Dumai, Belawan, Panjang, and Teluk Bayur.

According to USDA (2012), these four seaports have the facilities that can support the loading and unloading of large quantities of CPO including high capacity liquid storage tanks, wharfs that can accommodate large liquid bulk vessels and pumps and pipelines necessary to transfer palm oil from storage tanks to the vessels.

The development of these facilities, however, does not keep the pace with the overall growth of Indonesia's palm oil production (USDA, 2012). The wharfs of the aforementioned seaports can only serve one or two vessels per day with average loading time of 4 hours per vessel.

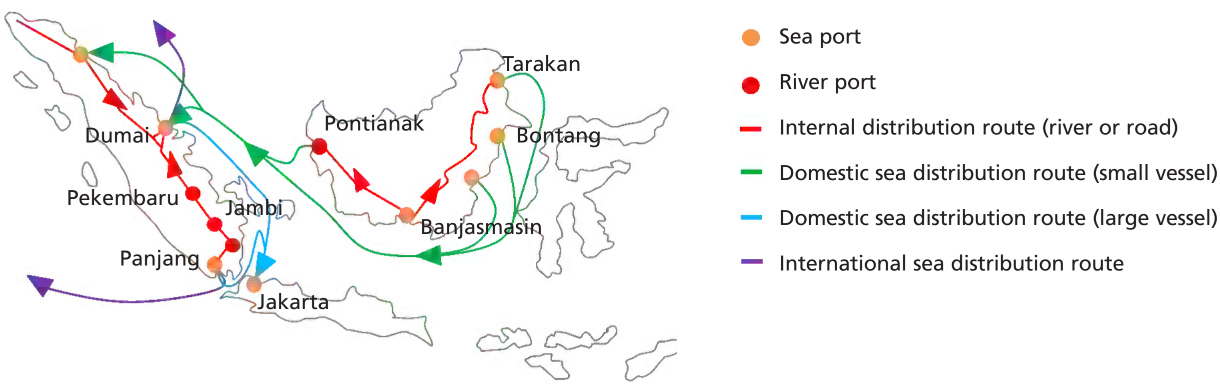
In 2012, Kalimantan produced 6.6 million tonnes of crude palm oil (CPO), equal to about 25 percent of total national production. However, Kalimantan does not have deep water seaports that can serve large vessels and USDA (2012) attributes to the lack of efficiency in transport and distribution of CPO part of the responsibility for the reduced export volumes and increased stocks recorded in 2011/2012 with regard to the previous marketing year.

Palm oil producers from the Kalimantan transport their palm oil to Dumai and Belawan seaport using small-medium sized boats before the palm oil can be exported to destination countries (USDA, 2012). The main biodiesel refineries in Indonesia are located on the eastern side of Sumatra and in West Kalimantan. The main consumption area for biodiesel is the populated island of Java, particularly in the area of Jakarta.

Biodiesel feedstock produced in Sumatra travels along the E-JLS road network and along internal waterways in order to reach processing and refining sites in the provinces of Riau, North Sumatra and Jambi. The feedstock produced in Kalimantan is sent for the most part via sea to Sumatra where it is also processed whereas a fraction is processed in the area of West Kalimantan. From the Sumatran ports of Dumai and Belawan, biodiesel and other oil palm products are sent to Java for domestic consumption, further processing or are exported directly. Distribution of biodiesel within the islands of Sumatra and Kalimantan relies on the JLS and JTK networks respectively. The Indonesian easternmost provinces are characterized by very poor road infrastructures and, although not densely populated, the difficulties in distributing biodiesel to the main cities in Papua and other areas in the Province of Nusa Tenggara are among the causes that prevented Indonesia from fulfilling the blending mandate in place in 2012.

