

AGRICULTURE BEYOND FOOD

Experiences from Indonesia



NWO-WOTRO & KNAW-SPIN – Agriculture Beyond Food Research Programme

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Netherlands Organisation for Scientific Research
WOTRO Science for Global Development



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AKADEMIE VAN WETENSCHAPPEN



AGRICULTURE BEYOND FOOD

Experiences from Indonesia

Colophon

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Preface

The Agriculture Beyond Food (ABF) programme is an example of inspiring Indonesia-Netherlands scientific cooperation. It builds on twenty years of experience with similar programmes of a multidisciplinary nature, fostering excellent research, capacity building and dissemination of results.

The programme fits in very well with the objective of the Joint Working Committee (JWC) for Scientific Cooperation between Indonesia and the Netherlands, namely “to promote long-term scientific collaboration between research groups in both countries by entering into bilateral research programmes based on the principles of reciprocity and mutual interest”.

In the framework of the Memorandum of Understanding between both governments, the Royal Netherlands Academy of Arts and Sciences (KNAW), the Netherlands Organisation for Scientific Research (NWO) and the Indonesian Ministry of Science and Technology (RISTEK) have sponsored the ABF programme.

The ABF programme has incorporated the high quality networks of previous bilateral projects and programmes and the lessons learned from them. An example of such a programme is the East Kalimantan Programme (EKP), which focused on coastal areas in the Mahakam delta and the Berau region, analysing the connection between natural processes, biological variability and human activity in coastal regions. Another prominent example is the programme on poverty-related infection-oriented research (PRIOR), in which collaboration between Indonesian and Dutch research teams was a strong pillar.

The ABF programme addresses one of today’s major societal challenges, how to achieve a sustainable and inclusive biobased economy, with high-level scientific research on the thin lines between food and non-food, commodities and waste products, livelihood opportunities and risks, and local and global economy.

This book provides insights into the main issues and key questions relating to the biobased economy, reflects on the objectives of the ABF programme, and offers policy recommendations. It summarises the projects conducted within the three major clusters at the heart of the programme: migration and forest transformation, breakthroughs in biofuel production technology, and the commoditisation of an alternative biofuel crop. The book ends with a number of lessons learned from the ABF programme on interdisciplinary programming.

The ABF programme is an important next step in multidisciplinary and transdisciplinary international research cooperation and provides a stepping stone for future research into the vision of a green and circular global economy.

Furthermore, it is important to note that negotiations have been initiated on a new generic basis for Indonesia-Netherlands scientific cooperation from 2016 onwards, possibly in the wider framework of EU-ASEAN, fostering and renewing the longstanding ties between the two countries.

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Representative examples of vegetable oils (by Miftahul Ilmi)

INTRODUCTION

The 'biobased economy' has been heralded as an answer to global concerns about the impact of climate change and the increasing scarcity of fossil fuels. The term depicts a future economy in which biomass will be used to produce fuels and manufactured goods from the petrochemical industry, such as plastics. The biobased economy thus implies an increase in the demand for biomass for purposes other than food. The technological opportunities are many. In labs all over the world scientists are developing applications that can make efficient use of biomass, for example by using waste streams for the production of biobased products. One application has already been widely adopted, namely, the use of biomass to produce liquid fuels for the transport sector. The introduction of biofuels is one of the most well-known and widespread approaches to reduce the use of fossil fuels.

Since the early 2000s many countries have made inroads into pursuing a biobased economy with the purpose of becoming less dependent on increasingly expensive fossil fuels and to reduce greenhouse gas emissions. Most notably, the European Union and several individual countries (including the US, China, Brazil and Indonesia) have introduced blending targets to encourage the use of biofuels. These policies have increased demand for crops that can be relatively easily converted to fuel, such as oil palm, jatropha, corn and sugarcane.

The development was initially greeted with much enthusiasm. The use of biofuels was not only bound to reduce global greenhouse gas emissions but would also create new opportunities for the agricultural sector. After all, with increasing demand and prices for agricultural produce, farmers would be able to improve their incomes. The initial excitement, however, soon made way for concern. NGOs and researchers started expressing worries about the possible negative consequences of non-food agriculture. If demand for lucrative non-food crops pushed up food prices, which seemed likely, this would impact consumers worldwide, with the risk of pushing millions of poor people deeper into poverty. Furthermore, large-scale agricultural expansion was likely to cause the displacement of smallholders and threaten remaining natural areas, due to a growing demand for land. Ever since, experts have been unable to agree on whether the promotion of biofuels – and the pursuit of a biobased economy in general – is a blessing or a curse.



The Agriculture Beyond Food research programme

While discussions continued within the walls of NGOs and university compounds, investors and companies did not wait for them to reach agreement. Eager to tap into the new markets, they have been stepping up their investments, primarily in tropical countries with good opportunities to expand agricultural production. This is having immediate effects on land-use practices in many countries, and particularly in the Indonesian archipelago, where investments in the production of crops like oil palm are rapidly changing the rural landscape and the playing field for farmers. To acquire a good grasp of the opportunities and constraints of the biobased economy, scientists thus need to come out of their offices and study what is actually going on in the field. And, equally important, they need to enter their labs to develop technological applications that enable a more efficient conversion of biomass. These are the premises of an ambitious interdisciplinary research programme launched in 2009, called 'Agriculture Beyond Food'. The programme comprises three clusters, which are briefly introduced below.

Sliding from Greasy Land? Migration flows and forest transformation caused by oil palm expansion

Demand for palm oil has been rising rapidly in recent decades due to increasing global demand for edible oil, and for ingredients for soap, cosmetics and paint. More recently, this has been joined by a growing demand for biofuel. Oil palm, extracted from the oil palm (*Elaeis guineensis*) is an attractive prospect because it provides a high yield per hectare. While a growing number of companies and smallholders started cultivating the crop, NGOs have warned that the expansion of oil palm plantations would lead to deforestation, peatland degradation and forest fires. In collaboration with Gadjah Mada University, Riau University, Mulawarman

University and the World Agroforestry Centre, Utrecht University initiated a research cluster called Sliding from Greasy Land?, to explore the often-ignored drivers behind the expansion of oil palm plantations and its socioeconomic and environmental consequences. The research specifically focuses on oil palm-induced migration flows, their role in forest transformation processes, and the associated carbon emissions and biodiversity loss in the Indonesian provinces of Riau and East Kalimantan (see page 33).

Breakthroughs in Biofuels: Mobile technology for biodiesel production

If biobased products are to contribute to the reduction of greenhouse gas emissions without threatening food security, suitable agricultural and other waste streams need to be identified and the conversion processes of biomass need to be optimised. Process technologists thus launched the concept of biorefinery, encapsulating all advanced technologies for producing biobased products with zero waste. The Breakthroughs in Biofuels cluster, coordinated by the University of Groningen in collaboration with Bandung Institute of Technology and others, has been researching technologies to use agricultural waste streams that are readily available in remote rural areas like Central Kalimantan. The research focuses primarily on the waste materials of the rubber tree (*Hevea brasiliensis*). These include the nuts, leaves and bark, which contain lipids, proteins and ligneous materials that can be used to produce fuel, feed and fertilisers. Rubber nut kernels, in particular, bear much promise to do this in an economically and socially viable manner. Mobile processing units, moreover, can bring the technology within reach of small producers in remote areas. In the Breakthroughs in Biofuels cluster, Indonesian and Dutch researchers have been working on developing new technologies in the lab and on implementing them at village level (see page 57).

JARAK: The commoditisation of an alternative biofuel crop

Jatropha (*Jatropha curcas*), known as *Jarak* in Indonesian, is a non-edible shrub that can be used to produce biodiesel. The plant is thought to grow well in dry areas. It was embraced as a ‘miracle crop’ that would enable biofuel to be produced on marginal and degraded lands – areas not suitable for food production. Enthused by the promising prospects, the Indonesian government started investing in jatropha plantations in 2006. The investments focused on Eastern Indonesia, which is much drier than the rest of the country. Subsistence farmers in remote areas suddenly became part of global networks for producing biofuel. But there was as yet no proven market and social scientists and agronomists wondered whether these farmers would be able to benefit from the new developments. Would jatropha schemes actually provide rural employment for the poor? And, what were the main drivers behind the jatropha boom? These are some of the questions that were addressed by researchers in the JARAK research cluster, coordinated by Leiden University in collaboration with Gadjah Mada University, Universitas Indonesia, and five other Indonesian and Dutch institutions (see page 81).

About this book

Agriculture for non-food purposes is surrounded by many complex questions; questions that can only be answered on the basis of robust and high-quality research. The Agriculture Beyond Food (ABF) programme has attempted to provide just that. Under the umbrella of the programme, Indonesian and Dutch researchers (including agronomists, anthropologists, biochemists, biologists, sociologists, chemical engineers, economists, geographers, historians and legal researchers) have conducted extensive research to shed light on the real opportunities and threats for

local communities and the environment. The results have been published in PhD dissertations and scientific journals. But the dissemination of the findings should not stop there. They are also relevant for a wider audience, particularly for policymakers, practitioners and scientists from other disciplines who are working on related issues. That is why the Agriculture Beyond Food programme decided to publish this book.

The book comprises three sections. Firstly, the scientific coordinators of the research clusters answer seven key questions related to agriculture beyond food from different scientific angles. Some of the answers may debunk persistent myths, while others add nuances to prevalent ideas and assumptions. The second section presents stories from the field, based on interviews with the researchers in the programme. These articles zoom in on typical and sometimes controversial stories that have emerged from the Agriculture Beyond Food programme. The articles are grouped per research cluster, preceded by a short introduction. The last section reflects upon the lessons and challenges that emerge from the ABF programme as a whole.

Biofuel in Indonesia: Oil palm and jatropha

Indonesia is highly dependent on fossil fuel: most of its energy consumption is based on oil. Meanwhile, as a result of the country's rapid economic growth Indonesia's own oil production is decreasing, while demand for energy is increasing. This resulted in Indonesia becoming a net oil importer by 2004 and, four years later, officially resigning as a member of OPEC, the organisation of oil producing and exporting countries.

Indonesia's growing dependency on oil imports is problematic because of the national subsidies on oil, which are aimed at keeping energy affordable for the Indonesian poor. This policy is imposing an increasing burden on the national budget. In 2014, for example, the government decided to cut the budget of all ministries and state agencies in order to pay the oil subsidies. Indonesian politicians know that eliminating the subsidies is not an option, as it would immediately lead to public protest. When the international oil price hit \$70 per barrel in 2005, this was a wake-up call to start searching seriously for alternative energy sources, including biofuels.

Since Indonesia is the world's largest producer of crude palm oil (CPO), this seemed the most obvious choice for the production of biofuel. High international and domestic demand, however, was driving up the price of palm oil, and jatropha quickly emerged as a second option. Jatropha seemed attractive due to the claim that it is better than food crop-based feedstock like palm oil. It is a non-edible crop and was therefore thought not to compete with food production, unlike oil palm. Moreover, since the advocates for jatropha argued it can grow on marginal lands, it would not result in the destruction of Indonesia's high biodiversity forests. Jatropha was seen as a solution for the revitalisation of millions of hectares of degraded land. In terms of costs, it was claimed that jatropha could practically grow by itself with only limited input and care. And finally, jatropha projects in marginal areas were compatible with the government's efforts to reduce poverty. This all culminated in a real jatropha hype. The results, however, were disappointing.

In Indonesia today, biofuel is mostly produced from palm oil and contributes around 4% to all diesel fuel used in the transportation sector. The Indonesian Ministry of Mining and Energy passed a new regulation in 2013 to speed up the use of biodiesel, raising the mandatory blending target in the transportation sector from 5% to 10% between 2014 and 2015, and there are even plans to increase this to 20% between 2016 and 2020. Oil palm is expected to remain the most important source of biofuel in the near future, while the search for new alternative feedstocks continues.

KEY QUESTIONS



Oil palm seedlings, West Kalimantan (by Yayan Indriatmoko, CIFOR)

Why agriculture beyond food?

The modern world relies heavily on fossil fuels (oil, gas and coal) for energy and power generation, for transportation, and for the production of chemicals (plastics, adhesives, synthetic fabrics, paint, etc.). Fossil fuel reserves, however, are limited. Especially oil reserves that can be used at affordable prices are being depleted quickly. Even if the developed nations succeed in stabilising energy use, rising prosperity in many countries of the developing world will lead to a sharp increase in worldwide demand for energy in coming decades. As these resources are becoming increasingly scarce, their already volatile prices are expected to rise. And increasing scarcity is not the only problem associated with our dependency on fossil fuels. Burning fossil fuels leads to the emission of greenhouse gases (especially CO₂), which causes climate change. More extreme weather is expected, with more severe and prolonged periods of drought in some places and extreme rainfall in others. Changing weather patterns will greatly affect agricultural options. Sea levels are expected to rise, causing the risk of flooding of low-lying areas. In order to mitigate global warming, it is vital that worldwide dependency on fossil fuels is diminished. Even if additional, exploitable reserves of fossil fuels were to be discovered, the wisest thing to do would be to leave them where they are. In short: we need to fight our addiction to fossil fuels.

Both global challenges – depleting fossil fuel reserves and climate change – have led to an intensification of the search for renewable energy alternatives in the last two decades. Wind, solar, hydro and geothermal energy are highly suitable for generating electricity and

for heating. However, for the chemical industry and the transportation sector, carbon-based energy resources will remain indispensable. And this is where agriculture beyond food comes in. Burning hydrocarbons – organic compounds consisting of hydrogen (H) and carbon (C) – produces energy. The only renewable source of carbon is biomass (plants, trees, grasses, agricultural waste, algae, etc.), making it a prime candidate to replace fossil fuels. The use of biomass to generate energy is hardly a new development. In fact it is the oldest, and still one of the most widely used, ways to provide energy for households. An estimated three billion people worldwide depend on wood, charcoal and dung for heating and cooking. In recent decades, more sophisticated and more sustainable methods to generate energy from biomass have been developed and commercialised, for example bio-ethanol from sugarcane and biodiesel from pure plant oils. The need

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to switch to renewable carbon-based alternatives to fossil fuels has led to the idea of a 'biobased economy'. In a biobased economy fossil fuels are replaced as much as possible by biofuels, but a range of other products are also made from biomass. Research on biomass conversion to biobased chemicals has led to the first commercial products appearing on the market. Polylactic acid, for example, a biobased plastic made from corn, tapioca or sugarcane, has high potential for packaging purposes. Biorefinery – the process of 'refining' products from biomass – is a fast growing business. The Coca-Cola Company, for example, has introduced the plant bottle: over 20 billion biodegradable soft drink bottles made from corn starch have been distributed worldwide. The notion of a biobased economy taps into the growing consumer preference for 'natural' products. Agriculture is increasingly being looked at for its potential to deliver alternatives to synthetic products. The demand for fibres of vegetative origin (not only good old cotton, but also elephant grass and even bamboo), medicinal plants, feed and many other products, such as rubber, resins and jellies, all add to the need for agriculture beyond food.

Agriculture beyond food is not new. For centuries cotton has been grown for the production of garments, bamboo and rattan are traditionally used for construction and furniture, and the paper industry depends on forestry. What is new is the diversity of the applications and the scale of agriculture beyond food needed to make a biobased economy reality. Modern agricultural technologies play a major role in this development, as the biomass has to be cultivated in an efficient manner for biorefinery technologies to be economically viable.

The development of the biobased economy faces its own challenges and pressing questions. For example, to completely meet global energy needs with biofuels will

take more land than is available for agriculture, certainly using the technologies that are currently available. And how can we assure that new products are produced in a sustainable way? How do we make sure that land continues to be available for other purposes, most importantly for food crops? What is the effect on food security? And what will the rising pressure on agricultural land mean for sovereignty over national and local territories? Will there be any place left for small farmers? And can they too benefit from the new focus on agriculture beyond food?

What are the drivers?

Global concerns about climate change and the depletion of fossil fuel reserves have pushed agriculture beyond food forward. At national level, other, more specific factors can play a role in either stimulating or slowing down the development of agriculture beyond food. Countries often have specific reasons for promoting the use of agriculture for other purposes than (local) food production. Many countries wish to limit their dependency on the import of fossil fuels. Access to energy is considered a strategic national interest; being completely dependent on oil and gas-exporting countries is a situation that most governments wish to avoid. Budget considerations also play a role: the import of large quantities of fossil fuel can impose an unsustainable burden on a country's balance of trade. The export of agricultural products (like biofuels), on the other hand, delivers new opportunities to earn foreign exchange and to reduce pressure on an already negative trade balance. Many countries are, furthermore, burdened by government subsidies on fossil fuels designed to promote development and to support poor people. As energy consumption grows, such measures are less and less affordable. Lowering fuel subsidies is not seen as an option, as this will spark mass protests. As an alternative governments focus on replacing fossil fuels with renewable energy sources, thereby lowering the burden of ever-increasing subsidy levels.

To stimulate the use of renewable energy sources, many countries have introduced 'blending targets': mandatory blending of fossil fuel with a certain percentage of renewable fuels. These measures have increased the demand for biomass suitable for energy production.

Blending targets set up by the United States and the European Union are partly responsible for the sharp price increase of, for example, corn in 2007.

Global considerations related to the need for renewable energy sources are hardly ever directly an argument for entrepreneurs and farmers to invest in certain crops, but in an indirect way, they do affect the cultivation choices of local farmers. Some jatropha projects in Indonesia, for example, were initiated by donor countries or by international development organisations.

The decisions of farmers and investors are also influenced by national policies and stimulation programmes to promote renewable energy, such as the budgets installed by the Indonesian government to subsidise the production of renewable energy. In 2007 the government committed 1.1 billion US dollars in the

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national budget for biofuel infrastructure subsidies, in addition to subsidies for plantation improvement, training, and research and development.

Other drivers from the global arena are big corporations and investment companies. Attracted by an expected hike in prices of natural resources (like fossil fuels), partly as a result of blending targets imposed by the EU and the United States, large companies have acquired huge plots of land in Asia, Africa and Latin America. Such large-scale acquisitions of land have often been referred to as 'land grabs' and they are estimated to

cover over 35 million hectares of land worldwide. A sizeable proportion of these lands are targeted for non-food agriculture. In all cases the land-grabbing process indicates that the pressure on arable lands is increasing.



The idea behind investments in jatropha projects was that they would not only generate economic value, but would also have a positive environmental impact (by Henky Widjaja)

Is agriculture beyond food sustainable?

Agriculture for non-food purposes is sustainable only if future production can be maintained without negative economic, social and environmental consequences. To answer the question it is therefore helpful to distinguish between the different dimensions of sustainability. Below we briefly address these sustainability dimensions for oil palm and jatropha – two crops that are considered to fit the Indonesian policy of stimulating the biobased economy.

To start with the economics: the economic success of oil palm seems to have no limits. Palm oil production has become one of the main drivers of economic development in Indonesia. At national level, it contributes considerably to export earnings. At local level, oil palm cultivation is no longer solely in the hands of large-scale companies, but also generates income for small-scale producers and a growing number of migrants are moving into oil palm growing areas in search of better livelihoods. The production of palm oil is expected to continue to rise as a result of the ever-growing demand for palm oil for fuel and other purposes.

While palm oil production has so far proved highly profitable, the experience with the production of jatropha is completely different. In 2006 the Indonesian government launched a nationwide programme to promote the cultivation of jatropha for the production of biofuel. The prospects of this poisonous shrub were thought to be excellent. Based on laboratory results, the expectations were that jatropha would grow well on degraded land not suitable for cultivating other crops; a good yield could be achieved without needing much

water or other input and management. Furthermore, the idea was that it could be produced by smallholders and as such would contribute to poverty alleviation. By 2013, none of these expectations had become reality and most jatropha projects have stopped before reaching the phase of full-scale production. There are many reasons for this. Farmers on the islands Flores and Sumba, for example, found that their plants did not contain as much oil as had been predicted, nor did they yield as many fruits per tree. Moreover, due to a lack of infrastructure – for example, processing facilities, and traders with trucks – the jatropha that was harvested could not be sold. Farmers often participated in jatropha projects because of the free inputs they received. However, those benefits only lasted for the limited project period. After that, many farmers shifted to other crops that gave them a better income and return on labour.