Figure 3.23.6

Bioenergy feedstock pathways: transport from production sites in Kalimantan and Sumatra via sea, internal waterways and roads to processing facilities (mostly located in north eastern Provinces of Sumatra) and exports and/or domestic distribution of biodiesel



Source: adapted from USDA, 2012

Summarizing, as of 2012 in Indonesia there were at least 14 critical supply and distribution routes (indicator component 23.1). The cumulative capacity of these routes in 2012 was assessed at about 26 million tonnes of CPO, and a cumulative capacity for FFB transport to processing facilities of 120 million tonnes (indicator component 23.2). As for the assessment of indicator component 23.3, the vast majority of such capacity is in the Island of Sumatra, which produced about 71.5 percent of the total bioenergy feedstock in 2012 and has exported and distributed domestically more than 90 percent of total biodiesel production. It was found that the island of Kalimantan, with a share of the bioenergy production of the country roughly equal to 25 percent of total[40] is the area where most infrastructures have been found inadequate for the management of the production, particularly the road network in West and East Kalimantan and the shallow seaports.

3.23.3 Main conclusions and recommendations

Results of indicator measurement

The biodiesel feedstock produced in Sumatra travels along the E-JLS road network and along internal waterways in order to reach processing and refining sites in the provinces of Riau, North Sumatra and Jambi. This road network is efficient for the transport of CPO to the refineries however, is several Provinces the scarce quality of the road surface makes transport and distribution slow and difficult. The feedstock produced in Kalimantan encounters several bottlenecks. The road system, with the exception of the Province of Central Kalimantan, appears to be not adequate to the volume of CPO transported (6.6 million tonnes in 2012). In addition, only few ports located far from the major production sites have adequate characteristics for the shipping of large quantities of feedstock through tankers. Once the feedstock reaches the ports of Pontianak, Tarakan or Bontang, it is sent for the most part to Sumatra where it is also processed. From the Sumatran ports of Dumai and Belawan, biodiesel is sent to Java for domestic consumption and/or is exported. Distribution of biodiesel within the islands of Sumatra and Kalimantan relies on the internal road and waterways networks used for the transport of the feedstock to the processing sites, along paths similar to those covered by the feedstock. Lastly, the poor conditions of the road system in the eastern provinces of Indonesia (e.g. Nusa Tenggara and Papua), coupled with the distance from the major production sites (in Sumatra and Kalimantan) and the low population density of the islands east of Bali, resulted in 2012 in the principle obstacle to reaching the fulfillment of the B10 mandate at the national level (ESDM, 2014).

Overall, the infrastructure for biofuel distribution appears to be relatively well developed in Indonesia. However, the road network is still inadequate in many areas of the country and the low capacity of several ports (particularly in Kalimantan) makes the infrastructure inadequate to support the existing demand for CPO and its products, including biodiesel. As a consequence of these upstream hurdles, a cascade effect limits biodiesel production and consumption.

As of 2012 in Indonesia there were at least 14 critical supply and distribution routes (indicator component 23.1). The cumulative capacity of these routes in 2012 was assessed

40 On the basis of the feedstock production realization as of 2012.

at about 26 million tonnes of CPO, and a cumulative capacity for FFB transport to processing facilities of 120 million tonnes (indicator component 23.2). As for the assessment of indicator component 23.3, the vast majority of such capacity is in the Island of Sumatra, which produced about 71.5 percent of the total bioenergy feedstock in 2012 and has exported and distributed domestically more than 90 percent of total biodiesel production. It was found that the island of Kalimantan, with a share of the bioenergy production of the country roughly equal to 25 percent of total[41] is the area where most infrastructures have been found to represent a bottleneck for the management of the production, particularly the road network in West and East Kalimantan and the shallow seaports.

Future monitoring of indicator 23 in Indonesia

Infrastructure and logistics for the distribution of bioenergy can significantly affect the development of the sector. As production expands in Indonesia, vessel traffic will increase and the palm sector will require greater port capacity. There are several consequences that could result from higher vessel traffic and the failure of seaports to expand, which may include:

- Longer times spent by vessels at the docks;
- Relatively slow moving palm oil from storage tank to the tankers;
- Longer waiting time for the trucks and small-medium boats to transfer their loads of palm oil to storage tanks.

In addition, weather related disturbances and congestion in the ports of Dumai and Belawan can potentially increase the quantity of palm oil stocks in transit from Kalimantan (USDA, 2012).

Furthermore, poor road quality in several parts of the country represents another important bottleneck which should be closely monitored.

Indicator 23 could be an effective tool to inform this type of analysis. As explained above, in the testing of this indicator in Indonesia, it was only possible to gather some relevant information. A more in-depth assessment, based on primary data collection and discussions, particularly with the private sector, should be conducted in the future, through the quantification of the three components of indicator 23.

Relevance, practicality and scientific basis of indicator 23

The testing of indicator 23 in Indonesia confirmed the importance of assessing the infrastructure and logistics for the distribution of bioenergy, which can significantly affect the development of the sector.

A quantitative assessment of this indicator could not be conducted in Indonesia, due to the lack of sufficiently detailed data and only estimates could be made. This issue might affect the measurement of indicator 23 in other developing countries as well. It was felt that further guidance for measuring the actual capacity of critical distribution systems for bioenergy and above all on how to attribute to bioenergy its share and disaggregate the

41 On the basis of the feedstock production realization as of 2012.

results by commodities transported along the same routes and distributed by the same multi-purposes infrastructures, would be beneficial as in many countries a thorough assessment of this indicator based on secondary data only is unrealistic.

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3.24 INDICATOR 24: CAPACITY AND FLEXIBILITY OF USE OF BIOENERGY

Description:
(24.1) Ratio of capacity for using bioenergy compared with actual use for each significant utilization route
(24.2) Ratio of flexible capacity which can use either bioenergy or other fuel sources to total capacity

Measurement unit(s):
Ratios

3.24.1 Testing of indicator 24 in Indonesia

For the testing of indicator 24 in Indonesia, necessary information was found in official statistics and in literature. In particular, in order to measure the indicator, data on the current share of diesel in the transport sector were compiled and information related to the so-called 'blenging wall' (i.e. the maximum level of biofuel blending that can be tolerated by the exisiting car fleet without retrofitting) was gathered. Regarding indicator component 24.2, as of 2012 there were no flex-fuel vehicles in Indonesia.

3.24.2 Key findings

24.1: Ratio of capacity for using bioenergy compared with actual use for each significant utilization route

In 2012, Indonesia consumed around 669 million litres of biodiesel (ESDM, 2013), accounting for approximately 7.10 percent (in volume) of total domestic diesel consumption in the transport sector. According to the Ministry of Energy of Indonesia, the current Indonesian transport fleet could run on biofuel blends of up to 20 percent without the need for retrofitting. Assuming a 20 percent biodiesel blending wall, the domestic transport sector could absorb up to 1.88 billion litres of biodiesel per year.

Therefore, as of 2012 the capacity ratio for biodiesel was: 669 million litres / 1.88 billion litres = 0.35 (see table 3.24.1). This means that the volume of biodiesel sold in 2012 in the country corresponded to 35 percent of the maximum volume of this biofuel that could be blended with diesel and used in the domestic transport sector without retroffiting the transport fleet.

24.2: Ratio of flexible capacity which can use either bioenergy or other fuel sources to total capacity

As of early 2014, there were no flex-fuel vehicles circulating in Indonesia. Therefore the flexible bioenergy capacity, as defined in the methodology sheet of indicator 24, and thus the flexible bioenergy capacity and the associated flexibility ratio was equal to zero for biodiesel.