From a social point of view, oil palm has a controversial track record. Many reports have been published about the negative effects of oil palm expansion on local farmers and their communities. These publications often report on the conflicts that emerged whenever large-scale oil palm plantations were established on agricultural or forested lands that were used or claimed by local communities, without their consent. The conflicts were thus primarily related to local people's lack of secure property rights. Also, there have been many accounts of farmers who were persuaded to join outgrower schemes with promises of material wealth, but who ended up with large financial debts or even lost their lands to the company.

Recently, in response to pressure from NGOs and consumers, the social performance of many companies has been improving. Moreover, in several parts of Indonesia oil palm is increasingly cultivated by independent smallholders, for whom it has become a profitable option, as the market for palm oil is well established. With rapidly increasing demand for agricultural land, however, new social problems are arising. Local communities are, for example, using their customary land claims to sell (forested) land to migrants and investors. In the short term this is attractive, with local communities – or certain individuals within those communities – receiving large amounts of cash. In the long-term, however, they lose access to their lands for future use. Furthermore, such uncontrolled land sales may cause new social problems and tensions between local people and migrants.

In the case of jatropha, the general sentiment among farmers is that they were given false promises. They were told that jatropha would give them high profits without needing much care. When it became clear that there was little money to be made with jatropha because no one would buy their produce, they felt they had wasted their time and energy. Many farmers reacted by cutting down their jatropha trees, while others leave their jatropha fields untended, hoping that market circumstances will change in the near future.

The third dimension of sustainability concerns the environment. The effects of the oil palm sector on the natural environment remain a major cause for concern. It is questionable whether the dominant production model, consisting of monocultures with high use of agro-chemicals, can be sustained in the long term. Moreover, oil palm plantations are encroaching upon natural forests and ecologically vulnerable areas, for example the lowland forests in East Kalimantan and the peatlands in Riau province. Habitats are being lost and carbon emissions from forest conversion and

AGRICULTURE FOR NON-FOOD PURPOSES IS SUSTAINABLE ONLY IF FUTURE PRODUCTION CAN BE MAINTAINED WITHOUT NEGATIVE ECONOMIC, SOCIAL AND ENVIRONMENTAL CONSEQUENCES

peatland drainage have increased tremendously. The environmental sustainability of biofuel production from oil palm therefore depends to a large extent on policies that can promote environmentally friendly modes of production and stop the expansion of plantations into natural forests and peatlands.

The idea behind investments in jatropha projects was that they would not only generate economic value, but would also have a positive environmental impact, as they would result in the rehabilitation of marginal lands. However, since the expansion of jatropha plantations was discontinued as soon as it became clear that they did not generate sufficient economic benefits, the environmental impact (either positive or negative) has been limited.

The above shows that there is no unequivocal answer to the question 'Are biofuels sustainable?'. It depends

on the dimension of sustainability you look at. Neither *Jatropha* nor oil palm production can be considered truly sustainable, but for different reasons. The Indonesian experience underlines the importance of appropriate policies – spatial planning in particular – to provide economic opportunities for local people, while limiting the negative social and environmental effects of agriculture beyond food. But a move towards greater sustainability demands more than that. It also requires the development and uptake of innovative technologies; technologies that enable more effective use of available biomass (preferably agricultural waste biomass streams) for non-food purposes. Innovative technologies by no means have to be high-tech. Particularly in remote marginalised areas, the use of agricultural waste for energy production seems promising.

Does agriculture beyond food threaten food security?

In 2008 riots broke out in the capital cities of several developing countries about rising food prices. It was commonly believed that the rising prices were at least partly caused by biofuel expansion, sparked by decisions in countries like the United States and in the EU to mandate blending of fossil fuels with biofuels. The riots intensified the discussion on food security related to the use of agriculture for purposes other than food production. The uncomfortable question is: does the ideal of a biobased economy conflict with agriculture's primary task to feed the world population?

FOOD SECURITY IS NOT ONLY RELATED TO THE AVAILABILITY OF FOOD, BUT ALSO TO PEOPLE'S ACCESS TO FOOD

At first glance the answer to this question seems relatively easy. Economic laws dictate that if individuals can decide freely what to produce based on what suits them best, an equilibrium between supply and demand will be reached. If farmers can make more profit by producing biofuels, they can use the surplus income to purchase food on the market. As soon as the focus

on biofuel production starts causing food shortages, food prices will rise. This will make it worthwhile for farmers to shift again from biofuel production to food production. However, food security is not only related to the availability of food, but also to people's access to food. A rat-race between biomass for food and biomass for fuel will result in a higher overall price of food, limiting access to it. Another reason why biofuels may jeopardise food security are market distortions. The use of biofuels is stimulated and subsidised by some governments, pushing the use of biomass for biofuels. This policy can prove counterproductive when it leads to food shortages.

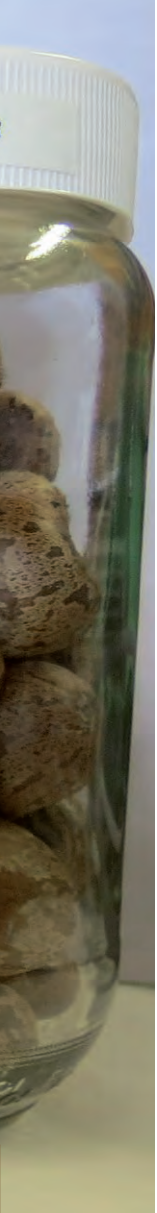
Are there ways to mitigate the extra pressure on agricultural systems caused by the introduction of a biobased economy? One option is to strictly limit the use of biomass to sectors where other renewable alternatives are not feasible. For heavy transport and aviation, for example, renewable carbon-based energy carriers are so far still the best option and thus need to be derived from biomass. Also for the chemical industry, and particularly for producing plastics and platform chemicals, biomass is the only renewable source for such carbon-based materials. But for electricity production and for heating, non-carbon-based energy sources like solar, wind, hydro and geothermal energy are certainly a viable alternative. Fuels based on hydrogen or synthetic photosynthesis may be developed in the future to further relieve the pressure on biomass. Secondly, some relief can be found in using second-generation biofuels produced from non-food biomass such as agricultural waste streams like straw, plantation

residues, or household waste. Another option is to cultivate biomass not on land but on water, like seaweed and algae. Of course, large-scale development of these activities will also impact ecosystems and this should be properly assessed before large-scale cultivation is considered. Thirdly, a smart use of biomass is needed. By using biomass for multiple purposes, the efficiency of biomass production can be increased enormously. This concept is called biorefinery, where – analogous to oil refining – all components of biomass are used. This will help to maximise the value of our production systems, to the benefit of both producers and consumers.

In an ideal world, agriculture beyond food does not need to threaten food security, but in practice it is already doing so. Price hikes of certain agricultural commodities may be good news for some farmers, but for urban dwellers – who spend a large percentage of their income on food – they constitute a direct threat. Land grabbing for biofuel production by powerful corporate players affects local markets and production capacity. Many countries, like Indonesia, are worried about their food security. On the one hand, Indonesia profits from agriculture beyond food, but at the same time research shows that rice production is being pushed to the fringes. In the Riau archipelago, for example, oil palm is replacing rice fields and the province now has to import rice from other areas.



Oil from sunflower, rubber and jatropha seeds may serve as an alternative to fossil fuels (by Yusuf Abduh)



Who benefits?

In theory, if the concept of agriculture beyond food really takes off and matures, the world as a whole may benefit from the move towards a low-carbon, biobased economy. Using biobased substitutes for consumer products that are a burden on the environment can help to curb climate change. Both consumers and producers can benefit from reasonable and stable prices for biofuels and the range of other products that can be made from biomass, while the availability of biobased products may help to meet the needs of a growing world population and rising demand from emerging economies. However, few global developments have ever led to an even distribution of benefits, and we should therefore distinguish between stakeholders at different levels.

Firstly, at country level, it seems likely that countries in the North will benefit more from agriculture beyond food because, while building their low-carbon economies, they are not faced with the negative

impacts of the increasing use of agricultural land for non-food purposes, such as land conversion, land grabs, the displacement of local communities or intensified migration into producing areas. On the other hand, if agriculture beyond food really takes off in countries like Indonesia, the export of biofuels, and possibly other biobased products, can become an important source of foreign exchange for the country. The benefits would increase substantially if not only biomass or raw products are exported, but if technologies for biorefinery are developed and established in the countries where the biomass is produced.

Secondly, who are the beneficiaries at local community level? There is no unequivocal answer to this question either. Research findings from the ABF programme suggest that smallholders in Riau province on Sumatra are increasingly enthusiastic promoters of oil palm. They cultivate it independently of large plantation companies and their village economies are thriving. Triggered by the increased demand for agricultural land, powerful individuals from within communities, often supported by the village leaders, are selling community lands to migrants and investors. While this may benefit a few people, the long-term consequences for the community as a whole are questionable, as the entitlements to the land are being squandered.

To empower local communities in Central Kalimantan, the ABF programme has been working on innovative technologies for the local rubber industry. The goal is to use the rubber seeds to produce pure plant oil that can be made into biodiesel or used as cooking fuel,

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which would make a difference in remote areas where diesel and kerosene are expensive and sometimes not available. Other waste streams from the rubber trees that grow in agroforests can be used to obtain protein for animal feed and fertiliser. By keeping the production processes local and small-scale, communities can benefit economically. Moreover, introducing new technologies in itself is important. Small-scale farmers in Indonesia need cash crops that fetch good prices to earn a living; the increased demand for biomass from agriculture and forestry might thus be an opportunity for farmers to improve their livelihoods.

Although agriculture beyond food provides new opportunities for farmers, it would be naïve to think that they automatically benefit from innovations in the area of agriculture beyond food. First of all, both market conditions and local, regional and national government policies and legislation must be beneficial and supportive. Another vital issue is the question of who owns the land used to cultivate non-food crops, and who owns the technologies. Research conducted into the jatropha sector by the ABF programme shows that benefits do not always accrue to local people. Against all expectations, local farmers in Flores, Sumba and South Sulawesi did not benefit from the jatropha boom. Their fruit contained little oil and the market price of the jatropha oil moreover was too low for them to make a decent living. If improved seeds were available at low cost, this could potentially benefit the farmers. However, whenever a new seed variety is brought onto the market, the cost is usually high because companies want to recover their research and development costs. Enticed by the widespread promotion of jatropha, many farmers planted the seeds they picked from wild jatropha shrubs growing close to their gardens. This resulted in a low yield, and they were unable to find buyers for their low-quality jatropha fruit.

Others, however, did benefit from the jatropha boom in Indonesia. They included researchers who studied the potential of the crop, consultants who conducted feasibility studies, government officials who arranged land permits, and even company staff who were tasked with compiling lists of local farmers willing to participate in jatropha schemes and who received a bonus for submitting a long list. Despite the fact that the majority of jatropha projects in Indonesia failed, companies that invested in jatropha still benefited if not economically then at least from favourable publicity. Many conventional energy companies or investors made sure they covered their 'green' and 'pro-poor' jatropha initiatives elaborately on their websites and used these projects to boost their image of taking corporate social responsibility seriously.

The question of who benefits from agriculture beyond food ultimately depends on the time horizon. The picture of who gains and who loses may shift over time. Local communities in biomass-producing regions may benefit from increased income and opportunities in the short term. However, when landscapes that currently comprise different land uses, including rice fields, agroforests and natural vegetation, are converted into monocultures for oil palm, this may have negative consequences in the long term. It would not only decrease levels of biodiversity, but also affect access to locally produced food and the provision of environmental services, such as soil and water conservation, natural pollination and local climate control, and increase vulnerability to price fluctuations in the world market.

Is there enough land?

As was discussed above, agriculture for non-food purposes should not come at the cost of food security. The question therefore becomes: is there enough land available for the production of agricultural commodities for non-food purposes if the first priority is and remains to meet the growing global demand for food? There are quite a few unknowns that make it hard to speculate about the availability of land. Much will depend on the growth rate of the global population in the coming decades. It is predicted that the world population will reach nine billion by 2050, but not only is this an estimate, the welfare levels of these people are also unknown. We have seen that increasing welfare levels in China, India and other emerging economies lead to a higher consumer demand for fossil fuels and for meat (the production of which requires a lot of land), as well as other consumer goods from the chemical industry that could possibly be produced through biorefinery in the future. Another uncertain factor is the gravity of climate change in the coming decades and the impact it will have on agricultural production, especially in risk-prone areas.

IT HAS BECOME CLEAR
THAT 'DEGRADED' AND
'MARGINAL' LAND ARE
NOT NEUTRAL CONCEPTS

Apart from these uncertainties, whether there will be enough land depends on the key economic sectors in which biomass will be used. If it is to be used to generate power on a global scale, there will certainly not be enough land. On the other hand, if biomass will primarily be used to produce biobased chemicals, the available land may be sufficient.

A second consideration, in addition to the intended use of the biomass, is what kind of land will be used for agriculture for non-food purposes. There is a growing consensus among scientists that prime agricultural land should not be used to cultivate energy crops or for other non-food purposes. This consensus has turned the attention to marginal or degraded lands. A study using spatial analysis in Indonesia, for example, concluded that there is enough land available for oil palm cultivation that does not compete with food cropping areas nor require the clearing of natural forest. This available land is scattered and therefore not suitable for large-scale oil palm plantations, but has potential for smallholder oil palm development. In practice, however, concerns related to food security and environmental impacts are hardly ever taken into consideration. The oil palm frontier in a province like Riau is moving into peat areas, while new frontiers are being opened up in Kalimantan and Papua, where landscapes are rapidly turning into large-scale monocultures.

It has become clear that 'degraded' and 'marginal' land are not neutral concepts. In 2006, the Indonesian government announced its plans to rehabilitate 10 million hectares of degraded land with biofuel crops,

including jatropha. By claiming that jatropha can grow on degraded land, it indirectly claimed that biofuel production would not threaten food production. However, such claims ignore the actual land-use practices of local people. Land that is considered marginal by planners and investors – suggesting a low economic value from an investment perspective – may have important functions in local society, for example for providing wood and fodder, as a watershed area, or as a habitat for specific species. Land may also play a central role in cultural practices.

Lastly, whether or not there will be enough land depends on the expected yields of agricultural crops and biomass streams. There are still many uncertainties about the possible yields per hectare of different crops on different types of land in different geographical and climatic regions. Oil palm has so far stood out as a very productive crop, with yields per hectare about five times higher than for jatropha. Whether or not there will be enough land available globally to develop a biobased world economy will partly depend on progress in agricultural research and the ability to increase the yield per hectare in a socially and environmentally sustainable way.



Oil palm fruit is loaded onto a truck near Bengkulu, Sumatra (by James Anderson, WRI)

What are the prospects of biorefinery?

The use of non-edible biomass to produce biobased products is attractive, as it does not compete with food security. This is where biorefinery comes in. The concept of biorefinery is analogous to oil refining, which produces fuels, energy, chemicals and other marketable products from crude oil. A biorefinery is a facility that produces these same products, but from low-value biomass. Biorefinery is appealing for several reasons. Firstly, unlike crude oil or other fossil feedstock, biomass is a renewable resource. Secondly, biorefinery allows for the efficient use of biomass waste streams and by-products. By aiming for full valorisation of the raw material (the biomass), and thus minimal waste, biorefinery presents a new way of looking at complex production chains. A third strong point of biorefinery is that it can be used on a large, industrial scale as well as for small-scale, local applications.

For application on an industrial scale, the production of biobased chemicals is interesting from an economic and sustainability perspective. Chemicals are high-value products and their production does not require high volumes of biomass. Biofuels, on the other hand, are high volume/low value products. Biobased chemicals are chemical building blocks made from biomass components such as sugars, fats and oils, lignin and proteins. They are used in products such as bio-plastics, adhesives and coatings, as well as in the fine chemicals and the pharmaceutical industry. Companies in the agro-food and chemical sectors are increasingly interested in developing sustainable biobased chemicals and materials. This is encouraged by national and European policies, for instance, the

European target that 10% of market plastics should consist of biobased, bio-degradable plastics by 2020. Polylactic acid (PLA), a biobased polymer, is already on the market and will be one of the leading contributors to the growth of bio-plastics. Research is ongoing to make the production process of such bio-plastics more sustainable. Much research now focuses on ways to change the biomass feedstock from food sources that are currently used (e.g. corn, wheat, sugarcane) to non-food biomass, such as agricultural waste streams and more 'exotic' sources such as seaweed. The advantage of using seaweed, apart from not competing with food production, is that its cultivation brings no risk of deforestation, does not need freshwater and does not depend on the use of fertilisers or pesticides.

The ABF programme has contributed to ongoing research on the production of biobased chemicals. Rather than focusing on large-scale high-tech applications, the programme has concentrated on small-scale technologies that can be used locally, for example using the seeds from the rubber tree for protein extraction. Protein from rubber seeds can be broken up (hydrolysed) into amino acids, which can in turn be used to produce biobased bulk chemicals. Researchers have been investigating how this can be done using as little energy and input of chemicals as possible. When an efficient and sustainable method is found to hydrolyse the protein extracted from the rubber seeds into amino acids, that method can also be applied to other seeds, such as jatropha or palm kernels.

In this particular example, an agricultural waste stream (rubber seeds) can be used for biorefinery processes that have direct value for communities at local level. Researchers from the ABF programme have also optimised a small-scale technology for extracting oil from the seeds and producing biodiesel out of the pure plant oil. The application of the technology in remote rural areas can create employment and provide households with access to biodiesel, which is now very expensive and sometimes not available. The by-product of this small-scale biorefinery process, the press cake from the seeds, can be used locally as fodder or as fertiliser.

scientists succeed in modifying the jatropha plant so that all of its fruits ripen at the same time, this would allow for mechanical harvesting, greatly improving its economic prospects. At the same time, however, it would cancel out the promise of employment creation. There are many more factors that influence the uptake and success of technologies. The social, economic, and environmental implications of the various technological possibilities should thus be carefully considered – before, during and after their development.

BIOREFINERY STARTS WITH THE DEVELOPMENT OF APPROPRIATE AND ACCESSIBLE TECHNOLOGIES

Research is also ongoing for jatropha, another non-food crop that is potentially interesting for local biorefinery. Opportunities to improve the economics of this crop by valorising by-products of the jatropha oil are currently being explored. Possible applications include its use for animal fodder and fertiliser (and also glue, paint and bio-plastics).

Biorefinery offers many opportunities. It starts with the development of appropriate and accessible technologies, for both large- and small-scale applications. But it does not stop there. The direction that technological developments take, after all, has social and environmental implications. For instance, if

CLUSTER
SLIDING FROM
GREASY LAND?



Oil palm fresh fruit bunches, Riau, Sumatra (by Carina van der Laan)

SLIDING FROM GREASY LAND?

Migration flows and forest transformation caused by oil palm expansion

Palm oil is increasingly used in the food processing industry as well as for the production of biofuels and other non-food purposes. Over the past decades, oil palm plantations have rapidly expanded in Indonesia, in particular on Sumatra and Kalimantan, and an estimated 6 million hectares of land is now under oil palm plantations. By 2020, Indonesia's oil palm industry is expected to have expanded by another 5 to 6 million hectares. At least 1.7 million hectares of this land is currently still forested, while close to 1 million hectares is peatland. Oil palm has been championed for bringing development to rural areas, but also criticised for being responsible for unsustainable processes of land-use change, including large-scale forest conversion and peatland degradation.

Most research into the expansion of oil palm plantations has focused on issues of land availability and the direct link between oil palm plantations and forest conversion. Very little research has been done on the indirect effects of palm oil production, most notably oil palm-induced migration. The Sliding from Greasy Land? research cluster was set up to address this gap. The integrated, multidisciplinary approach helped improve understanding of the socioeconomic and environmental dynamics at work in forest transitions in order to support local and national policy processes. The various research projects that fall under the cluster

addressed: (i) the direct and indirect environmental effects of expanding oil palm plantations; (ii) the response mechanisms of local people and migrants, who try to make a living in areas where large- and small-scale oil palm plantations are expanding; and (iii) local governance arrangements, particularly related to the planning of oil palm plantations.