Table 3.24.1

Capacity ratio of Indonesian biodiesel, 2009 - 2012

Year	Diesel used by transport sector	Litres of biodiesel (B100) sold per year	Share of biodiesel in transport sector (by volume)	Litres of biodiesel for 20% blending	Capacity ratio
2009	10,378,815,000	119,000,000	**1.15%**	2,075,763,000	**0.0573**
2010	10,891,587,000	223,000,000	**2.05%**	2,178,317,400	**0.1024**
2011	9,198,546,000	359,000,000	**3.90%**	1,839,709,200	**0.1951**
2012	9,417,437,000	669,000,000	**7.10%**	1,883,487,400	**0.3552**

Sources: ESDM, 2013 and 2014

3.24.3 Main conclusions and recommendations

Results of indicator measurement

Regarding indicator component 24.1, the volume of biodiesel sold in 2012 in Indonesia corresponded to 35 percent of the maximum volume of this fuel (i.e. 20 percent) that could be blended with fossil-based fuels and used in the domestic transport sector without retrofitting the car fleet. This means that current biodiesel production could tripple in Indonesia without facing any technology constraints on the demand side.

Concerning indicator component 24.2, the flexible bioenergy capacity and the associated flexibility ratio was found to be null in Indonesia, due to the fact that, as of early 2014, there were no flexible-fuel vehicles in the country.

Future measurement of indicator 24 in Indonesia

As the bioenergy sector continues to expand in the country and the national car fleet evolves, it will be important to monitor the biofuel absorption capacity of the domestic transport sector. However, based on the capacity ratios that were calculated for this indicator, this absorption capacity, which will remain at 20 percent unless vehicles are retrofitted, is unlikely to be a constraining factor for the Indonesia biofuel industry for the foreseeable future.

Relevance, practicality and scientific basis of indicator 24

The relevance of the issues addressed by indicator 24 was confirmed during the testing in Indonesia.

This indicator falls under the *Energy security/Infrastructure and logistics for distribution and use* theme and its relevance on the demand side was emphasized in the indicator methodology sheet. However, indicator 24 also provides relevant information related to the absorption capacity of the domestic market, and thus on the potential for an expansion in the domestic supply of biofuels.

Last, but not least, when this indicator was measured, a typo was found in the methodology sheet. In the example described in the Scientific basis section, the numerators and denominators for the calculation of the capacity ratios of countries A and B were inverted. This should be fixed, as it might confuse readers/users.

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CHAPTER 4

CONCLUSIONS

The Global Bioenergy Partnership (GBEP) agreed upon a set of twenty-four indicators for the assessment and monitoring of bioenergy sustainability at national level. In particular, the GBEP indicators aim to inform policymakers about the environmental, social and economic sustainability aspects of the bioenergy sector in their country, guiding them in the development and implementation of sustainable bioenergy policies.

In order to assess and enhance the relevance and practicality of the GBEP indicators and to strengthen the capacity of countries to measure bioenergy sustainability, the indicators needed to be pilot tested in a diverse set of national contexts. Given the broad range and complexity of the environmental, social and economic sustainability issues addressed by the GBEP indicators and in light of the relative novelty of the bioenergy sector, technical and financial assistance was deemed necessary in order to test the indicators in selected countries.

This report presents the results of the testing of the GBEP indicators in Indonesia, which was implemented by FAO with support from the International Climate Initiative (ICI) of the Federal Ministry of the Environment, Natural Resource, and Nuclear Safety of Germany.

In order to contribute to national capacity development, while assessing the relevance and practicality of the GBEP indicators within the specific country context, the measurement of the indicators was entrusted to a team of researchers from the Bogor Agricultural University (IPB) supported by researchers from the Indonesian Soil Research Institute, Indonesian Geospatial Information Agency (BIG) and international experts. FAO stimulated the institutional coordination for the project by involving the relevant stakeholders, under the lead responsibility of the Ministry of Energy and Mines, Directorate General of Renewable Energy and Energy Conservation.

The testing provided Indonesia with an understanding of how to establish the means of a long-term, periodic monitoring of its domestic bioenergy sector based on the GBEP indicators. Such periodic monitoring would enhance the knowledge and understanding of this sector and more generally of the way in which the contribution of the agricultural and energy sectors to national sustainable development could be evaluated.

The testing in Indonesia also provided a series of lessons learnt about how to apply the indicators as a tool for sustainable development and how to enhance their practicality. These lessons learned, which were shared and discussed with neighbouring countries at regional level, as well as the trainings carried out during the project showed the importance of these activities in the measurement of the GBEP Indicators and in the facilitation of South-South cooperation.

4.1 SUSTAINABILITY OF BIOENERGY IN INDONESIA: PRELIMINARY FINDINGS AND RECOMMENDATIONS

The main findings related to the sustainability of the Indonesian bioenergy sector that arose from the testing of the GBEP indicators in the country are summarized below. A more detailed discussion of them can be found under each indicator. Overall, the pilot-testing of the indicators provided interesting insights on the status of the bioenergy sector in Indonesia and on its sustainability. However, for a number of indicators, data constraints only allowed for a partial measurement and analysis. Therefore, the results and recommendations emerging from the pilot-testing in Indonesia should be considered as indicative.

As shown in this report, production of palm oil-based biodiesel has increased significantly in recent years in Indonesia, following the introduction of biofuel blending mandates and in response to the growing international demand for both palm oil and biodiesel. Regarding heating and cooking and off-grid electricity generation, as of 2012 there was no significant use of modern bioenergy in Indonesia.

In Indonesia, the growing demand for palm oil, including as biofuel feedstock, has triggered a supply response, in the form of an expansion in the harvested area of oil palm. Thanks to this increase in production, there was no diversion of palm oil from the food market to the biofuel market, as confirmed also by the data available in national and international statistics. According to FAOSTAT, between 2008 and 2012, the supply of palm oil for food increased in Indonesia. However, the land-use changes associated with the oil palm expansion have given rise to a range of environmental, social and economic impacts.

In 2010, around 8.4 million hectares were planted with oil palm in Indonesia, of which 91.6 percent in the islands of Sumatra, Kalimantan and Papua. Between 1990 and 2010, about 6.35 million ha of land were converted to oil palm in these three islands.

According to the Life Cycle Analysis (LCA) of GHG emissions that was performed under indicator 1, this expansion led to the conversion of high carbon stock areas (e.g. forests, timber plantations, etc.), causing significant emissions of carbon dioxide. In addition, about 1.25 million ha of peatland were drained and converted to oil palm cultivation, resulting in high, continuous GHG emissions from peat decomposition. Overall, the results of the LCA confirmed that land-use change, especially from forests, is the most important contributor to total GHG emissions from the Indonesian palm oil industry.

Other important consequences of land use change associated with oil palm expansion are habitat loss and impacts on biodiversity. As of 2010, 17 percent of Indonesian oil palm plantations were found in High Conservation Value areas.

Another important source of GHG emissions along the palm oil supply chain is the methane released by the anaerobic fermentation of palm oil mill effluent (POME). As of

2012, only around 5 percent of the over 600 Indonesian palm oil mills were equipped with methane capture systems. An analysis of the economic viability of these methane capture systems should be conducted and, if necessary, measures to promote their wider adoption might be considered.

In addition to land-use change and the associated effects in terms of GHG emissions and biodiversity, a number of other environmental issues were assessed and analyzed.

With regard to soil quality, in East Kalimantan, soil erosion affects oil palm production areas. Concerning soil organic carbon, data is scarce due to the lack of periodic monitoring. Regarding water quality, it was found that large quantities of pollutants, mainly nitrate and phosphate, are discharged into the bodies of water near the oil palm plantations. As a result, in several areas pollutant concentrations in rivers often exceed the thresholds set by law, particularly around smallholders plantations on peat soils. Further and more refined investigations of pollutant loadings in the internal waters in Indonesia due to biodiesel feedstock production are needed, including mathematical modelling of material transport. With regard to non-GHG airborne pollutants, the low level of mechanization in oil palm cultivation results in relatively low emissions of such pollutants. Concerning tailpipe emissions, tests have demonstrated that biodiesel can significantly reduce the emission of most non-GHG pollutants when compared to fossil-based diesel, showing the potential environmental and health benefits of a shift from traditional fuels to biofuels, especially in densely populated urban areas.