Sliding from Greasy Land? focused on two locations. The main focus was on Riau, where oil palm plantations have already dominated the landscape for a long time,

Institutions involved

- Faculty of Forestry, Gadjah Mada University, Yogyakarta
- Faculty of Agriculture, Riau University, Pekanbaru
- Mulawarman University, East Kalimantan
- World Agroforestry Centre, Bogor
- International Development Studies, Faculty of Geosciences, Utrecht University
- Copernicus Institute for Sustainable Development, Utrecht University
- IS Academy on Land Governance for Equitable and Sustainable Development (LANDac), Utrecht University





Research projects

- 1** Food or fuel: Food policies and the role of oil palm induced land conversion on food security in Sumatra? (Dr. Paul Burgers)
- 2** Collapsing forest ecosystems through palm oil plantations: competing claims for resources and land (PhD study by Ari Susanti, under the supervision of Dr. P. Burgers and Prof. A. Zoomers)
- 3** Oil palm production and migration flows (PhD study by Suseno Budidarsono, under the supervision of Dr. P. Burgers and Prof. A. Zoomers)
- 4** Balancing the needs for food and fuel with the provision of critical environmental services in local land use planning (PhD study by Carina van der Laan, under the supervision of Dr. P. Verweij and Prof. A. Faaij)
- 5** Balancing ecology and economy on peatlands (Oka Karyanto)

Location

- Siak Sri Indrapura, Bengkalis, Rokan Hilir, Pesisir Selatan and Jambi
- Siak Sri Indrapura, Bengkalis and Rokan Hilir
- Rokan Hulu, Kampar and Pelalawan
- Kutai Kartanegara and Kutai Barat
- Pulau Padang and peatland areas near the coast

and where small-scale producers manage more than 60% of the oil palm area. The second research site was East Kalimantan. This province is much less densely populated and oil palm has been introduced relatively recently. Incorporating both areas in the research allowed the development paths in both areas to be compared, helping to understand the processes at work and allowing lessons to be drawn from one area that may be relevant for the other.

Master's studies under the Sliding from Greasy Land? cluster

- M. Derkzen (2011): Convert or conserve? Forest as the fuel for oil palm – an assessment of rural livelihoods and their strategies to cope in an oil palm environment in Riau, Sumatra
- S. Heijman (2011): Is the forest reduced to just an economic resource in an era of rapid oil palm expansion? An inquiry into the forest use and perspectives of the forest of local Malay communities in Riau, Sumatra
- E. Hertel (2011): Validation of ALOS PALSAR and Landsat-based land use and land cover maps: A contribution to the WWF Global Land Use and Sustainable Biomass Production Project in Indonesia
- I. Kies (2011): Aboveground woody biomass and structure of regenerating lowland forest in East-Kalimantan, Indonesia
- A. Mitsiou (2012): Oil palm expansion in Kutai Barat district East Kalimantan, Indonesia: Local drivers and implications for forest cover, local food production and local communities
- R. Visser (2011): Aboveground biomass of tropical secondary forests in East-Kalimantan Indonesia
- L. Sazzer-Krebbbers (2012): Assessing stand characteristics in relation to natural and anthropogenic disturbances and environmental factors in regenerating forest in East Kalimantan, Indonesia
- G. Sonderegger, H. Lanting (2012): The challenge of sustainable peatland farming: Characterising agricultural systems in Padang Island, Sumatra regarding their sustainability
- Rafflis (ongoing): Legalitas Perizinan berdasarkan UU Kehutanan dan penataan Ruang dalam tinjauan Hukum Administrasi Negara (The legality of licenses under the forestry law and spatial planning from a public administrative perspective)



Oil palm plantation in Jambi, Sumatra (by James Maiden, CIFOR)

SMALLHOLDERS LOVE OIL PALM

Oil palm boosts the local economy in Riau, but at what cost?

In Riau province, large-scale companies are no longer the sole drivers of oil palm expansion. Smallholders have enthusiastically embraced the crop, and for good reasons. Research shows that villages with palm oil are better off than those without it. Attracted by this success, thousands of migrants move into Riau every year to cultivate oil palm independently of large plantation companies. While boosting the local economy, oil palm plantations are rapidly replacing remaining forest and food crop areas.

Riau is located in the centre of Sumatra. Seen from above, a large part of the province is covered with a green blanket of oil palm, interspersed with roads. Planted with mathematical precision, the crowns of the individual palm trees form a regular pattern of little stars. The remaining patches of natural forest stand out as anomalies in the monotonous landscape. For many observers it exemplifies forest destruction by large-scale commercial interests. But there is more to the story of Riau.

With about 1.9 million hectares covered with oil palm plantations, Riau is the largest producer of palm oil

in Indonesia. In the 1970s the government started supporting companies wishing to establish oil palm plantations in the province. The rapid growth of plantations has often led to conflicts with local people due to unclear land governance and a lack of sound spatial planning. Despite such conflicts, the area under oil palm cultivation grew consistently, while the area covered with forest reduced at an almost equal pace. Recently, however, the main actors behind the expansion of oil palm in Riau have started to change. Whereas the growth of the area cultivated with oil palm used to be driven by large-scale commercial companies, today this is no longer the case. According to Ari Susanti, who has been studying oil palm trends in Riau, many researchers and NGOs have focused on large-scale oil palm plantations for too long. In doing so, they have turned a blind eye to the increasing roles of smallholders – both migrants and locals – who are rapidly becoming an important driving force behind the expansion of oil palm.

The second wave

In the early days of large-scale plantation development, the industry was supported by transmigration programmes to fulfil labour requirements. Some of these migrants started working as wage labourers on plantations, while others became 'supported

smallholders', cultivating oil palm as part of a large-scale scheme and using farm inputs provided by the company on credit. Since the mid 1990s, Riau has been experiencing a second wave of migrants. These are mostly farmers who move to the area to become independent smallholders, cultivating oil palm by their own means.

The independent smallholders are no longer part of a company's plantation, but arrange farm inputs themselves. Consequently they can sell the produce to any mill they choose. Their emergence was made possible by a new government regulation in 1995, which allowed mills to be established that do not manage their own oil palm plantations, and therefore need to purchase their Fresh Fruit Bunches (FFB) from independent producers. Since then the number of mills in Riau has been steadily growing, as has the number of migrants moving to the province to establish their own plantations. This trend is not likely to stop in the near future.

Currently about a quarter of the population in Riau province are migrants, and their numbers continue to grow. The province is not only attracting second-wave migrants from Java, but also large numbers from other Sumatran provinces. Some of them have been working as wage labourers on oil palm plantations and managed to save money with which they are now establishing their own small-scale plantations. There are also domestic investors buying up larger areas, sometimes up to several hundred hectares. They invite smallholders to come and cultivate oil palm, of course taking a share of the profit. And, while local communities were not initially interested in oil palm, they now see that oil palm farmers are earning good money and want to benefit from the oil palm boom as well.

Riau is the place to be for oil palm farmers, for at least two reasons. Firstly, it has many mills. In 2009 there

were a total of 173 (of which 46 did not manage their own plantations) and the number has been growing since. In other words, the demand for oil palm from independent producers is high. Secondly, the road network in Riau has grown tremendously over the last decades. While in 1984 the province only had 13.6 km of roads per 1000 km², in 2009 this had increased to 267.6 km. This is vital for oil palm producers, who need to deliver their fruit to a mill within 48 hours of harvesting.

THE EXPANSION OF OIL PALM THREATENS FOREST AREAS AND FOOD PRODUCTION

Oil palm as a development agent

What has been the socioeconomic effect of the rapid expansion of oil palm in Riau? Based on data from the Indonesian Central Bureau of Statistics, researcher Suseno Budidarsono has compared developments between 1993 and 2010 in villages with and without oil palm. His sample includes 516 villages, of which about 60% are dominated by oil palm. Budidarsono not only looks at changes in terms of per capita income, but also takes into account the number of schools and shops, access to electricity, roads, health institutions, banks, etc. He found that the oil palm-dominated villages stand out positively on almost all of these development indicators.

The oil palm villages are characterised by a process of wealth accumulation and investments in the non-farm sector, explains Budidarsono. In these villages, people's

purchasing power has grown rapidly, which has stimulated other types of investments. This translates, for example, into a growing number of retail, repair and video rental shops, and small supermarkets. The economic activities in the oil palm villages are thus diversifying, and the availability of purchasable food items is growing. Where the perception among NGOs is one of oil palm companies exploiting labourers and small-scale farmers, Budidarsono qualifies this view, saying “the farmers love oil palm”. From an environmental perspective, he admits, the situation at the forest frontier is a cause for concern.

Pushing back the forest frontier

Oil palm plantations by smallholders are replacing the last remaining areas of natural forest in Riau, many of which formally have protected status. How then do farmers acquire access to those lands? Budidarsono stresses that local communities have recently started facilitating the expansion of oil palm in these areas. This is partly because they claim customary rights to large stretches of forested areas, and have begun to sell these lands to migrants who want to cultivate oil palm. Locals are pro-actively looking for buyers, he says. This means it is very easy to get land, as long as you have money. Budidarsono experienced this first-hand on several occasions, when the person he was interviewing asked him whether he wanted to purchase land. Seen as a potentially wealthy outsider, Budidarsono received offers for as much as 1800 hectares of uncultivated lands, to be converted into oil palm.

When Budidarsono asked about the formal status of the land that he was offered, he was told ‘That’s my headache, not yours’. This illustrates the situation on the ground. There is a grey area of state regulations, which local leaders seem to be using to their advantage. In the current Indonesian legal setting, local communities can claim customary rights to land, and based on this claim,

village leaders feel entitled to provide individuals with an official letter that grants them the right to cultivate that land. Whether this is legal or illegal is difficult to answer. It all depends on which regulation you look at. From the perspective of the Ministry of Forestry most of these transactions are illegal, because many of these lands are classified as forest areas.

Over the past three decades the expansion of oil palm has led to significant deforestation. It is estimated that between 1982 and 2010 more than 80% of the oil palm plantations in Riau province have replaced forest areas. Today, the ongoing migration of independent smallholders, facilitated by local communities who are willingly selling their land, is exerting great pressure on Riau’s remaining natural forest. Susanti’s research shows that oil palm plantations have recently started expanding at the expense of peatland areas in the eastern part of Riau, which are less suitable for agriculture and thus render low profit margins, while their conversion releases enormous quantities of carbon.

Competition with food

In addition to the loss of natural forests, and the associated loss of biodiversity and increase in carbon emissions, Susanti is worried about another trend. She found that oil palm is increasingly replacing food crops, in particular rice production. In a survey among 255 randomly selected oil palm farmers in eight villages in areas near the forest frontier, she found that 46% of these farmers had planted oil palm on areas that before were primarily used to produce food. Her findings are confirmed by an analysis of province level data, which shows that around 8,000 out of 20,070 hectares of rice fields were converted into oil palm plantations between 2002 and 2009.

As a consequence, Riau has become a net importer of rice and other food items, including fruit and

vegetables. Although the income from oil palm allows people to buy food items quite easily, this development is not without risks. In mid 2008, Budidarsono recalls, the transport of rice to Riau was hindered due to floods, which caused the price of rice in the area to double. The local government responded by trying to prevent further conversion of rice fields by providing training, fertilisers and seeds to farmers who keep their rice fields. But, so far, this has not been successful.

Similar worries exist at national level. Rice is the staple food of the vast majority of Indonesians. If Indonesia were at some point to become fully dependent on other countries for its rice, so the government argues, its national food security would be in jeopardy. Not least because converting oil palm back to rice fields would be a massive undertaking. Maintaining the domestic production of rice at affordable prices is therefore seen as an issue of national security.

Ari Susanti and Suseno Budidarsono

Ari Susanti and Suseno Budidarsono are Indonesian PhD researchers with the International Development Studies (IDS) group at Utrecht University. Ari Susanti studies the processes of oil palm expansion in Riau Province, combining quantitative and qualitative methods. She is also a staff member at the Faculty of Forestry, Gadjah Mada University. Suseno Budidarsono is an Agricultural Economist at the World Agroforestry Centre in Bogor, Indonesia. His research focuses on the relationship between the expansion of oil palm, migration and rural development. For this he analyses data from 1993 to 2010 from the Indonesian Bureau of Statistics, complemented by interviews in the field.

The challenge

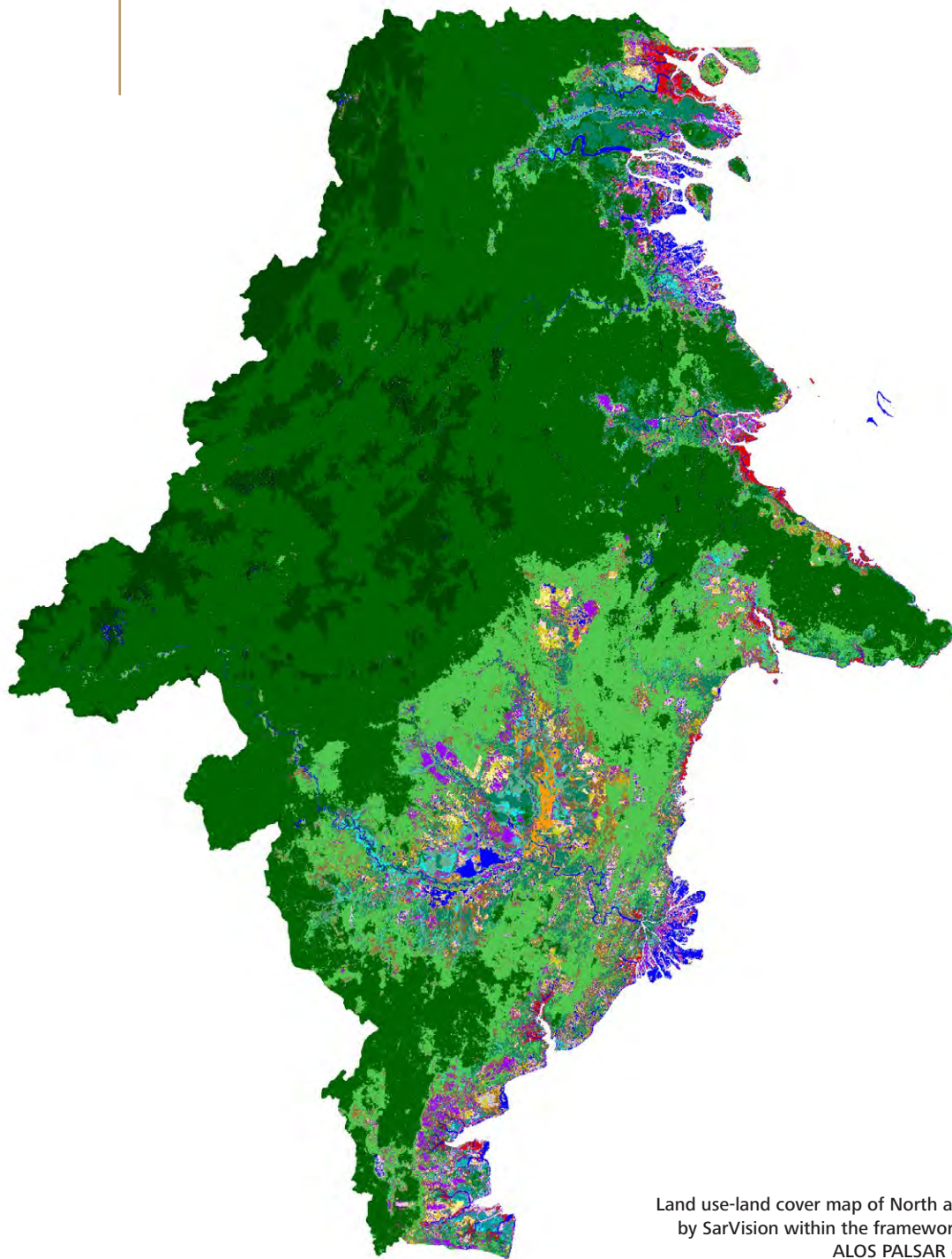
Riau is faced with a major dilemma: The expansion of oil palm leads to local development, but it may also cause new social problems (notably related to access to land) and it threatens forest areas and food production. Moreover, the conversion of a diverse landscape with different land-uses into a landscape consisting only of palm plantations, in combination with heavy reliance on agro-chemicals, may generate environmental problems in the longer term. For this reason there is an urgent need to better regulate the expansion of oil palm in the province. But how can this be done? Firstly, the government needs a spatial plan that clearly indicates where new oil palm plantations are allowed and where not, taking into account the long-term environmental consequences. For this, predictive computer models, such as the one being developed by researcher Carina van der Laan, can be helpful tools (see the article 'Not all degraded lands are alike' elsewhere in this publication). But a spatial plan alone is not enough. The findings of Susanti and Budidarsono highlight that the expansion of smallholders, be they migrant or local, warrants special attention. This development requires, amongst others, unambiguous regulation on customary land claims and the authority of local leaders to sell land to private investors. In addition, Budidarsono stresses, an effective way to control further expansion is to limit the establishment of new mills in the area, as they are creating the demand for oil palm in the region.

Not all experiences with smallholder involvement in palm oil production have been positive; there are many accounts of supported smallholders who have been cheated by companies, and of small-scale farmers being displaced from their lands. Moreover, those who cannot afford to invest in oil palm plantations are faced with rising prices for food and non-food items. This is of particular concern in areas like East Kalimantan where oil palm expansion has begun recently. But the research shows that story of oil palm is no longer just

about local people losing out, as the crop has become highly lucrative for a growing number of smallholders. The example of Riau shows an inconvenient truth that many find hard to accept: while constructing roads and establishing mills and oil palm plantations threatens the natural environment, it does spur economic development – at least in the short term.

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- Lowland forest
- Riverine forest
- Swamp forest
- Mangrove forest
- Mangrove nipah forest
- Peat swamp pole forest
- Peat swamp padang forest
- Forest mosaics
- Shrubland
- Medium shrub
- Ferns / grass
- Grassland
- Cropland (upland)
- Cropland (irrigated)
- Plantations (oil palm)
- Tree cover, burnt
- Water bodies
- Layover / shadow
- No strip coverage
- Montane forest

Land use-land cover map of North and East Kalimantan for 2007 (developed by SarVision within the framework of the JAXA Kyoto & Carbon Initiative. ALOS PALSAR data courtesy ALOS K&C (c) JAXA/METI).

NOT ALL DEGRADED LANDS ARE ALIKE

Accounting for the regeneration capacity of disturbed landscapes in land-use planning

Decision-makers tasked with planning the location of new plantations would need to consider the long-term environmental consequences of their decisions. Land-use planning can be greatly improved by the use of computer-based decision support models. Most of these models, however, do not account for the fact that different degraded areas have different capacities to regenerate. This is what doctoral researcher Carina van der Laan is trying to improve.

The future of East Kalimantan province seems predestined. If you want to know where it is heading, just take a look in Riau province, located 1,500 kilometres away on the island of Sumatra. The areas are on a similar development path, but at different stages. Researchers from the Sliding from Greasy Land? cluster are working in both East Kalimantan and Riau, and every time they share their findings they are struck by the similar trends they detect. Indeed, East Kalimantan today looks much like Riau did a few decades ago, with large-scale fires and explosively growing plantations in a landscape that still has extensive areas of logged-over and primary forest. In Riau today, the

fires and plantations have led to the loss of forests and desiccation of peatlands, and consequently to high levels of biodiversity loss and carbon emissions. Moreover, plantations for the palm oil and pulp & paper industries are competing with local food production. Is this also East Kalimantan's fate?

According to the researchers from Utrecht University, this does not have to be the case. East Kalimantan can learn from Riau and improve its land-use planning, allowing it to develop into a multifunctional landscape in which social, socioeconomic and ecological considerations are taken into account.

A focus on degraded areas

The negative effects of agricultural expansion can be limited by focusing future expansion on 'degraded lands' instead of opening up natural forests or food production areas. This may sound obvious, but it gives rise to new questions, such as: What are degraded lands? And, what are the effects of converting them to farmland?

The term 'degraded land' can be used to refer to land with all kinds of vegetation types – from logged-over forest to grassland, and everything in between. According to Carina van der Laan, researcher in the

Sliding from Greasy Land? cluster, it is important to differentiate between various types of degraded areas and to understand the social, environmental and economic effects of their conversion to agriculture. She warns against lumping them all together into one category. Policymakers may consider all degraded lands to be suitable for oil palm expansion. But this is far too simple. Some so-called degraded lands are grass and shrublands that are part of former shifting cultivation systems and which play a vital role in sustaining local people's livelihoods. Moreover, the environmental effects of converting one degraded area may be very different from converting another. Turning a logged-over forest with regeneration potential into an oil palm plantation, for example, can have severe negative effects in terms of carbon storage and biodiversity, while planting oil palm on unused grasslands may be much less problematic.

Carina van der Laan

Carina van der Laan started her PhD research with the Energy and Resources Group at the Copernicus Institute of Sustainable Development, Utrecht University, in April 2010. She is exploring the current and future impacts of oil palm and rubber expansion on carbon stocks, biodiversity and food production in East Kalimantan, Indonesian Borneo. With her research she aims to support decision-making by the private and public sector on sustainable land-use planning. Carina is collaborating with SarVision the Netherlands, WWF Indonesia and WWF Samarinda, the University of Gadjah Mada in Yogyakarta, the University of Mulawarman in Samarinda, and the World Agroforestry Centre in Bogor. Prior to her PhD research, she studied Sustainable Development in Utrecht and worked for WWF in Zeist.

THE AIM IS TO PREDICT FUTURE EFFECTS OF LAND-USE DECISIONS AS ACCURATELY AS POSSIBLE

Improving projections

Both policymakers and NGOs are increasingly using spatial decision support models to show the expected effects of certain land-use choices. Over the years these models have become ever more sophisticated. But Van der Laan, who has been analysing these models in the course of her PhD, discovered that many of them are not taking account of at least one important aspect: the regeneration capacity of degraded forests. If you are trying to decide whether or not to convert a degraded forest into farmland, she explains, you need to take into account the fact that *not* converting the area will mean that the degraded forest will be able to regenerate. Many current models act as though the degraded forest will stay as it is during the model run, and this does not allow a fair comparison.

A model that does not account for an area's regenerative capacity is likely to underestimate the negative effects of converting the area to farmland. In practice degraded land is thus often allocated for plantation development without a full understanding of the potential negative consequences of this decision for carbon stocks and biodiversity. Van der Laan sees this as a serious omission. Her research aims to contribute to a better land-use planning process by improving an existing model, so it takes into account the differences between various types of degraded lands and their regeneration capacities.

To arrive at an improved model, Van der Laan first and foremost needs robust empirical data regarding land-use changes in the past, and regarding carbon stocks and biodiversity levels in different types of degraded lands. Gathering her data, she focuses on East Kalimantan, analysing time series of optical and radar satellite images and crosschecking them with data from the Indonesian National Bureau of Statistics. In addition, she works with Master's students measuring tree diameters in forests with different levels of degradation. This information is used to calculate biomass and carbon stocks using allometric equations, and the same information may also be used as a proxy for biodiversity. Van der Laan will incorporate the empirical data into a modelling exercise, helping her to make projections for the future of East Kalimantan.

Smarter land-use planning

Eventually Van der Laan and her research partners will develop a spatial decision support tool that can be customised by adding and deleting certain variables, allowing its application in other disturbed tropical forested landscapes, and doing justice to the variation between degraded landscapes and to their capacity to regenerate.

In present-day Indonesia, smarter and more responsible land-use planning is a *sine qua non*. It is required to make sure that areas like East Kalimantan can benefit from agricultural development, while avoiding the negative environmental effects that are currently being witnessed in other Indonesian provinces, like Riau. With improved models such as the one that Carina van der Laan is working on, decision-makers have a tool at hand with which they can make better-informed choices on

Accurate maps to make agricultural expansion more sustainable

There is a need to identify the lands that can be used for the expansion of oil palm plantations in a sustainable manner. This is what a group of Dutch and Indonesian researchers have been working on in the province of West Kalimantan, in collaboration with the Sliding from Greasy Land? research cluster. First, they selected several initiatives promoting sustainable oil palm, i.e., the Roundtable on Sustainable Palm Oil (RSPO), the Roundtable on Sustainable Biofuels (RSB) and the Renewable Energy Sources Directive (RES-D). Each of these has its own set of sustainability criteria. The researchers then translated these sustainability criteria into spatially explicit indicators for the province of West Kalimantan. They used spatial data to produce a map that precisely indicates which areas in West Kalimantan are in line with the various sustainability criteria, and which are not. The researchers found that a large share of the inactive concessions (i.e., areas for which a plantation permit exists but which are not yet cultivated) did not seem suitable for sustainable cultivation. Interestingly, outside the existing concessions, they have identified about half a million hectares that could be used for sustainable oil palm plantations – mostly grass- and shrublands. Many of these lands are located in areas that are erroneously labelled as forestlands on government maps. The researchers were able to create a map indicating the sustainability risks of expansion. After ground checks, for example regarding land ownership, such a map would provide a better basis for the planning of oil palm plantations compared to the old and inaccurate maps that have been used up to now. The method the researchers developed in West Kalimantan is now being tested and implemented in other parts of the world and for other crops.

where to plan agricultural expansion and where not. The aim is to predict future effects of land-use decisions as accurately as possible, to allow for land-use planning that maximises the positive and minimises the negative effects.

Suggested reading

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FOR PEAT'S SAKE

An alternative development model for Indonesian peatlands

Peatlands are under increased pressure of plantation development as they are seen as the last 'underutilised' resource. However, large-scale drainage to make peatlands suitable for agriculture is a high risk business as its viability in the long run is still unknown. Traditional farming systems on shallow peatlands require less draining and as such seem to balance economic and environmental objectives. However, so far the potential of these systems has received little attention. Oka Karyanto, calls for an alternative, integrated approach to peatland development – based on independent science.

Peatland conversion in Indonesia

Indonesia holds an estimated 20 million hectares of peatland. Much of this land is covered with forests that supply high quality timber. Traditionally, farming was limited to the shallow peatland areas with crops adapted to the wet conditions. Nowadays, large-scale plantations of oil palm and fast growing tree species for the pulp & paper industry are being established on deep peatland areas, i.e., lands that have peat layers of more than 3 meters. These systems are not adapted to the wetland ecosystem and only thrive through intensive peatland drainage, in combination with large amounts of chemical inputs.

The conversion of peatlands has several negative effects. It changes peat forest from the most efficient global carbon sink system into a CO₂ emitting system. This is aggravated when fire is used to open up the peatlands. Fires tend to smoulder for months or even years, exacerbating the CO₂ emissions. Haze problems are also often caused by fires on drained peatlands. Last but not least, peatland drainage causes land subsidence. Some areas along the east coast of Sumatra are already experiencing the negative effects of drained (deep) peat areas. For several years, the city of *Tembilahan* in Riau province, for example, faces daily floods during high tide.

The Indonesian government recognises the risks and has several regulations in place to protect the peatlands. In 2011, the President suspended the provision of new licences on peatlands in Riau – the province with one of the largest peat areas in Indonesia. Many of the peatlands, however, were already under concession before the President's instruction, therefore large parts of the peatlands in Riau continue to be drained and converted into oil palm plantations or tree plantations for the pulp & paper industry. Recently these peatland areas have become centres of economic development, attracting large amounts of (foreign) capital and a growing number of migrants in search of a new livelihood. This has sparked a sensitive discussion about



Draining peatland for oil palm establishment in Riau (by Wakk)



developing peatlands and its viability in the long run, without jeopardising targets for economic development and environmental protection, including the CO₂ emission reduction targets set by the Indonesian government.

The absence of good maps that show the location and depth of the peat is particularly problematic for sustainable management. It results in large-scale and small-scale plantations encroaching upon the peatdomes, which are the deep peatland areas where water is naturally stored and released during dry periods, thereby keeping the peatlands moist even during dry periods. Draining these peatdomes means that the entire eco-system becomes vulnerable to drought and prone to fires. Therefore, large-scale plantations often implement so-called eco-hydro technology. This technology divides an area into specific water zones, depending on elevation. Water levels in the canals surrounding each zone are maintained through a series of comb-like relocation channels. Scientific evidence shows, however, that this technology cannot maintain the required water levels during the dry season. It is crucial to have good peatland maps to make decisions about where to develop activities. A research group from Gadjah Mada University, led by Oka Karyanto, therefore developed an advanced airborne sensing technique, called LiDAR which is now becoming available. It enables well-informed decision-making in peatlands, allowing for the separation of production zones from conservation zones.

Science-based evidence

Mr. Karyanto works in the Forestry Faculty of Gadjah Mada University in Yogyakarta and has been studying peatlands for many years. He warns that the risks of peatland conversion are real, and he has been trying to get his message across to decision makers in Indonesia. His group has initiated a series of ‘high-level stakeholder

LOCALLY DEVELOPED AGRICULTURAL SYSTEMS ARE WELL ADAPTED TO THE SPECIFIC NATURAL CIRCUMSTANCES IN PEATLAND AREAS

consultations’ which involve key representatives from the government, the private sector, NGOs, and the academic community to discuss Indonesia’s future peatland management.

During a recent high-level stakeholder consultation in Jakarta, several NGO representatives and some independent academics criticised large-scale investments in peat areas. The majority of the other stakeholders received these critical remarks with scepticism. Most domestic stakeholders do not support the scientific arguments concerning the negative consequences of peatland drainage. Several private sector representatives and politicians even believe that scientific reports stressing the risks of peatland drainage are part of efforts to weaken Indonesia’s position in international trade, in response to the country’s increasing share in global markets for palm oil and pulp & paper. Such notions are further strengthened by the fact that most scientific publications on these issues are not authored by Indonesian scientists. During the consultation, the supporters of peatland conversion referred to this as ‘scientific colonialism’. Academics themselves proved divided and were not able to deliver a clear message on how Indonesia should manage its peatland areas.

According to Karyanto there is a need for robust scientific cost-benefit analyses that include the long-term environmental consequences such as subsidence and CO₂ emissions. Moreover, he stresses, much more evidence is needed on the feasibility of existing alternative livelihood systems in peatlands, especially those which do not necessarily need drainage and hence could provide inspiration for an alternative development pathway for peatlands. Such technologies could for example be incorporated into future business models of large concessionaires to mitigate the negative impacts of intensive draining, or help newcomers to build a sustainable livelihood.

Alternative development pathways

In large parts of Sumatra and Kalimantan, smallholders have developed agricultural systems on peatlands that require little or no drainage. They cultivate economically valuable perennial crops including sago, rubber, coconut and fruit trees, while some also produce rice. In South Kalimantan, for instance, communities cultivate rice in a tidal peatland system. Farmers know exactly which species do not mind having 'wet feet' and thrive well under peatland conditions. Such locally developed agricultural systems are often overlooked, even though they are well adapted to the specific natural circumstances in peatland areas.

Gabi Sonderegger and Hester Lanting of Utrecht University, under the supervision of Paul Burgers and Oka Karyanto, studied small-scale farming practices in peat areas on Pulau Padang in Riau province. They found that most farmers cultivate a combination of rubber and sago without extensive peatland drainage. Sago is often used as a substitute for rice, but the flour can also be used for various modern food items and in the chemical industries. This area is known to be among the best sago producing areas in Indonesia.

Sonderegger and Lanting discovered that several farmers on Pulau Padang experimented with planting oil palm in the early 2000s (after the government started subsidy programs providing free inputs), but according to the farmers, the oil palms do not grow well on deep peat soils and require large amounts of fertilisers and herbicides, driving up the costs. With relatively low yields, farmers did not judge this to be a viable option for peatland areas. A recent survey showed that despite similar inputs (fertilisers and maintenance), oil palm grown on deep peatland only reaches 20% of the profits of oil palm planted on shallow (fertile) peatland.

Locally developed small-scale systems tend to require much less drainage compared to large-scale oil palm plantations, thereby reducing greenhouse gas emissions and the risk of subsidence. Moreover, these small-scale systems allow for a combination of cash- and food crops, and can thus play an important role in providing local food security. Research from Karyanto's colleagues in the Sliding from Greasy Land? cluster shows that local food production is of increasing importance in a province like Riau, which is now importing rice. Sago grown on undrained peatland could be one promising alternative route of peatland development and local governments have started to become more interested in ways to improve local food production along these lines.

Oka Karyanto

Oka Karyanto is a senior researcher at Gadjah Mada University in Yogyakarta. He specialises in the ecology of peatland areas. Karyanto is the main Indonesian counterpart in the Sliding from Greasy Land? research cluster.

The way forward

Karyanto and his colleagues stress the need for a science-based discussion on ways to integrate the needs of local people in peatland areas, while securing large-scale investments and minimising environmental risks due to peatland drainage. They found, however, that there is little trust in international science among the stakeholders. That trust needs to be restored. This does not only require more involvement of Indonesian scientists in the debate, but also calls for increased efforts to communicate the research outcomes to other sectors of society, and to engage in an open discussion to try and integrate the multiple perceptions and interests in peatland management. The stakeholder consultations organised by Karyanto's group are an important first step in that direction, setting a basis for mutual understanding. In-depth research is needed on the feasibility of specific large-scale developments, including future projections of risks associated with large-scale peatland draining. Such projections must be accessible to all relevant stakeholders. With small-scale migrant farmer families entering the peatland areas, of special importance are opportunities for systems that combine cash crops with food production. Integrated farming systems with little or no drainage, which have existed for generations, may provide the starting point for an alternative development pathway.

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Young oil palms planted on former rice fields, West Sumatra (by Paul Burgers)

A BLESSING AND A CURSE

Conclusions from the cluster Sliding from Greasy Land?



The demand for palm oil is ever increasing. It is considered a healthy fat for the food processing industry, and is used to produce low-carbon fuels and many other non-food items. The growing demand has triggered unprecedented levels of oil palm expansion, especially in Indonesia. It has become Indonesia's favourite crop, generating large amounts of foreign exchange as well as economic development in rural areas.



One of the main overall conclusions of the Sliding from Greasy Land? cluster is that small-scale producers are increasingly becoming a driving force for further oil palm expansion. In Riau province, the first palm oil producing province in Indonesia, over 50% of the land under oil palm is now managed by small-scale producers. High earnings from palm oil production, employment prospects, rapid urban development and good road access are attracting ever more migrants from other parts of Sumatra and from other Indonesian islands. They often start working as labourers on existing oil palm plantations or find work in the non-farm sector and then use the money

they have earned to purchase land to cultivate oil palm independently. They can easily buy land from local communities. Unclear boundaries between land within and outside the state forest zone, combined with weak law enforcement, allow local communities (or more accurately: powerful individuals within these communities) to claim land as part of their village territory and then treat it as a marketable commodity. In many cases village heads may even provide some sort of land certificate. Selling land has become a lucrative business, as many migrants are looking for areas to cultivate, while entrepreneurs with an interest in land speculation further increase the demand. Although it generates immediate cash income, the money tends to accrue to a limited number of people, and there are concerns about the long-term social and environmental consequences of these developments.

The growing demand for land to cultivate oil palm is moving the forest frontier into remaining and weakly protected state forest areas in the eastern parts of Riau province – including national parks and peatland areas – leading to biodiversity loss and carbon emissions. In addition to problems associated with conversion of natural areas, researchers found that farmers are increasingly converting their own rice fields into oil palm plantations. One reason for moving away from rice production is the increasingly unpredictable rainy

season. Oil palm has become a good alternative, as it is less prone to changing climatic conditions. With high palm oil yields and the opportunity to buy mainly imported rice, it is a rational choice for many farmers to move away from rice production. Between 2002 and 2009 around 40% of all converted rice fields in Riau had been turned into oil palm plantations. The conversion of rice fields in combination with the province's rapid population growth (5%) due to in-migration has made Riau into a net importer of rice. The government – through a state-owned enterprise called BULOG that imports rice into the province – tries to keep rice supplies and prices stable, but this is considered a short-term solution. Although the income earned with oil palm cultivation enables local people to buy their food in shops, the decrease in rice production has become a national concern. The Indonesian government has therefore made it a policy objective to become self-sufficient in rice production. This is considered important for national stability, since rice accounts for a relatively large share of household expenditures in most parts of the country.

The results of the Sliding from Greasy Land? cluster underline the urgent need to close the loopholes in the law, which allow semi-formal land deals between local people, migrants and speculators, and to manage population growth (migration in particular) and land use in oil palm areas. Although there is a strong national food policy, in the Indonesian decentralised context the implementation of this policy is largely in the hands of provincial and district governments with limited capacity and resources. Furthermore, the research outcomes stress the importance of land-use planning, with a focus on guided agricultural expansion into areas that are already severely degraded. This is particularly important in more recent production areas like East Kalimantan province, which is now witnessing land conversion processes similar to those in Riau a few decades ago, characterised by the rapid development of large-scale

plantations and conversion of forest areas. Guiding oil palm expansion towards degraded areas instead of opening up land within natural forests or converting food production areas, is expected to result in positive effects in terms of carbon storage, biodiversity and local food security.

Better planning requires sufficient capacity at local government level. For this reason researchers have been working on a decision-support model, designed to help local governments to oversee the consequences of their planning decisions. Such modern tools, based on satellite images and computer models, can be used to make sure that planning takes account of current vegetation, levels of degradation, regeneration capacities and land-uses. The aim is to enable local governments to find optimal trade-offs between development objectives, local food security and environmental conservation. This is especially urgent for provinces like Riau with extensive peatland areas and East Kalimantan where the oil palm boom is now rapidly changing the landscape.

CLUSTER
BREAKTHROUGHS
IN BIOFUELS



Rubber seeds ready for processing (by Ad de Leeuw)

BREAKTHROUGHS IN BIOFUELS

Mobile technology for biodiesel production from Indonesian resources

Like most countries, Indonesia is still heavily dependent on fossil resources for energy generation. Indonesia is a net importer of oil and its economic growth is strongly affected by the global price of fossil fuels. Biofuels have increasingly attracted the attention of the Indonesian government because of their potential to reduce dependency on fossil fuel and to meet global environmental requirements. The government has installed several regulations to stimulate the development and use of alternative transportation fuels. The 'Energy Mix Target' calls for a reduction in oil consumption by 20%, increasing coal use to 33%, and renewable energy to 17% by 2025.