With regard to social sustainability, in addition to the food security implications mentioned earlier on, other issues were explored as well, for instance with regard to the income effects and the number and quality of jobs associated with biofuel feedstock production and processing. As explained above, the increased in the demand for palm oil for biodiesel in Indonesia has triggered a supply response, leading to a significant expansion in the planted area (and subsequently harvested area) of oil palm. This has resulted in a considerable increase in the number of people employed in palm oil production. Regarding the quality of the jobs created in this sector, compared to the average agricultural worker oil palm workers seem to benefit from a higher level of formalization of employment, better wages and benefits, and better protection against occupational risks. The increase in the demand for palm oil for biodiesel production has also provided additional income-generating opportunities for agricultural producers, including smallholders, who accounted for around 35 percent of total palm oil production in Indonesia in 2012.

With regard to land tenure, a few cases of land conflicts were reported in literature, including in the context of oil palm plantations, with lack of adequate legal recognition of customary rights to land identified as one of the main causes.

Last, but not least, concerning energy access, it was found that to date modern bioenergy has not played a significant role in providing access to modern energy services and in displacing traditional uses of biomass, which still accounted for over 18 percent of the Total Primary Energy Supply (TPES) in 2012.

With regard to the economic sustainability aspects, the Indonesian biofuel sector appears to be cost-competitive. However, yields have been stagnant for many years, whereas higher yields have been obtained in experimental trials thanks to the research and development of improved varieties and management regimes.

While the gross value added generated by the biofuel industry in Indonesia is relatively small compared to the GDP (e.g. 0.026 percent in 2012), the demand for goods and services associated with this industry has been reported to trigger multiple indirect and induced effects on the economy, including in terms of employment.

From an energy balance perspective, the Indonesian palm oil-based biodiesel supply chain is rather efficient compared to the production of other first-generation liquid biofuels. However, there appears to be room for further improvement in the feedstock production phase of the supply chain (particularly in the case of independent smallholders), as well as for the refinery component of the processing phase.

Furthermore, even though in 2012 biodiesel accounted for only 0.19 percent of the total primary energy supply (TPES) in Indonesia, this modern bioenergy led to around 282 million USD of estimated savings from avoided oil imports and generated 657 million USD of export revenues.

With regard to the logistics of the biodiesel supply chain, distribution to the easternmost provinces of the archipelago, namely Papua and Maluku, may be difficult due to the lack of efficient infrastructures and this is considered the main cause that has prevented the country from fulfilling the B10 mandate in 2012. Distribution hurdles are also found in the two main producing islands, i.e. Sumatra and Kalimantan. The latter, in particular, suffers from limited processing facilities and poor internal distribution routes (e.g. dirt roads and shallow ports). For this reason, large quantities of feedstock need to be transported in relatively small batches from Kalimantan to Sumatra. In order to meet higher biofuel mandates, it is suggested that these logistical issues are thoroughly assessed and managed.

4.2 POTENTIAL ROLE OF THE GBEP INDICATORS FOR FUTURE MONITORING OF BIOENERGY SUSTAINABILITY IN INDONESIA

As already mentioned, the findings summarized above and the related recommendations, which are discussed more in detail under each indicator, should be treated as indicative, as during the project only partial analyses could be conducted for some indicators. Filling these data gaps would be important in order to enable an effective monitoring of the GBEP indicators in the future and thus assess over time the sustainability of bioenergy production and use in Indonesia. Data gaps were particularly significant for the social sustainability indicators. As emerged during this project, surveys may represent a useful tool to fill in these gaps.

As explained in chapter 2, Indonesia is considering new ambitious biofuel targets. By 2025, the country aims to supply 25 percent of its diesel demand for all sectors, thus not limited to transport, with domestically produced biodiesel. In order to meet this additional demand, biodiesel production would need to increase by over five times compared to 2012. The environmental, social and economic implications of this exponential increase in biodiesel production should be carefully considered.