Biodiesel produced from pure plant oil is currently, alongside bioethanol, an important renewable energy source in Indonesia, and the Indonesian government has ambitious plans to further increase production levels, mostly from oil palm. However, as the Sliding from Greasy Land? research shows, expansion of large-scale oil palm plantations may have negative effects on the environment and on food security. In this light, the possibilities of small-scale production of biodiesel from non-food oils and fats – particularly waste products – are interesting and highly relevant. Biodiesel production with small and mobile units that can use local resources, such as oil from rubber seeds, can be a promising venture. But, for this to become reality, such accessible

and small-scale technologies need to be developed. Furthermore, technologies are needed that enable the use of by-products of local biodiesel production – such

Institutions involved

- Bio-Engineering Department, School of Life Science and Technology, School of Business and Management and Department of Industrial Engineering, Bandung Institute of Technology
- Department of Agricultural Engineering, Gadjah Mada University
- Faculty of Agriculture, Center for International Co-operation in Sustainable Management of Tropical Peatland, CIMTROP, University of Palangkaraya
- Agro-technology & Food Innovations, Biobased Products, Wageningen University & Research centre (WUR)
- Institute of Mechanics, Processes and Control, University of Twente
- Chemical Engineering Department, Faculty of Mathematics and Natural Sciences; Department of Operations and Department of Global Economics and Management, Faculty of Economics and Business, University of Groningen





Research projects

- 1** Techno-economic evaluation on seed processing technology (post-doctoral study, Dr. C.B. Rasrendra, supervision Prof. A.A. Broekhuis, Prof. H.J. Heeres, Dr. S. Kersten, Dr. G. van Rossum and Dr. R. Manurung)
- 2** Exploratory experimental studies on biodiesel synthesis in mobile production units using Centrifugal Contactor Separators (CCS) equipment (PhD study, Muhammad Yusuf Abduh MSc, supervision Prof. H.J. Heeres and Dr. R. Manurung)
- 3** Techno-economic evaluations of biodiesel synthesis in mobile production units using CCS equipment (post-doctoral study, ir. Arjan Kloekhorst, supervision Prof. A.A. Broekhuis, Dr. S. Kersten, Dr. R. Manurung and Dr. Y. Sulistiyanto)
- 4** Development of technology for biodiesel production using locally produced enzymes (PhD study, Miftahul Iلمي MSi., supervision Prof. M. van der Maarel, Prof. H.J. Heeres, Dr. Chusnul Hidayat and Dr. Pudji Hastuti)
- 5** Optimal planning and control of mobile processing technology with multiple inputs and outputs (post-doctoral study, Dr. Ratih Dyah Kusumastuti, supervision Prof. D.P van Donk and Prof. Togar Simatupang)
- 6** Isolation and valorization of peptides and amino acids from the rubber tree, oil palm and Jatropha Curcas plant (PhD study, Widyarani MSc, supervision Prof. J. Sanders, Dr. M. Bruins and Dr. E. Ratnaningsih)
- 7** LERD, establishment of a technology introduction framework for relevant stakeholders (planners, small entrepreneurs and NGOs) (Ad de Leeuw, Dr. Bartjan Pennink, Dr. J. Siswanto and Dr. S. Limin)

Location

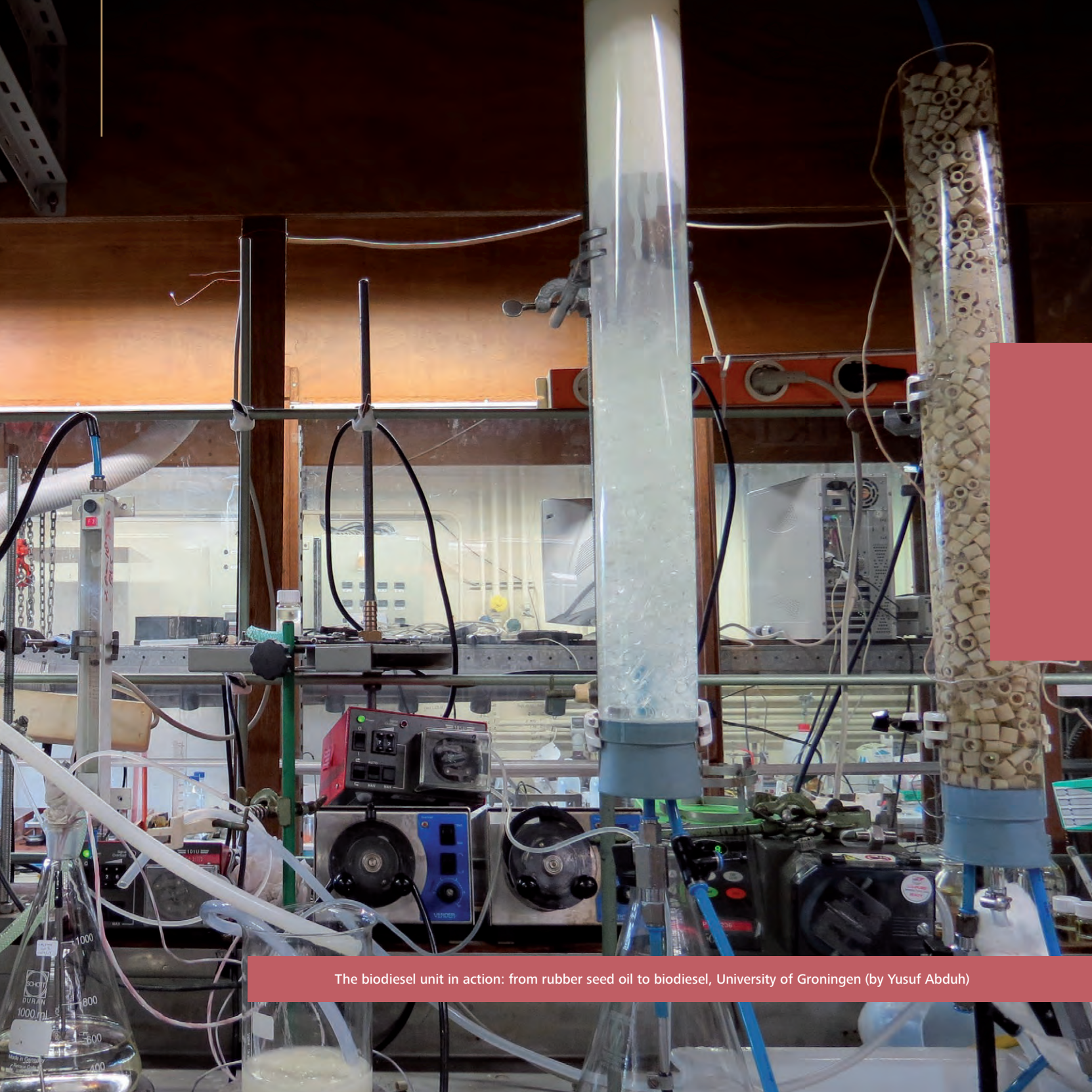
- Bandung
- Bandung
- Groningen
(the Netherlands)
- Yogyakarta
- Depok
- Bandung
- Area around
Palangkaraya

as press cakes – to enhance the economic value of the biodiesel product chain. Such by-products often contain protein and can, for example, be used to improve the soil structure, as cattle feed, or to reduce dependency on expensive fertilisers.

The Breakthroughs in Biofuels cluster explored the technical possibilities of small-scale and accessible technologies to produce biodiesel and to valorise its by-products. Most of the research took place in university laboratories in Indonesia and the Netherlands, but the cluster also aimed to implement some of the developed technologies in the field. For this it focused on the part of Central Kalimantan known as the 'Ex-Mega Rice Project area' (referring to the 1995 'Mega Rice Project' with which the government unsuccessfully tried to transform 1 million hectares of peatland into rice plantations). Here, local biodiesel production can help to increase the energy supply in remote villages, which currently have to import expensive fuels from other parts of Indonesia. Breakthroughs in Biofuels consisted of seven research projects, which were carried out by both Dutch and Indonesian researchers with backgrounds in the natural sciences, economics and business.

Master's studies under the Breakthroughs in Biofuels cluster

- R. Baars (2010): Combining Technology Transfer with Technology Push: A new Framework applied in Central Kalimantan, Indonesia
- M. van Kammen (2010): How to achieve successful GCL empowerment in poor, rural areas? A new framework applied to the mobile biodiesel project in Central Kalimantan, Indonesia
- J. Fredriks (2012): Working out a technology push by using hybrid franchising. An exploratory research of the MBD project in Central-Kalimantan, Indonesia
- R. de Windt (2012): The synergy between social entrepreneurship, community empowerment and social capital for the local economic development of the smallholder rubber culture in Central Kalimantan
- G. Boon (2013) Introducing Management Control in Local Economic Development: A LED model applied in Kalimantan, Indonesia
- P.M.P. Bot (2013): Uncertainties in the Bidirectional Biodiesel Supply Chain: An Empirical Model Developed in Central-Kalimantan, Indonesia
- A. Fernández Martínez (2013): Experimental and modeling studies on biodiesel synthesis and refining in a dedicated bench scale unit
- N.J.W. Verkruijss (2013): Overcoming electricity blackouts in remote rural areas by collective institutional entrepreneurship: MBD project as catalyst: The implementation of renewable energy in Pulang Pisau, Central Kalimantan
- A. Hommes (2014): Development of a kinetic model for enzymatic biodiesel synthesis in a biphasic system



The biodiesel unit in action: from rubber seed oil to biodiesel, University of Groningen (by Yusuf Abduh)

RUBBER SEEDS THAT TRAVEL

Optimising a mobile biodiesel technology

Small-scale biodiesel production can be a promising venture for people in remote rural areas in Central Kalimantan. It will improve their access to energy and at the same time help to create jobs and income. Researchers in Indonesia and the Netherlands have designed a mobile biodiesel unit and proved that a local waste product, the seed from the rubber tree, can be used to produce biodiesel.

Between laboratory cabinets, countertops with glassware holding brightly coloured liquids and intricate experimental setups, there is a white plastic bag tossed under a table. Yusuf unties the knot and takes out a handful of seeds the size of small chocolate Easter eggs. Their skin is smooth and covered with a dark and light brown camouflage pattern. They are rubber seeds. This seven-kilo bag travelled by motorcycle, plane and then bicycle from a rubber forest in Central Kalimantan to the chemical engineering lab at the University of Groningen. Yusuf plays with the seeds in his hand. Normally left to rot or germinate on the moist forest soil, they are the primary ingredients of his scientific experiments.

Muhammad Yusuf Abduh, doctoral student in chemical engineering, has been working on an innovative technology for producing biodiesel in the labs at the University of Groningen and the Institut Teknologi Bandung in the capital of West Java. The outcome of his research is intended to benefit the indigenous Dayak people of Central Kalimantan as well as long-time Javanese transmigrant communities. “The energy crisis in Indonesia is felt most severely by people in remote rural areas,” says Yusuf. “Their access to electricity is unreliable and they pay a high price for fuel. We can make a real difference by enabling them to produce their own energy using pure plant oils and biodiesel from local resources. This could help to create jobs and diversify people’s incomes.” The objective of the research was to design a mobile technology for producing biodiesel that can travel from one *desa* (village) to another. The researchers in Groningen found a promising bioresource in a local waste product: the seeds of the rubber tree.

Triple C-S

Its scientific name – transesterification – may be a tongue twister, but the basics of the process of producing biodiesel from rubber seeds are not too hard to follow. The pure plant oil, extracted from the seeds with a hydraulic press, is fed into a reactor together

with an alcohol (usually methanol) and a catalyst. The oil reacts with the alcohol, forming two liquid layers. The upper layer consists of crude biodiesel with remnants of alcohol; the lower layer is rich in glycerol and alcohol. The two layers are separated and the crude biodiesel is washed with water to remove residues of alcohol and catalyst. The washed biodiesel is then dried to achieve minimal water content. This process takes place every day in many biodiesel factories around the world. The challenge taken up by Yusuf and his colleagues in Groningen was to optimize the potential of a technology that is compact enough to be fixed onto a truck – a mobile mini factory. The chosen technology is called continuous centrifugal contactor separation (CCCS). Its key feature is that it integrates the reaction and separation phases in a single device and can therefore operate continuously – 24/7 if so desired – unlike the conventional production process that takes place in batches and requires different tanks for the synthesis, separation, washing and drying of the biodiesel.

Muhammad Yusuf Abduh and Miftahul Ilmi

Muhammad Yusuf Abduh and Miftahul Ilmi are doctoral students from Indonesia. They are conducting their PhD research at the University of Groningen in the Netherlands in cooperation with the Bandung Institute of Technology in Bandung and the Gadjah Mada University in Yogyakarta, Indonesia. Yusuf is a chemical engineer by training (MSc, University of Groningen and Bandung Institute of Technology) and is working on optimizing the process of biodiesel synthesis in mobile production units using continuous centrifugal contactor separators. Ilmi is a biologist by training (MSc, University of Indonesia) and is studying the use of enzymes as catalysts for the production of biodiesel.

A MOBILE BIODIESEL UNIT THAT CAN TRAVEL FROM VILLAGE TO VILLAGE IS A SOLUTION FOR REMOTE RURAL AREAS IN INDONESIA

The 'triple CS', as Yusuf calls it, was developed in the United States by CINC Solutions and originally used for cleaning nuclear waste. The research lab at the University of Groningen, led by professor Erik Heeres, was the first to prove its usability for the synthesis of biodiesel – made from sunflower oil bought at the local supermarket. In the past four years, Yusuf has built on this initial 'proof of concept'. He not only explored the possibilities of using jatropha and rubber seed oil from Indonesia, but most importantly he worked on optimizing the operational conditions of the CCCS device. The objective was to obtain the highest possible yield of biodiesel (measured against the input of pure plant oil) of the highest possible quality. While it is true that even pure plant oil will make most motors run, refined biodiesel intended for the market needs to comply with a range of international quality standards.

Yusuf's experiments with changing the reaction temperature, the rotational speed of the reactor, the oil flow rate and catalyst concentration have resulted in proof that CCCS technology can achieve the same high yield as conventional batch technology. Moreover, the quality of the biodiesel produced by the CCCS is always uniform, something that is not guaranteed in

batch production. In other words: good news on both yield and quality. Combined with the already established advantages of the device – it is compact, robust and easy to operate – its small-scale application in a mobile setup appears possible. There is, however, still a vital hurdle to be overcome: the cost. Yusuf performed a preliminary calculation and found that the biodiesel made of oilseeds in his CCCS laboratory setup is about three times as expensive as the local market price for diesel in Indonesia.

Creative solutions

So what can be done? One obvious option is to use different, cheaper, inputs to produce the biodiesel. Yusuf has experimented with using ethanol instead of methanol as the alcohol for the biodiesel synthesis. While ready-made ethanol is more expensive than methanol, it is possible to produce it from local waste streams, which could reduce the costs and create new business at the same time. The idea itself is not new, as ethanol is already being produced from, for example, molasses, a waste product from sugarcane factories. But given that this research aims to devise small-scale, local solutions and technologies – which a sugar factory clearly is not – the suggestion is to use cassava that is also cultivated by the local people in their agroforests. The feasibility of producing ethanol out of cassava with local fermentation technologies has not yet been studied. However, Yusuf's lab experiments showed that using ethanol instead of methanol in the CCCS is definitely a go: it gives a faster reaction and thus higher production, and even a higher yield of biodiesel. And there is a bonus as well: using ethanol made from local biomass produces even 'greener' biodiesel.

Feeding the fungus

There is yet another input that can be worked on to reduce the costs of the biodiesel synthesis: the

catalyst. The chemical catalysts commonly used for the commercial production of biodiesel are expensive. Certain enzymes are also known to do the job and have several advantages, such as a lower energy consumption due to a lower reaction temperature, a higher purity of the glycerol by-product, and a simplified production process with no need for the biodiesel to be washed and purified. However, enzymes are two to three times more expensive than chemical catalysts – so at first glance that does not seem too helpful. And yet it may be, says Miftahul Ilmi, a biologist trained at the Gadjah Mada University in Yogyakarta. In his doctoral research, conducted at both the University of Groningen and his home university lab, he is experimenting with producing enzymes using cheap and easily available local waste. If it works, there will be a double advantage: firstly, producing enzymes locally and from local waste streams will reduce the cost and secondly, similar to using ethanol, using a natural enzyme instead of a chemical catalyst produces 'greener' biodiesel. Ilmi has been using the press cake that remains after extracting the oil from nuts and seeds to 'grow' enzymes. A layman's explanation of the chemical process is as follows: Enzymes are produced by fungi. Fungi need to eat. There are different foods, called substrates in the lab, that may be suitable for them and Ilmi has been investigating whether the fungi think the press cake from the rubber seed and jatropha fruit make a good meal.

The results so far are positive: the fungi 'eat' the rubber seed and jatropha press cake. Ilmi found out that, when he pre-treats the press cake by giving it a 45-minute bath in sodium hydroxide, it clearly becomes even more 'tasty': the fungi move into overdrive and the production of enzymes is quadrupled. So in theory, enzymes can be produced using local waste. But how do the enzymes perform as catalysts? According to Ilmi, "they are a little slow". Where a chemical catalyst needs about 20 minutes to help synthesize the pure plant oil to crude

biodiesel, Ilmi's setup in the lab with his 'homemade' enzyme took about two hours. The yield was the same, but the slowness is a problem. Time, after all, is money. "The process needs optimizing," says Ilmi. And he has identified one possibility to explore: if the enzyme can be recycled in the CCCS setup, something that is not possible with chemical catalysts, this would significantly reduce the cost.

Plenty seeds

Yusuf and Ilmi hope that the work they have done in the past few years will come to benefit their fellow citizens in Kalimantan's Ex-Mega Rice area. They are convinced that the technology itself is easy enough for local communities to use, but realize that implementing a mobile biodiesel factory will present a few challenges of its own (see the article in this publication on the work done by Ad de Leeuw). Meanwhile they will return to their home universities to teach and continue their research. What are they looking forward to? Always having plenty of rubber seeds within reach to keep on experimenting.

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PROTEIN FROM RUBBER SEEDS

Promoting local livelihoods and a biobased economy

What is commonly considered agricultural waste may have unexpected value. The protein extracted from the seeds and leaves of the rubber tree can be used by farmers in Indonesia as animal feed or fertiliser. Advanced research shows that the same protein may also provide building blocks for a biobased chemical industry. One day, some of our plastics may be made from rubber seeds.

The Pará rubber tree (*Hevea brasiliensis*), indigenous to the Amazon rainforest, was introduced to Southeast Asia in the late 19th century. Today, Indonesia is the world's second largest natural rubber producer. Rubber is made from the milky latex harvested by making incisions in the bark just deep enough to touch the latex vessels that spiral up the rubber tree. At least 80% of all rubber production in Indonesia depends on smallholders who sell the latex harvested from their agroforests and small plantations to processing plants, with only 20% coming from large rubber plantations. Prompted by this fact, researchers from Indonesia and the Netherlands decided to explore whether the rubber

tree also provides other products that can help improve the livelihoods of the rubber tappers and their families and boost the local economy in Central Kalimantan. Two doctoral students from Indonesia are studying the viability of a small-scale technology to produce biodiesel from the seeds of the rubber tree, which smallholders currently do not use (see the article in this publication on the research conducted by Mohammad Yusuf Abduh and Miftahul Ilmi). Widyarani, doctoral student at Wageningen University, is investigating the usability of other waste streams from the rubber tree.

Protein

When oil is extracted from rubber seeds using a hydraulic press, a beige-coloured solid substance remains. This dry and brittle press cake – rich in protein, minerals and fibre – can be mouldered and used as organic fertiliser on people's farms. But is there not even more value to be extracted from it? According to Widyarani, "around 20% of the press cake of rubber seeds consists of protein. If we manage to extract and use this protein, the cake might become more valuable." The extracted protein could be used locally as an additive for animal feed or fertiliser. Widyarani's research suggests that it can also be used for technical applications such as glue or as an emulsifier for food processing. Protein is indeed increasingly seen as an



Enzyme synthesis using protein-rich residues from seed expellers (by Miftahul Ilmi)

WE CAN START TO MAKE ECONOMIC USE OF PARTS OF THE TREES THAT UP TO NOW HAVE SIMPLY BEEN DISCARDED AS WASTE

important input for the production of all kinds of biobased products, not least biobased chemicals. In R&D labs around the world, researchers are busy developing technologies for the efficient extraction of protein from different biomass sources. In the Netherlands, a first mobile grass refinery plant is piloting with extracting proteins from grass – to eventually replace soy as primary ingredient for cattle feed – while the left-over grass fibre can be used in the paper industry. A colleague of Widyarani from China, who shares her lab in Wageningen, is experimenting with extracting protein from green tea leaves – a promising technology for the world’s largest tea producing country.

Widyarani focused her research on finding the most efficient method for extracting protein from waste streams of the rubber tree. She started with the press cake that remains when oil is pressed from the rubber seeds, experimenting with press cakes obtained at different pressing temperatures. She also tried using the entire rubber seed kernel without first removing the oil. The latter proved to make no difference in terms of protein yield, but the simultaneous extraction led to a lower oil yield, and so this method was abandoned. The outcome of Widyarani’s experiments is a three-step process. First, the press cake of the rubber seeds is

submerged in a bath of water and an alkaline is added, which extracts the protein from the cake. The result is water containing protein and a solid residue. Second, the residue is removed and acid is added to the water to precipitate the protein. This produces water with a deposit of protein. Third, the protein is taken out and freeze-dried. The end product is a protein substrate that looks like a light brown, coarse powder. The solid residue formed in step one contains fibre and a little remnant of protein, and can be used as cattle feed or fertiliser, or made into briquettes.