In particular, as the bioenergy sector continues to expand and higher biofuel mandates are considered, it is essential to monitor the land-use changes associated with bioenergy feedstock expansion, given the important implications that land-use changes can have for a range of environmental, social and economic sustainability issues. Remote sensing, field visits and stakeholder consultation are complementary tools that have proven valid for the assessment of the sustainability of bioenergy at the national level and that could be used in the future to analyze the land-use changes associated with bioenergy feedstock expansion.

In order to ensure that the increase in the demand for biodiesel associated with the aforementioned targets is met sustainably, it is recommended to implement measures aimed at increasing the productivity of palm oil production, for instance through the introduction of improved varieties and management practices. With regard to oil palm expansion, it is recommended to prioritize low carbon stock areas such as degraded lands, shrublands and grasslands, where oil palm cultivation could contribute to sequester more carbon than it would naturally occur. On the other hand, further conversion of forests, both disturbed and undisturbed, and of wetlands and peatlands should be avoided, given the negative impacts that their conversion would have both in terms of biodiversity loss and GHG emissions. The avoidance of new oil palm development on peat soils and, where possible, the conservation and re-wetting of these areas are also suggested as priorities for the sustainable development of Indonesia, as this would prevent the emission of large amount of GHG for an extended period of time.

Last, but not least, in order to ensure a reliable biodiesel supply and more in general a secure and diversified modern bioenergy mix, it is recommended to assess the viability of other biodiesel feedstocks beside palm oil as well as of other liquid, solid and gaseous fuels. The social implications of the future oil palm expansion should be considered as well, for instance in terms of allocation and tenure of land for bioenergy feedstock production. Concerning food security, according to the results of the AGLINK-COSIMO model described in indicator 10, the increase in biodiesel blending mandates to 25 percent proposed in the new National Energy Policy would result in a decrease in the availability - and an increase in the price - of palm oil on both domestic and international markets. It is recommended to carefully consider these effects in order to inform possible adjustments to the policy framework and the design of potential corrective or mitigation measures.

This report is focused on palm oil-based biodiesel, reflecting the indications emerged during discussions with relevant stakeholders in Indonesia and the relevance of biodiesel within Indonesia's modern bioenergy mix. As the production and use of other types of biofuels and feedstocks increase in Indonesia, it is recommended to apply the GBEP indicators to these other forms of bioenergy as well in order to monitor their environmental, social and economic impacts.

4.3 RELEVANCE AND PRACTICALITY OF THE GBEP INDICATORS: LESSONS LEARNT FROM THE TESTING IN INDONESIA

One of the main objectives of the testing of the GBEP sustainability indicators for bioenergy in Indonesia was to assess the relevance and practicality of these indicators, in addition to strengthening the capacity of this country to measure bioenergy sustainability. With regard to the practicality, as confirmed by the testing in Indonesia, the GBEP indicators are rather data and skills intensive. For the testing, it was not possible to get hold of a number of data related to various indicators, especially within the Social basket. Part of this data was not available (an issue that might be in common with other developing countries as well) while in other cases it was not possible to get access to them due to a number of reasons, including the commercial sensitiveness of some of the information. This shows the importance of involving all relevant stakeholders in the process, ranging from relevant government departments/ministries (e.g. those dealing with agriculture, energy, environment, rural development, food security, infrastructure, etc.) to producer associations, universities and NGOs. Stakeholder engagement and ownership of the process is key in order to get access to the necessary data and information, receive inputs and feedback, discuss and interpret the results, and ultimately inform policy discussions and decisions.