Protein is present not only in the press cake of the rubber seeds, but also in the latex, the bark of the tree and the leaves. Removing protein from the latex is a complicated process and unlikely to be feasible on a small scale; removing it from the bark will not be economical because the protein content is very low and the rubber tappers remove only a few grams of bark each day. But the leaves offer an opportunity. Grinding the leaves, adding water and then pressing the mixture produces a green juice. When this liquid is heated, flocks of protein appear. These can be filtered out and dried to make the same protein powder as from the press cake. The remaining residue of ground leaves can in theory be used to produce ethanol.

Love of the local

A key element of Widyarani’s research is that the technologies can be used on a small scale: the objective is a local biorefinery at village level and the farmers and rubber tappers should be the primary economic beneficiaries. From an environmental perspective too, and especially given the bad roads in large parts of Kalimantan, it would not make sense to transport the biomass to a factory and then the final product back to the villages. “Moreover,” says Widyarani, “biomass always contains a lot of water; for rubber seeds this is at least 20%. Transporting biomass to a processing

factory several hours away for this reason alone would be inefficient if you think of the fossil fuel used. Moreover, factories discard the waste water, while local people can reuse it to irrigate their farms.”

Widyarani is optimistic about the potential of her protein extraction technology for local communities in Central Kalimantan. “The lab equipment we use is not available in the villages where the rubber tappers live,” she says. “But with a few modifications in the process, the principle can certainly be applied.” Farmers can use a hammer to break up the brittle rubber seed press cake into small pieces. They then add water with an alkaline, for instance sodium hydroxide, which can be bought locally. Although a centrifuge is used in the lab to separate the protein extract from the solid residue, Widyarani suggests that the extract can also be filtered through a piece of cloth. After adding acid to the extract, they can leave it to settle for one night in a closed container, and then filter out the precipitated protein using another cloth. “The farmers are familiar with using certain chemicals for the rubber tapping and production process,” says Widyarani. “It will not be too hard to find out which alkalines and acids are safe to use and available from the local shops.”

Towards a biobased economy

Widyarani would be enormously pleased if farmers in Kalimantan’s Ex-Mega Rice Project area were to apply her research results. But her ambitions go beyond that. “We cannot rely on fossil fuels forever and Indonesia would thus be smart to make a start developing a biobased economy as soon as possible,” she says. Indonesia indeed appears well placed to take on the challenge, considering the significant biomass waste streams from both smallholder and plantation agriculture that are readily available. “The best thing about using the seeds of the rubber tree for making biodiesel and extracting protein is that we are

not asking farmers to plant them specifically for this purpose – as has been the case with *jatropha*,” says Widyarani. “The trees are there already, and we can start to make economic use of parts of them that up to now have simply been discarded as waste.” This reflects the core mission of Widyarani’s research group at Wageningen University: to explore the possibilities of using cheap resources of agricultural waste as a raw material for the chemical industry or to be used locally. The vision of the Biobased Chemistry and Technology group is that renewable biomass will eventually replace crude oil, not only for fuel but also for the production of plastics, synthetics and other chemical products.

Biobased chemicals are made from sugars, fats, oils, lignin – and proteins. This is what Widyarani calls “the more challenging part” of her doctoral research: to explore the possibility of using the protein extracted from rubber seeds as a building block for producing biobased bulk chemicals. Proteins are large molecules that consist of chains of amino acids. “We want to break up the protein into its building blocks, preferably into single amino acids,” Widyarani explains. “If I manage to do that, it will be like finding my own holy grail.” It is not that it is not yet possible to break up (in scientific terms: hydrolyse) the protein into single amino acids; it is about the way in which it is currently done.

Widyarani

Widyarani holds a Bachelor’s in Environmental Engineering from the Institut Teknologi Bandung and an MSc in Environmental Sciences from Wageningen University. She is a member of staff at the Research Centre for Chemistry, Indonesian Institute of Sciences, in Bandung. Her PhD research at Wageningen University focuses on protein biorefinery from biofuel waste streams.

A lot of chemicals are used for the reaction, which moreover takes place at a very high temperature of 110 degrees Celsius. Widyarani's aim is to find a more sustainable hydrolysing process, reducing the input of chemicals and the energy needed for heating. "If we can find a clever and sustainable way to hydrolyse the protein extracted from the rubber seed press cake into amino acid building blocks," she says, "this can then be applied to the press cakes of other seeds such as jatropha or palm kernels." Making biobased building blocks for the chemical industry out of all sorts of biomass that Indonesian farmers currently consider agricultural waste will contribute to the vision of establishing a sustainable national biobased economy – in Indonesia or anywhere.

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Rubber seed drying with locally made equipment (by Ad de Leeuw)

FROM LABORATORY TO VILLAGE

The challenges of implementing biodiesel technology in Kalimantan

Developing new technologies in university labs is one thing – implementing these innovations on the ground in Indonesia is an entirely different ball game. The benefits of producing biodiesel locally from agricultural waste may be indisputable, yet research found that the first challenge comes with simply collecting and storing the rubber seeds.

“You would think there is a war going on. Pang! pang!” This is how Ad de Leeuw describes walking through the agroforests of Central Kalimantan when the seeds of the rubber tree start falling. The three-lobed seedpods hanging from the branches ten metres up split open at the seams and the sudden release of tension launches the seeds like bullets away from the tree. “It’s a startling noise,” says De Leeuw. “And it goes on for weeks.”

Rubber seeds collected from these agroforests were used by the researchers at the University of Groningen and Wageningen University & Research centre to

experiment with ways of making biodiesel and extracting protein from the press cake (see the articles in this publication about the research conducted by Mohammad Yusuf Abduh, Miftahul Ilmi and by Widyarani). And it is in the villages near these forests that their results are intended to make a positive impact. A successful translation from lab to village, however, is anything but self-evident. Tim Zwaagstra, coordinator of the Breakthroughs in Biofuels cluster at the University of Groningen, explains: “When it comes to implementation, there are many issues that our researchers have no answers to. For instance, what technologies are locally available, where and how do we collect the rubber seeds and at what price, are people interested at all in using rubber seed oil as a source of energy and if so, are there local entrepreneurs willing to take on this innovation?” Consequently, Ad de Leeuw, who has lived and worked in Indonesia on and off for the last 25 years, was hired to investigate whether the proven lab technologies stand a chance of being successfully adopted by people in Kalimantan’s Ex-Mega Rice Project area.

Waterland

De Leeuw chose to focus on three villages in the Ex-Mega Rice Project area. Buntoi, Bawan and Pilang are all within a three-hour car drive from Palangkaraya,

the provincial capital of Central Kalimantan where the university participating in the research is located. De Leeuw's task was to find out whether the idea of the researchers at the University of Groningen of building a 'biodiesel factory on wheels' – a 20-foot container fixed to a lorry – was a viable proposition. He did not need

Ad de Leeuw

Ad de Leeuw works as consultant for the University of Groningen. He has worked in Indonesia for prolonged periods of time in the past 25 years. First as a sales manager for Olivetti Indonesia and General Manager of Solna Indonesia, and later as Director of PaperNet Indonesia. Between 1999-2007 he was Director of the Netherlands Education Centre in Jakarta. His involvement with the Agriculture Beyond Food programme focuses on exploring the possibilities for implementing small-scale biodiesel technology in Central Kalimantan.

Bartjan Pennink

Bartjan Pennink is a senior lecturer in Global Economics and Management at the University of Groningen, and project leader for Ad de Leeuw's field activities. With ITB, Nuffic and Bappenas, he has executed numerous projects supporting Indonesian communities in less developed areas in developing their own business plans and working them out for their own situation. In connection with ABF he supervised several Master's students' theses and elaborated on some of them for scientific publications. He has developed a multi-level actor model for the description of local economic development, and has worked on ideas of social franchising with Prof. Simatupang and Dr. Siswanto of ITB in this context.

to think about the 'on wheels' option for very long: "The area is a waterland. There are barely any roads. Transport follows the rivers and the canals that were dug to irrigate the rice paddies that never materialized." And he adds: "Personally I believe these canals were dug to transport wood that was logged illegally." Whichever is the case, the biodiesel factory will have to be fixed to a boat, not a lorry. Another, more urgent question was where, when and how can we collect the rubber seeds? And secondly, what technologies are available and feasible for conditioning the fresh seeds and extracting the oil?

At the first crack

"When we started, we knew next to nothing about the rubber seeds," says De Leeuw. "The indigenous Dayak farmers do not use them, so the seeds are left to rot or germinate – or are eaten by wild boars and monkeys. We didn't even know when exactly the seeds fall off the trees, the pattern appeared to be irregular." Online research taught De Leeuw that the intensity of solar radiation is an important factor. The bright, intense sunshine around the time of the September equinox, when the sun crosses the equator, flips a proverbial switch on the rubber tree and it starts flowering. About five months later, the seedpods crack open.

De Leeuw grew up in the woods near the Dutch town of Breda, where as a young boy he collected acorns and blueberries to sell. It gave him a love of the forest and some early business intuition too, but collecting rubber seeds in Central Kalimantan is a totally different ball game. Because the local people do not use the rubber seeds, there is no infrastructure for collecting them. "You might assume that the men who go off into the forests every day to tap latex from the rubber trees might just as well pick up some seeds on the way," says De Leeuw. "No way! For the Dayak, collecting seeds and fruits is not a men's job, so it means an additional

task for women or children – which might not be so bad in this case, as it can earn them some money.” De Leeuw was chatting to some people by the roadside and asked whether they would be willing to sell him one kilogram of rubber seeds for 1,500 rupiah, roughly equivalent to 10 eurocents. Before the conversation was over, a group of children appeared from the forest and handed him a plastic bag full to the brim with seeds.

De Leeuw took that as a tentative go-ahead and set a target: to organize the collection of 1,000 kg of seeds to try and obtain 200 litres of pressed rubber seed oil. In each of the three villages, one person was appointed to manage the collection and storage of the seeds. De Leeuw knew that, at the first crack of a seedpod, collecting the seeds would have to start at once. “When the seeds have just fallen they have this beautiful wax-like shine like freshly polished shoes,” he says. “Leave them a few days, and the shine is gone. The moisture enters the seed and soon you will see a rootlet coming out; leave it a bit longer, and you have a rubber tree in the making!” He knew this, and yet the first harvest of the seeds in March 2014 still came just a little too soon.

Drying the seeds

Treating the rubber seeds is perhaps the biggest challenge – especially when this has to happen at minimum cost in a remote village in Central Kalimantan. To extract the protein, it is sufficient to leave the seeds to dry in the sun for a week. However, to retrieve a reasonable amount of oil from them, the rubber seeds need to be dried continuously at around 60 degrees Celsius for at least 24 hours. There are no ready-made ovens for this. And so De Leeuw started experimenting. He taped two cardboard boxes used for packing cigarettes to each other and fixed an electric heater at the bottom to blow in warm air and a ventilator at the top to draw it out again. He then filled the boxes with the rubber seeds and it worked perfectly. “A cardboard

WHEN THE SEEDS HAVE JUST FALLEN THEY HAVE THIS BEAUTIFUL WAX- LIKE SHINE LIKE FRESHLY POLISHED SHOES

box costs 60 eurocents,” says De Leeuw. “You can fold it up and carry it with you on the back of a motorcycle. We had designed a truly local, mobile oven!” That was the proof of principle ticked off, but when he was handed 1,200 kg of seeds sooner than expected, there was a slight hiccup: the electric heaters were sold out. It was a weekend, so to avoid losing the first precious harvest to humidity, the seeds were spread out along the corridors of the university building. The same day De Leeuw flew from Palangkaraya, via Surabaya on Java, to Balikpapan to buy the heaters – an 18-hour round trip.

The next logistical problem ironically proved to be the local need for the rubber seed oil as a source of energy: the electricity supply in the selected villages was not sufficient to allow the self-made ovens to run for 24 hours. But with some perseverance five cardboard box ovens were eventually drying the seeds, three at the university and two at a local metal workshop. By late March, 780 kg of dried rubber seeds were stored in watertight tanks. A seven-kilo bag of seeds was then sent from Tjilik Riwut airport in Palangkaraya, via Sukarno Hatta airport in Jakarta, to Schiphol, to be taken the last few kilometres to the University of Groningen on the carrier of De Leeuw’s bicycle.

Oil press

In Indonesia, a Chinese press used for retrieving oil from the jatropha fruit can be bought for a few thousand euros. However, De Leeuw's task is to find a truly local technology that is affordable for the Dayak farmers. In Palangkaraya, he experimented with using several hydraulic jacks transformed into oil presses with the help of the local metal workshop, where he became a regular customer. He tested the contraption on peanuts, and although oil did indeed come dripping out, it was clear that this technology would not work for larger quantities. At the Groningen lab, therefore, Mohammed Yusuf Abduh will help De Leeuw to find a suitable technology for extracting the oil from the seeds, using a German oil press bought by the university. De Leeuw is not too worried about this part of the technology. "It is a matter of patient experimenting," he explains. "Which screw works best, at what pressure, do we need to shell the seeds, cut them in pieces and of what size to increase the oil yield? All this we can work out; collecting and conditioning the seeds efficiently remains the bigger challenge."

Alternative income

De Leeuw's work has so far focused on the basics: developing the local infrastructure and technology for extracting pure plant oil from rubber seeds. The major next step is to study the feasibility of implementing a local, mobile biorefinery to make biodiesel out of this oil or extract the protein from the press cake. That is what the researchers in Groningen and Wageningen have devoted their doctoral research to. It will be a while, says De Leeuw, before the mobile biorefinery unit will be calling at the villages in Central Kalimantan. Meanwhile, a less sophisticated way of producing biodiesel can still be tried. "Put the filtered rubber seed oil in an empty water tank and add an alcohol," says De Leeuw. "Separate the glycerol in a settling tank, and there you have your biodiesel. I'm sure it will make a

motor run! We already tried running a simple diesel engine on the pure plant oil and it ran like clockwork." De Leeuw, is clearly not easily put off. However, he does emphasise that the Indonesian government needs to abolish its subsidies on fuel if any of this biodiesel business really is to make an impact.

And what do the local communities that have followed his efforts say? Are they interested in using the rubber seeds? If we are to believe Dr. Suwido Limin of Palangkaraya University, the answer is certainly yes. Limin, who has been involved with the Agriculture Beyond Food programme from the start, is a Dayak himself. He believes that anything that can provide additional sources of income for Dayak farmers and prevent them from selling their lands to investors who want to establish oil palm plantations is worth trying.

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THE VALUE OF RUBBER SEEDS

Conclusions from the Breakthroughs in Biofuels cluster

The government of Indonesia has launched various policies and programmes to stimulate domestic biofuel consumption. The government's focus is on the development of large production units, which mainly use the easily accessible palm oil as feedstock. In 2012, 26 large biodiesel factories were operational in Indonesia, producing 2,200 million litres on an annual basis. At the same time, there has been little attention to the possibilities of small-scale biofuel production in rural communities, using local waste products.

The objective of the Breakthroughs in Biofuels cluster was to explore the possibilities for developing small-scale biodiesel processing technologies that can be used in remote areas with limited infrastructure. With biodiesel produced from locally available oil seeds, people will be less dependent on importing expensive fuels from other parts of Indonesia. It will moreover stimulate local development by creating jobs and diversifying people's incomes. The research focused on the Ex-Mega Rice Project area in Central Kalimantan, where farmers who cultivate rubber trees in their agroforests tap and sell the latex for the production of natural rubber. However, the rubber trees also produce

an oil-rich seed with an estimated yield of 1000-1200 kg/ha/yr. This seed is currently treated as waste and to date there has been limited scientific attention for the possibilities to use and valorise the rubber seeds. The Breakthroughs in Biofuels cluster selected this seed as a possible source for producing biodiesel.

The first objective of the research was to design a small-scale, mobile technology for producing biodiesel from rubber seed oil, which would be particularly suitable for remote rural areas. At university laboratories in Indonesia and the Netherlands, researchers first of all established that rubber seed oil indeed has the potential to be used as a source for the production of biodiesel as well as for direct use in stationary diesel engines. The researchers designed an integrated lab scale unit for biodiesel synthesis, purification and drying, using continuous centrifugal contactor separator (CSSS) technology. This technology, which was originally designed for cleaning oil spills, integrates the reaction and separation of biodiesel production in a single device. The advantage is that it can operate continuously, as opposed to the conventional production process that requires different tanks for the synthesis, separation, washing and drying of the biodiesel. By optimizing CCCS technology, the researchers managed to obtain a higher biodiesel productivity (while maintaining the quality of the biodiesel) than when using the



A small-scale rubber seed expeller for use in remote areas (by Ad de Leeuw)

conventional technology. The properties of the biodiesel proved to be within the international quality standards. The conclusion is that CCCS technology has great potential for local, small-scale production of biodiesel. Its compact size, robustness and flexibility in operation are particularly relevant to local use in remote rural areas.

The researchers also investigated whether ethanol can be used instead of methanol to produce biodiesel and lab experiments led to a positive conclusion. The advantage of ethanol is that it can be produced by fermenting local biomass waste streams and as such is a 'green' alternative for methanol. Moreover, particularly in rural areas in developing countries, ethanol is more readily available than methanol.

The second objective of the research was to develop technologies for using by-products of local biodiesel production in order to enhance the economic value of the product chain. The press cake that remains after extracting the pure plant oil from the rubber seeds is the primary by-product. First, researchers experimented with producing enzymes from the press cake for use as a catalyst in biodiesel production. They obtained good results by optimizing pre-treatment methods of the press cake. This is relevant because using an enzyme produced from local waste produces greener biodiesel than when chemical catalysts are used. Secondly, researchers investigated the potential use of the protein that the press cake contains. This protein can, for example, be used to improve the soil structure, as cattle feed, or to reduce dependence on expensive fertilisers. But it can also be extracted for further processing into high value products, in particular biobased chemicals. For this, the protein, which is a large molecule, needs to be broken up into its building blocks. The researchers are developing a sustainable process for breaking up the protein molecules, using fewer chemicals and lower temperatures. The use of other by-products from the rubber tree has also been explored, and the

leaves in particular seem to have good potential for protein extraction. If it becomes possible to make biobased building blocks for the chemical industry out of agricultural waste, this will be an important step towards establishing a biobased economy.

Thirdly, the Breakthroughs in Biofuels cluster explored the possibilities for implementing the technologies developed and proven in the lab in rural areas around Palangkaraya, the provincial capital of Central Kalimantan. Within the project duration, it has not been possible to explore the actual introduction of innovative CCCS technology. Research therefore focused on the conditions for introducing simpler technologies, especially the application of pure plant oil extracted from rubber seeds. The research also looked into harvesting of the rubber seeds, which is an entirely new phenomenon as the seeds have always been considered a waste product and were left on the land. So far, the first 1,000 kilograms of rubber seeds have been harvested, along with a proverbial harvest of invaluable experiences relating to local possibilities and adversities. Experimental research into different pressing methods to extract the oil from the seeds, as well as the subsequent use of the oil for local power generation, is in progress. The local introduction of lab-proven CCCS technology as an option for a small-scale, mobile production unit will be explored in the future.

CLUSTER
JARAK



From a technical point of view jatropha is an excellent source for bio-fuel (by Roeland Muskens)

The commoditisation of an alternative biofuel crop in Indonesia

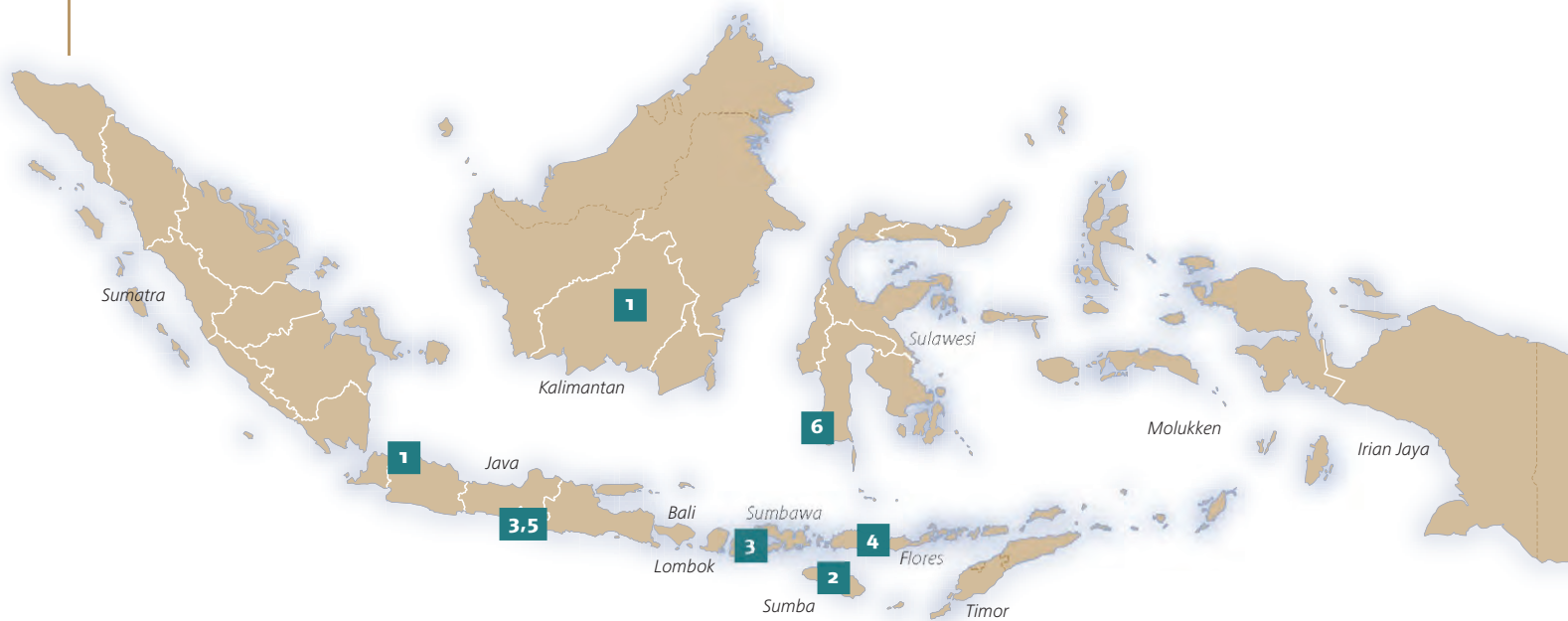
Jatropha (*Jatropha curcas*) promised much: clean non-fossil energy, and new income sources in marginal areas that grew the crop. This promise inspired million dollar investments in plantations – in Indonesia and elsewhere – and plans for many more. In only a few years *jatropha*, an ordinary hedge plant known as *jarak pagar* in Indonesian, was turned into a valuable commodity for energy production. The JARAK research cluster aimed to build a scientific knowledge base to enable these claims to be objectively addressed. It traced the rise of *jatropha* as a commercial crop in Indonesia, assessing the assumptions underlying its introduction, investigating the production potential in Indonesian circumstances, and identifying how legislation, governance and policies support local producers' livelihoods. More abstractly, JARAK studied how innovations for 'agriculture beyond food' induce commoditisation, making local producers core actors in addressing worldwide problems, and in turn exposing them to both livelihood opportunities and threats.

JARAK combines research in three domains: legal environment and governance, socioeconomic aspects, and plant production. The researchers wanted to understand how the rise of *Jatropha curcas* could be explained, and whether the claims underlying this introduction were well-founded. They also studied how these claims were transformed into laws and

policies, how these were implemented, and the extent to which this was in accordance with the rule of law. Another area of study addressed the socioeconomic

Institutions involved

- The Van Vollenhoven Institute for Law, Governance and Development, Leiden Law School, Leiden University (lead institution)
- Institute of Cultural Anthropology and Development Sociology, Faculty of Social and Behavioural Sciences, Leiden University
- Faculty of Social and Political Sciences, Gadjah Mada University, Yogyakarta
- Centre for Anthropology Studies, Department of Anthropology, Faculty of Social and Political Sciences, University of Indonesia, Jakarta
- Research Center for Biological Resources and Biotechnology, Bogor Agricultural University, Faculty of Law, Universitas Parahyangan, Bandung
- Plant Research International and Plant Production Systems, Wageningen University & Research Centre
- Royal Netherlands Institute of Southeast Asian and Caribbean Studies, Leiden
- International Institute for Asian Studies, Leiden



Research projects

- 1** Information flows in jatropha commoditisation (postdoc, Suraya Afiff)
- 2** Domestic policies, large scale investments and land use schemes (postdoc, Jacqueline Vel)
- 3** Agronomic aspects of jatropha development in Indonesia Gunung Kidul, (PhD study by Juliana Tjeuw, under the supervision Prof. K. Giller, Dr. M.A. Slingerland, Dr. R. Jongschaap and Prof. S. Suharsono)
- 4** Socio-legal and governance issues of jatropha in Flores (PhD study by Loes van Rooijen, under the supervision of Prof. J.M. Otto, Ir. J.A.C. Vel and Prof. K. Soetoprawiro)
- 5** Farmers' perceptions and labour relations in Gunung Kidul (PhD study by Gunawan, under the supervision of Prof. P.M. Laksono and Dr. P. Semedi)
- 6** Farmer-business collaboration in South Sulawesi (PhD study, Henky Widjaja under the supervision of Prof. G.A. Persoon and Dr. J.A.C. Vel)

Location

- Jakarta, Central Kalimantan
- Sumba
- Gunung Kidul, Yogyakarta and Sumbawa Besar
- Sikka, Flores
- Gunung Kidul, Yogyakarta
- Makassar, Sulawesi

and ecological consequences of the commoditisation of jatropha and the prospects for sustainable and feasible jatropha cultivation.

After the JARAK research cluster was initiated, in 2010, it became clear that virtually all jatropha projects faced a structural problem: the reality of jatropha did not live up to its optimistic official promotion. The research responded to this by also investigating questions relating to the causes of the jatropha hype and the reasons for its sudden decline.

Field research was conducted in areas where jatropha plantations had been planned or were already in operation: the relatively dry areas of eastern Indonesia (Sumba and Flores), operational sites in Yogyakarta province and South Sulawesi, and logged-over forests in West Kalimantan. Jakarta and other big cities were sites for field research among policy-makers and investors. Agronomy research took place in Central Java and Sumbawa. Additionally, JARAK carried out four more thematic post-doctoral studies with a focus on historical and comparative research (externally funded by KITLV and IIAS).

Postdoc fellowships in the JARAK cluster

IIAS postdoc fellowship:

- Dr. Denyse Snelder (CIS Centre for International Cooperation, VU University Amsterdam): "Jatropha on marginal lands: case study Philippines"

KITLV postdoc fellowships:

- Dr. Deasy Simandjuntak (Royal Netherlands Institute of Southeast Asian and the Caribbean Studies, Leiden): "How to sell a dream: An ethnography of international brokerage in Indonesia's jatropha industry"
- Dr. John McCarthy (Crawford School of Public Policy, Australian National University, Canberra): "Comparing trajectories of agrarian change emerging around jatropha, sugar and oil palm in Indonesia"
- Dr. Marleen Dieleman (National University of Singapore- Business School): "Unraveling the role of business stakeholders in Jatropha biofuel production"
- Dr. Tristram Moeliono (Faculty of Law, Parahyangan University Bandung): "Analyzing regulatory frameworks for biofuel policy and alternative approaches from socio-legal research"



Jatropha – from green gold to taboo (by Loes van Rooijen)

UNRAVELLING THE JATROPHA HYPE

The rise and fall of a super crop

The recent history of biofuel crop jatropha has been a roller coaster: in just a couple of years it has evolved from 'green gold' to 'something of a taboo'. Suraya Afiff studied the rise and fall of jatropha in Indonesia. Why did so many experts turn a blind eye to the critics? And what are the dangers of the current negative vibrations around jatropha?

Less than ten years ago jatropha was globally considered a biofuel super crop: the solution to the energy problem, the climate problem and rural poverty; three solutions in one unsightly shrub. Globally, millions of dollars were invested and millions of hectares of land were projected for jatropha cultivation. Programmes were set up for jatropha-kerosene as a renewable jet fuel, to use jatropha for local development, to provide local energy companies with jatropha-based biofuel... the possibilities seemed endless.

A couple of years later it was over. Most jatropha projects were wound up; the results were not as good

as predicted, yields were disappointing, and marketing proved difficult. Now, only a few jatropha initiatives remain.

The rise and fall of jatropha was a typical hype-disappointment cycle, says Suraya Afiff, head of the Center for Anthropological Studies at the Department of Anthropology, University of Indonesia, and post-doc researcher at the Royal Netherlands Institute of Southeast Asian and Caribbean Studies (KITLV) in Leiden, the Netherlands. In a recent article for the journal *Sustainability* Dr. Afiff meticulously unravelled the rise and fall of jatropha as the prime candidate in the Indonesian quest for renewable energy.

Quick fix

A front-page story on the potential of jatropha in the well-respected national newspaper *Kompas* on 15 March 2005, can be considered the starting point for the jatropha hype in Indonesia. The article appeared in the middle of a national energy crisis. Oil prices on the world market had doubled in only a few years, making the national subsidies on fossil fuel all but unaffordable for the national government. When jatropha was heralded as a 'quick fix' for the energy crisis, it was soon met with public euphoria. In her article, Afiff presented a simple diagram to visualise the jatropha-hype.

Counting the number of articles mentioning 'jatropha' in *Kompas* between 2004 and 2012, the diagram showed a sharp rising line from zero articles in 2004 to 28 in 2005 culminating in a maximum of 60 in 2006. After that the decline set in, with 33 articles in 2007 and the line never rose again above fifteen. In 2012 only one article mentioned the former 'green gold'. Jatropha was publicly pronounced dead.

The strongest early advocates for jatropha in Indonesia can be found in the Bandung Institute of Technology (ITB), Afiff explains. The key figure was Dr. Tatang

Soerawijaya, a professor of chemical engineering technology who headed the Center for Research on Energy at ITB. From the early 2000s onwards Soerawijaya and his team were well received in Indonesian policy circles, leading to the establishment of the Indonesia Biodiesel Forum (IBF). Headed by Soerawijaya, the IBF consisted of government officials, academics, journalists, entrepreneurs and other stakeholders interested in biodiesel issues. The discussions about jatropha had raised expectations of national energy independence. As Afiff writes in her article, "jatropha became a symbol of national self sufficiency in energy."

Growth, development and production of *Jatropha curcas L.* in Indonesia

The JARAK cluster included agronomic research on jatropha plant and production systems by PhD researcher Juliana Tjeuw. Tjeuw investigated jatropha in monoculture, intercropping and hedge systems. She studied how plant parameters above and below ground (such as the stem base diameter and the proximal root diameter) relate to seed yields in different jatropha production systems. She explored various intercropping scenarios using maize as a test crop, and compared seed yields in relation to different management strategies. She also experimented with the use of jatropha leaf mulch as a source of organic nitrogen, canopy pruning to reduce above ground competition, and root pruning to reduce below ground competition. With her results she will be able to show the extent to which above and below ground competition in intercropping systems results in yield trade-offs. The results will provide yield predictions for different jatropha production systems, which will help farmers to choose the most profitable management practices.

Another name worth mentioning is that of Dr. Robert Manurung, a chemical engineer who received his PhD from Groningen University in the Netherlands. Manurung, also from ITB, made Indonesian public and government institutions more receptive to the possibility of using jatropha oil directly as an alternative fuel, without the complex treatment needed to convert it to biodiesel. His main interest was to find solutions for affordable fuel for power generation in remote areas. Manurung had close contacts within the Indonesian government, including the Minister for Research and Technology at that time, who was also an ITB graduate. Through these contacts jatropha – and other biofuel solutions – quickly became the focus of a national effort, leading to the 2006 National Energy Policy. This policy mandated that biofuel should account for 5% of the total national energy supply in 2025.

For the Indonesian public the jatropha hype really caught on after the National Geographic magazine in Indonesia covered (and sponsored) an expedition in 2006 where three cars fuelled with jatropha oil drove all the way from Atambua in the eastern province of East Nusa Tenggara to the capital Jakarta, a distance of 3,200 kilometres. In Jakarta the expedition was received by president Yudhoyono, who held an enthusiastic

JATROPHA HAS BECOME SOMETHING OF A TABOO: NOBODY WANTS TO BE ASSOCIATED WITH IT ANYMORE

speech about the seemingly limitless possibilities of jatropha. “This PR campaign really won the public over for jatropha,” Afiff says. “Unfortunately the people involved – scientists included – had little eye for the nitty-gritty.”

Reversal

After reading countless articles, seminar reports and presentations from that period, Afiff came to the conclusion that the scientists, policy-makers, entrepreneurs and journalists had been blind to the disadvantages and objections. “There were people who pointed at the scanty track record of jatropha and who came up with less favourable reports,” she says. “But these critical voices were quickly set aside, as officials, scientists, journalists and entrepreneurs were too excited with the myth of the potential future of the crop.”

Very soon after the jatropha hype had reached its peak, in 2006, a reversal set in. Already by the end of 2006, the first reports were heard from disappointed farmers. They complained about the limited assistance they received from government institutions. Moreover, for the first time, a government official publicly admitted that the productivity of jatropha was only

1-2 tonnes of seeds per hectare; a lot less than the 7 tonnes predicted at the height of the hype. From 2008 onwards the tone of media coverage on jatropha had changed profoundly. *Kompas*, for example, reported a growing number of jatropha projects failing and farmers complaining about the low price paid for the seeds and not being able to sell their produce. Farmers were quoted as saying they had cut down their jatropha trees as they were unprofitable. It also became clear that, although the shrub did survive as promised under harsh circumstances, without water and other inputs, it produced only a few nuts – not nearly enough for a profitable harvest.

Suraya Afiff

Suraya Afiff is post-doc researcher at the Royal Netherlands Institute of Southeast Asian and Caribbean Studies (KITLV) in Leiden, the Netherlands. Before obtaining her PhD degree from the University of California at Berkeley, she worked between 1988 and 1994 at WALHI (the Indonesia Forum for the Environment/Friends of the Earth Indonesia), one of the major national environmental groups in Indonesia. Since 2005, she has been teaching at the graduate programme at the Department of Anthropology, Faculty of Social and Political Sciences at the University of Indonesia. Since 2007, she has also served as head of the Center for Anthropological Studies at the University of Indonesia. She is interested in issues relating to the politics of the environment in Indonesia. Her recent research focuses on land tenure issues, land and natural resource conflicts, climate change, forest governance, environmental and agrarian movements, and community-based management.

Soon after that, the jatropha hype turned into its opposite: a negative hype. “Jatropha has become something of a taboo,” says Afiff. “Nobody wants to be associated with it anymore. Former advocates of jatropha solutions are as quiet as the grave nowadays. They don’t want it to be remembered that they ever promoted the shrub. Getting funding for new jatropha initiatives or for plant breeding research is almost impossible.”

Source of innovation

Hypes, however, are not only a bad thing. Of course, governments, investors, funding agencies and farmers wasted their time and money. And, of course, jatropha did not live up to its expectations. But, says Afiff, hypes are also a powerful source of innovation: “During a hype, a lot of money and energy is available, providing opportunities to experiment, to test and to learn. In only a few years, we have learned a great deal about jatropha, and about the possibilities and limitations of biofuels. Without the hype, that would have taken much more time. We know that jatropha produces excellent oil that is easily extractable. Technically it offers a great deal of options. But we also know that, in present circumstances, profitable exploitation of jatropha is problematic. There may be a future for jatropha as a high-value niche product. In any case work needs to be done on the plant itself, for example raising the productivity per hectare, augmenting the oil content and detoxifying the nuts.”

A major lesson, concludes Afiff, is that policy-makers, scientists and practitioners should keep an eye open for limitations when pursuing an innovation. “In each development, each project and policy decision there must be ample room for criticism,” she says. “The people involved should view their work from different angles; not just focus on technical possibilities, but also on the economic, social and cultural dimensions.”

Even during a hype, projects must be grounded on real, solid research, not on mere assumptions. Suraya Afiff formally concludes in her article that “engineers need to seriously consult other qualified experts to further assess the applicability of the technology in society”, and that they should also pay attention to what the proposed users themselves think about the new technology.

As for the negative vibrations now surrounding jatropha, they create the risk of the baby being thrown away with the bathwater. The biggest danger is that this will prevent researchers from working steadily on new energy solutions for local communities.

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JATROPHA FOR ELECTRICITY?

Unbridgeable obstacles

In theory it seems very logical: allowing energy supply and demand to meet at local level. Locally produced jatropha oil appeared perfect to meet the energy needs of local electricity companies. Why did it prove to be much more complicated in practice?

Fast economic development has its own limitations. Take, for example, energy use. Demand for electricity in Indonesia rises annually by more than 7% and the growing middle class wants a reliable electricity network. In the early 2000s, the national electricity company, PLN, realised that current conventional energy resources (mainly coal and diesel) would not be able to meet this growing demand for energy. Moreover, concerns about pollution and climate change forced PLN to look for more sustainable energy sources. PLN's second policy goal was to increase the rural electrification rate, i.e. find means to provide access to electricity for people in remote areas that have not yet

been connected to the electricity grid. The plan was for at least 90% of the population to have access to electricity by 2020. However, it will not be easy to meet that target, and complete electrification remains a distant dream. Many households lack access to the electricity grid, especially on the 16,000, often isolated Indonesian islands outside Java and Sumatra. On the eastern island of Sumba in the province of Nusa Tenggara Timur (NTT), for example, until recently only 30% of households had access to electricity.

In the early 2000s jatropha was promoted as a very suitable and renewable alternative to fuel the diesel-powered generators that provide electricity on the Indonesian archipelago. Especially in the dryer islands in NTT, jatropha was expected to grow well. There already was a lot of jatropha on the island, growing as a wild shrub in the coastal area, or planted as a fence to protect garden vegetables from pigs and goats. The shrub needs little water and few other inputs to survive, and makes good fencing. It is therefore no wonder that farmers and local entrepreneurs were enthusiastic when they heard that jatropha could be a valuable cash crop for energy production.

After the Indonesian president approved the National Energy Policy in 2006, government funding and assistance became available for local jatropha projects.



Access to electricity for small business: cell phone charging service and selling refrigerated food, Sumba (by Jacqueline Vel)

500 RUPIAH PER KILO WAS NOWHERE NEAR ENOUGH

JARAK researcher Jacqueline Vel studied the rise and fall of such projects on the island of Sumba. Among them was an initiative by a local employee of the national electricity company PLN, who saw the opportunities. Intrigued by the sustainability challenges facing PLN and the possibilities of jatropha, he started a project to encourage local farmers to grow jatropha to feed into PLN diesel generators. The first concern was if the jatropha oil could safely be blended into the diesel used for the generators without jamming the engine or leading to less than perfect combustion. After some tests this proved not to be a problem: jatropha oil was of sufficient quality. From a technical point of view jatropha was an excellent solution. Given the interest PLN showed for the product, its good relations with a network of farmers and the availability of a jatropha press, success seemed at hand.

There was however one obstacle that proved unbridgeable. Calculating back from the price that PLN could offer for one litre of jatropha oil, taking into account minimum costs for transportation, processing etc., and based on the oil content of the local jatropha variety (no more than 20%), the farmers could only be paid 500 rupiah (3 euro cents) for each kilo of seeds. They found this unacceptable. They knew how much work was involved in producing the seeds: they had to sow the seeds, tend the plants, pick the nuts and crack the husks, all by hand, and 500 rupiah per kilo was nowhere near enough. Despite frequent assumptions to the contrary, the labour of marginal farmers does not come free of charge. As a result, the project was soon discontinued.