In the planning phase of the testing in Indonesia, the engagement of national consultants, ministries and other stakeholders was considered fundamental to obtaining a national perspective on the practicality of the GBEP indicators, to assessing the national capacity to measure the indicators in real-life conditions and to making use of the project to strengthen and diversify national discussions on the sustainability of their country's bioenergy sector. For this reason, FAO established an effective institutional coordination mechanism, involving all relevant stakeholders under the lead responsibility of the Ministry of Energy and Mines. As shown by this project, a proactive engagement of all relevant stakeholders including government agencies, private sector associations and civil society organisations is key to the effective measurement of the indicators and to a proper interpretation and use of the results. A network of focal points within each relevant organization could be considered in the future as a means to strengthen institutional coordination and stakeholder engagement.

As mentioned above, the GBEP indicators cover a broad range of complex environmental, social and economic issues and some of the indicator methodologies are rather sophisticated. A multidisciplinary team of experts with an in-depth knowledge of the national context and of the domestic bioenergy sector is needed in order to measure these indicators. In Indonesia, this task was entrusted to a team of researchers from the Bogor Agricultural University, supported by researchers from the Indonesian Soil Research Institute, Indonesian Geospatial Information Agency (BIG) and other national research centers of excellence. The quality of the work delivered by the experts from these institutes confirms that Indonesia is in the position to measure the GBEP indicators in the future and possesses the necessary skills and competences. However, in some cases and for some indicators, it might still be useful to integrate the local expertise with international expertise, as was done during the testing, including through extensive and detailed training sessions.

As realized during the testing in Indonesia, in order to enhance the practicality of the GBEP indicators, more clarity and guidance would be needed regarding both methodological and practical issues related to the implementation of certain indicator methodologies. An implementation guide would be needed in order to complement the GBEP report on the sustainability indicators.

Further guidance would be necessary, in particular, on the complex and crucial issue of the attribution of impacts to bioenergy production and use. For instance, if data is available on the impacts of a certain environmental, social and economic variable for the production of a crop, part of which is used for bioenergy, should the attribution of the impacts to the latter be done on the basis of the mass balance, of the energy content or of the economic value? How should historical impacts of multi-purpose perennial crops currently used for bioenergy feedstock production be treated and attributed to such production? Depending on the indicator considered and on the concerns and priorities of the user(s), the answer to these questions might change. Therefore, for each indicator a range of suitable approaches for attribution could be identified and illustrated in detail providing specific examples, and the pros and cons of using one approach versus another should be discussed.

Furthermore, in order to significantly reduce the time, skills and cost required in order to measure the GBEP indicators, an Information Technology-based application should be developed. This would allow users to easily enter all data required for the 24 indicators into one single data entry sheet and to get a set of results for each indicator based on the related methodologies. In addition to the aforementioned benefits, this process would also simplify considerably the data collection process, and it would allow to easily save and share the results and to re-run the tool over time with up-to-date information.

Last, but not least, given the global nature of the GBEP indicators, the report containing the methodology sheets should be translated into other official languages of the UN beside English, e.g. French and Spanish. This would greatly facilitate the dissemination and implementation of the indicators in developing countries around the world.

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The Global Bioenergy Partnership (GBEP) has produced a set of twenty-four indicators for the assessment and monitoring of bioenergy sustainability at the national level. The GBEP indicators are intended to inform policymakers about the environmental, social and economic sustainability aspects of the bioenergy sector in their country and guide them towards policies that foster sustainable development.. FAO, which is among the founding members of the Global Bioenergy Partnership, tested the indicators in Colombia and Indonesia, with generous support from the International Climate Initiative (ICI) of the Federal Ministry of the Environment, Natural Resource, and Nuclear Safety of Germany.

This report presents the results of the testing of the GBEP indicators in Indonesia. The testing provided Indonesia with an understanding of how to establish the means of a long-term, periodic monitoring of its domestic bioenergy sector based on the GBEP indicators. Such periodic monitoring would enhance the knowledge and understanding of this sector and more generally of the way in which the contribution of the agricultural and energy sectors to national sustainable development could be evaluated. The testing in Indonesia also provided a series of lessons learnt about how to apply the indicators as a tool for sustainable development and how to enhance their practicality.




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