The lesson was clear: economic viability is a necessary precondition for an innovation to succeed. Farmers will only produce biofuel crops if it offers them a clear and reliable profit. Another reason why the appealing idea of jatropha for electricity turned out to be much more complicated in practice was the nature of the electricity company. PLN organises the electricity supply on the island. It is the largest diesel importer on the island, with long, well-established relationships with the state oil company and the industry that produces generators. PLN is not a biodiesel processing company; it could buy readymade biodiesel, but other companies and traders would have to take responsibility for the production and services that link farmers' jatropha seed production to the PLN's electricity generators. Successful jatropha-for-electricity projects require a well-established supply

Jacqueline Vel

Jacqueline Vel is a researcher and coordinator of the JARAK cluster. She worked for six years in a grassroots rural development project in Sumba (NTT), Indonesia. She obtained her PhD degree from Wageningen Agricultural University in 1994, and was researcher/lecturer at the University of Amsterdam (Asian Studies) between 1998 and 2006. Since 2006 she has been a researcher at the Van Vollenhoven Institute for Law, Governance and Development at the Leiden Law School, Leiden University. Her publications in social and social legal science focus on Eastern Indonesia, and on the themes of land rights, natural resources, democratisation, local politics and rural development. Several articles and a translation of her PhD thesis have been published in Bahasa Indonesia. For the NGO Hivos she conducted a study on the potentials for cultivating crops as feedstock for energy production in Sumba.

chain and that did not yet exist in Sumba. Subsequently, PLN opted for other sources of renewable energy (see box). The success of jatropha projects thus depends not only on the performance of alternative crops and farmers' decisions, but also on alternative sources of renewable energy.

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PLN goes solar

PLN has now abandoned jatropha as a renewable alternative to fossil fuels, opting for biogas, wind energy, (micro) water energy and, above all, solar panels. In 2010, the company initiated the SEHEN (Extra Super Energy Saving) programme to bring electricity to the more remote Indonesian islands. The programme entails providing small solar panels for individual households. The panels provide enough power for three light bulbs. For PLN, distributing solar panels is a quick and relatively easy way to boost electrification without the need to expand the grid. Through the SEHEN approach PLN hopes to quickly increase the number of people with electricity on the remote islands to 70%. PLN is collaborating with the Dutch NGO Hivos in a programme for developing renewable energy.

LOCAL SETBACKS FOR JATROPHA

“Degraded land is a political concept”

In Indonesia ample degraded land was thought to be available: ideal for jatropha production. In the relatively dry eastern provinces of Nusa Tenggara Timur, approximately 2 million hectares was categorised as degraded land. In reality, however, not all degraded lands are available. Seemingly abandoned plots of land often play a vital role in the survival of local farmers. Researcher Loes van Rooijen investigated the introduction of jatropha in Sikka district on the island of Flores.

When the global buzz about jatropha – the biofuel super shrub – emerged, all eyes in Indonesia immediately turned towards the east. In this dryer part of the archipelago there was supposed to be plenty of ‘degraded land’: land that was hardly suitable for intensive agriculture. Jatropha could grow on this land. Had jatropha advocates not assured that the plant would produce high yields in harsh circumstances, without irrigation and without chemical fertiliser? It was projected that Indonesia had some 10 million hectares to spare of exactly that kind of barren land. Indonesian policy-makers, energy experts, agronomists, investors,

development experts and the public at large anticipated a bright future.

The province of Nusa Tenggara Timur (NTT) was one of the areas targeted. NTT consists of over 500 islands of which Flores, Sumba and the western half of Timor are the largest. Many parts of these eastern islands enjoy only a couple of months of rain each year. The dry conditions, it was assumed, made NTT highly suitable for jatropha; much more so than the fertile, ‘emerald green’ islands of Sumatra and Java. But now, almost ten years later, the conclusion is that jatropha never took off in NTT. A present day visitor to these parts of Indonesia will find jatropha shrubs sparsely dispersed in the landscape or used as a fence, but will not find the millions of hectares of plantations once dreamed of.

Dutch social scientist Loes van Rooijen focused her doctoral research on the role that local circumstances played in national attempts to roll out jatropha production over the archipelago. She conducted her research in the Sikka regency on the island of Flores. In Sikka, a small district with a total area of about 170,000 hectares, about 20,000 hectares were qualified as ‘degraded land’ and deemed suitable for the production of jatropha. How did the local authorities and the farmers in Sikka respond to the national jatropha ambitions? How did the idea fit in



The uncultivated hills in Sumba featured as 'empty land' in many jatropha project proposals, but are locally claimed as clan property and used for herding livestock, hunting and gathering (by Jacqueline Vel)

with local agrarian practices? How did farmers react? To answer these questions Van Rooijen, involved with the JARAK research group at the Van Vollenhoven Institute (Leiden University), interviewed various stakeholders in biofuel governance at local level including district administrators, officials from the agricultural, industry and trade, regional investment coordination, forestry and regional planning agencies, representatives of local NGOs and the Catholic church, and farmers.

Where food is a challenge

In contrast to the early enthusiasm, things did not go smoothly with jatropa development in Sikka. “Sikka is an agrarian society,” says Van Rooijen. “About 80% of the people earn their living from the land. Plantation crops – cacao, cashew and coconut – in particular contribute to the regional domestic product. Some 60,000 hectares in Sikka are used to produce these crops and, naturally, the attention of local policy-makers goes towards these products.” Moreover, as Van Rooijen explains, NTT is a province where food security is still an issue and where occasional food shortages due to failed harvests, caused by lack of rainfall, are a fact of life. “Farmers were cautious,” says Van Rooijen. “To use agricultural resources for non-food production when market conditions are uncertain is not an obvious choice for people there.” Moreover, people were not familiar with jatropa as a cash crop, and realising that the seeds are not edible, they knew that the jatropa harvest would be worthless if the biofuel plan did not work out as promised. Another factor that hampered the introduction of the new crop was the fact that, for the farmers in Sikka district, the production cycle of jatropa was not ideal. It takes several years for a jatropa shrub to bear fruit. This hardly fits with the short-term perspective of poor farmers, who have few resources and hardly any reserves. They therefore focus on the here and now, targeting their investments on crops that promise a quick yield and have a secure

A PRESENT DAY VISITOR TO THESE PARTS OF INDONESIA WILL NOT FIND THE MILLIONS OF HECTARES OF PLANTATIONS ONCE DREAMED OF

market. Jatropa, on the other hand, requires long-term planning.

It is therefore no wonder that, despite the incentives offered, farmers were reluctant to participate wholeheartedly in the jatropa project. In total, Van Rooijen estimates, only some 100 hectares – out of the target of 10,000 hectares – of jatropa were actually planted. “The exact number is hard to calculate,” says Van Rooijen, “as most farmers planted the shrubs as a hedge or within a system of intercropping: mixing jatropa plants with corn, peanuts or cassava.”

The politics of mapping

But it was not only local enthusiasm that proved less than favourable. Van Rooijen found out that the qualification of plots of land as ‘degraded’ was a highly sensitive issue. The term is officially used for land that is not suitable for agricultural use due to erosion, loss of soil layers, lack of vegetation, low fertility or a slope of more than 30%. To emphasise the feasibility of the transition to jatropa cultivation, policy-makers wanted to present the available conditions as positively as possible. In doing so, favourable circumstances were

sometimes exaggerated and local limitations easily overlooked.

Land use, however, is a factor that cannot be determined from a distance based solely on maps or satellite imagery, stresses Van Rooijen. Especially in areas where many small farmers operate, plots of land may seem idle, but can be vital for the survival strategies. For example, land that only receives sporadic precipitation will be used immediately when some rain falls. Other seemingly empty plots of land are occasionally used as pasture for cattle, or to collect wood or fodder. In addition, land qualified as degraded may have a vital function as a watershed area or play a role in cultural practices. "To determine land as 'degraded' or 'marginal'

is a highly political act," says Van Rooijen, "It is assumed that such land is not productive. This is only true from a certain, macroeconomic investment perspective. In fact, qualifying land as marginal marginalises the people working it, too. In a matter of speaking: they fall off the map."

Profit is what counts

In recent years, a significant part of the public services in Indonesia have been decentralised to district level. The district has an important role in spatial planning, environmental impact assessments and permit procedures. The district also has more authority to formulate its own policy appropriate to the local conditions. "The problem is that these new tasks are often not accompanied by sufficient budgets," says Van Rooijen. In Sikka the national enthusiasm regarding biofuel and more specifically jatropha was not shared. Of course, on a general level, the national concerns about fuel scarcity, import dependency and climate issues were acknowledged and shared. But the jatropha enterprise was not seen as something that would benefit local interests. The various district government agencies had their own policy priorities and local ownership was found wanting. In the early stages of the process money was allocated to district level to set up nurseries and for pressing and refining machinery. But after two years, the funding ended and local enthusiasm was too weak to carry it forward. Lack of coordination between government agencies also contributed to the failure. Pressing machines were procured while the jatropha seedlings still needed to be planted. On her visits to district offices in the island's capital, Maumere, Van Rooijen saw the pressing machines standing idle in a corner of the government premises. They had never been used. But at the same time she also witnessed some disappointment that the project had not paid off. Civil servants had, in fact, followed national instructions and guidelines:

Loes van Rooijen

Loes van Rooijen is a PhD researcher who studied cultural anthropology and political sciences at the University of Amsterdam. During her studies she focused on political institutions in Southeast Asia, minority participation and conflict mediation. After finishing her studies, Loes worked as a policy advisor and project leader in the province of North Holland's Department of Nature, Landscape and Recreation. Here she was involved in spatial planning projects concerning recreation, nature conservation and water capture. Her research for JARAK investigates how the provincial government of NTT and the district government of Sikka have responded to national policy on biofuel and jatropha in particular. Her thesis explores how to govern the biofuel sector at regional level while strengthening its potential for local economic development and at the same time abate negative externalities related to social and environmental impact.

local working groups and commissions had been set up, people were assigned to manage and execute the jatropha enterprise. At the very least the project had ensured temporary employment for a number of people. “At the time many people involved had the feeling they were participating in something important,” says Van Rooijen. “There was a national sentiment that biofuel – and especially jatropha oil – could solve a number of problems, not least reducing national dependency on oil imports.”

Looking back, however, government officials involved in the project do not easily admit that they had at one point been enthusiastic about jatropha. In Van Rooijen’s words, “success has many fathers, failure is an orphan”.

Van Rooijen does not agree with the sometimes heard assumption that the expectations for jatropha did not pay off because of the lack of capacity of local government. “The local government was not necessarily the weakest link,” she insists. “In the end the business case of jatropha was just insufficient. Farmers could not make a profit. And ultimately that is what counts.”

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A 'PROYEK' IS USUALLY NOT MEANT TO SUCCEED

Short-term planning caused many jatropha projects to fail

Many of the jatropha projects in Indonesia failed because they were intended to, says PhD researcher Henky Widjaja. They were 'proyek' and not projects. A proyek serves the financial and political goals of the initiator rather than the development ideals they claim. For people involved a proyek means 'easy money'. The proyek mentality is an unpleasant reality faced by many development initiatives, including jatropha development, and can be seen as a cause of its current failure.

It is hardly news anymore: many jatropha projects set up in Indonesia (or elsewhere) over the last ten years have had less than positive results. There have been many articles publicised about the disappointing yield of *Jatropha curcas*, about the withdrawal of investment companies after the financial crisis in 2008, and about the national subsidies on fossil fuels making the jatropha

“From planting to harvest. Treat the jatropha plant as well as possible to make the harvest as large as possible!” Japanese propaganda poster for Jatropha in Indonesia during the occupation (author Unknown). Source MUSEO1: TPC-IC-II-161 (litho), Kamptekeningen uit bezet Nederlands-Indië (1942-1945), NIOD Koninklijke Bibliotheek – National Library of the Netherlands.

biofuel business case a questionable proposition. But, according to Henky Widjaja, some of the blame can also be placed on the specific way that jatropha was introduced within the Indonesian political, social and cultural context. Patronage politics are often a deciding factor in the success or failure of any innovation in Indonesian society. Widjaja looked into twelve jatropha projects, of different shapes and sizes on the Indonesian island of South Sulawesi. The twelve projects can be grouped according to their leading actors: government, scientist-university, piloted commercial investments and corporate social responsibility (CSR) projects. But they can also be categorised by type of activity: oil pressing development, nursery, demonstration plot, reforestation and commercial plantation. The outcome was that all the projects observed had only a short life, between six months and three years depending on the budget duration, and none reached production stage.

Easy money

It is important to appreciate that in Indonesia the specific word 'project' – or *proyek* in *Bahasa* – has a specific connotation, which is usually not favourable. A *proyek* is commonly associated with 'easy money'. The term was coined during the development period of the *New Order* era – 1970 to 1990s – under former president Suharto and still persists to the present day.

The do's and don'ts of new cash crop introduction

Based on his research, Henky Widjaja sums up a few do's and don'ts to observe when investing in new cash crop introduction.

- Start off with a proven technique, in order to be able to make solid promises to farmers; in other words, be transparent and clear about the current state of the technology and plan development so that farmers can make their own risk assessment.
- Compensate farmers for their opportunity costs in testing the new crop, and provide a clear guarantee of the accessibility of inputs (improved seeds and other technologies) and a concrete market guarantee.
- Be sure to include long-term planning, with clear phases. Development is a long-term process.
- Start small to avoid 'free riders'.
- Investigate and incorporate the local social, political and cultural context in the business plan development.
- Closely monitor and evaluate the actual implementation in order to draw lessons for a gradual improvement of strategies for the new crop.
- Governments must be able and willing to stimulate and facilitate market conditions. This is crucial for a new sector where the market is still growing.
- Try not to be dependent on government budgets as these are usually only for one year. A clear link with the market should be established: market involvement in the whole process from R&D up to the marketing should be encouraged.

In this era, Widjaja explains, the government and international development organisations initiated many projects to bring development to the Indonesian islands. These initiatives, however, were highly politicised and served the short-term financial and political goals of those involved – usually politicians from leading political parties as well as the NGOs – rather than the long-term development needs of rural Indonesia. The goal of any *proyek* is to satisfy the immediate and short-term needs of the initiator. The right people have to get on board and, once that has been achieved, more money can be raised. "It is not the intention that a *proyek* should be successful and sustainable," says Widjaja. "The aim is that the money is raised and spent." To participate in a *proyek* is seen as an opportunity to earn a salary for a short period or to benefit in other ways from the money that is temporarily available. Anything in Indonesia can be 'projecticised' (*diprojekkan*), and this is exactly what happened with the *jatropha* initiatives, Widjaja found out. Looking at the *jatropha* hype from this angle, it is no wonder that after a couple of years all projects went up in smoke. They were intended to do so. "All *jatropha* projects I studied were designed and financed for the short term; they were mere trials, not intended to evolve beyond the trial phase."

When patronage matters

One of the projects Widjaja scrutinised was the PT Jatro Plantation* (PT JP for short), a national investment claiming to cover some 17,000 hectares (40 million trees) in South Sulawesi. Farmers were provided with cash and in-kind loans paid at the beginning of their participation. PT JP had a short life cycle: it was started up in 2007, froze all its activities in 2009, and was terminated in 2011. PT JP was the *proyek* of former cabinet minister and National*Party chairman Fauzie Perkasa,* who invested about 100 billion Rupiah (over 60 million euros) in the enterprise. Curiously Perkasa chose local politician and businessman Abdul Arief* as

* PT Jatro Plantation, the National Party, Fauzie Perkasa and Abdul Arief are all fictionalised names.

A KEY FACTOR THAT THE FARMERS MISSED WAS TRANSPARENCY IN THE JATROPHA BUSINESS CASE

director of PT JP. Arief was a senior National politician, chairman of a national sport association, but also highly criticised for his involvement in illegal schemes, having served several jail sentences. Arief involved many of his family members in the PT JP management. Using his family network and the network of the local National Party, he managed to secure the cooperation of some 8,000 farmers, supposedly controlling a little over 17,000 hectares of land. Research by Widjaja showed that the land that was claimed to be available and the participation of the outgrowers was based on mere photocopies of land certificates. “On paper it looked impressive, in reality less than half of the land was available. Cultivation never got off the ground.”

Widjaja calls this ‘the economy of appearances’, a term coined by Anna Tsing. In the early stages of a *proyek* everything must seem in perfect running order: all the right actors must be on board, all the necessary signatures must be in place. The prospects of the enterprise are portrayed in an overly optimistic scenario, to attract additional funds. But the paper reality does not exist on the ground.

Apart from the fact that in a *proyek* most things are not as they seem, Widjaja also concluded that the political patronage system that many jatroptha projects implicitly or explicitly relied on, failed. In the case of PT JP, the system did not get the farmers on board. Farmers

confided in Widjaja that they never believed in jatroptha. “They did not trust their patrons who approached them with the jatroptha proposal,” says Widjaja. The patrons were seen as just *proyek* brokers, intermediaries for the outside company, acting only for the commission they received. The farmers never entered the scheme out of loyalty for the brokers, but only because of the incentives offered (cash and in kind loans). The trust and reciprocity of the ‘old’ patronage system was lacking. A key factor that the farmers missed was transparency in the jatroptha business case. In his research Widjaja compared the jatroptha outgrowers scheme with cassava production for a big Korean company. “Aside from the existence of increasing demand for cassava and the attractive price for farmers,” he says, “the local collector who acted as middleman for the cassava company was clear about his intentions and about prices. These middlemen were connected with the farmers through the traditional commercial patronage system, not only buying cassava or other products from farmers but also supplying them with working capital

Henky Widjaja

Henky Widjaja has a professional background as a programme staff officer for several international development organisations (JICA, UNDP, the World Bank and AusAID) focusing on decentralisation policy development, local economic development and agribusiness development in eastern Indonesia. He earned his degree in economics from Universitas Hasanuddin in Makassar, Indonesia, and studied development studies for his Master’s degree at the Institute of Social Studies in The Hague, the Netherlands. He is currently a JARAK researcher and PhD candidate in anthropology at the Van Vollenhoven Institute and Faculty of Social Sciences, Leiden University.

and other resources if necessary. It was obvious for the farmers that he shared in the risks. The broker for the jatropa *proyek*, on the other hand was vague about the business proposition, and he did not share the risks.”

It is a mistake however, Widjaja stresses, to see the farmers as the principal victims of a jatropa *proyek*. “Of course there were some farmers who participated because they truly believed that jatropa would bring them everything that they were promised. These farmers were highly disappointed when there turned out to be no market for their jatropa nuts. Most farmers however only stepped in because they saw a window of opportunity to earn some side income from

participating in a *proyek*. They were part of it. Next time they will not behave any differently.”

Localising strategy

Widjaja fears that interrupted projects like the PT JP case have damaged the chances of jatropa to really prove its worth as a new cash crop. “Innovation needs time. I think that the failure of jatropa projects is for a large part due to the short-term character of investments. There was money to start it up, but follow-up money was never available.” And even if there were initial long-term plans – as was the case op PT JP, which was initially designed for a period of 25 years – corruption



The jatropa nursery that would provide seedlings for thousands of hectares in Central Sumba had been abandoned by the end of 2012 (by Jacqueline Vel, Memboro)

Farmers' involvement in jatropha projects

The cultivation of jatropha by smallholders on marginal lands was expected to provide a remedy for ecological degradation, poverty, unemployment and the energy crisis. Based on these expectations, the Indonesian government, as well as numerous companies and NGOs, decided to invest in jatropha projects. They moved into rural areas, looking to involve local farmers. How did local farmers perceive these projects? That was one of the questions posed by PhD researcher Gunawan. He conducted an ethnographic study among farmers in Purwodadi village in Gunungkidul regency on Java. In this village many farmers were involved in a jatropha project run by the local government. Gunawan found that the farmers still saw jatropha mostly as a wild plant rather than an agricultural commodity, and felt strange about planting it. Their participation in the project, according to Gunawan, can partly be explained by existing patron-client relationships between the local government and farmers. In other words: farmers' participation was a form of obedience to the village government. In this way, they wanted to maintain their good relationship with the government and show that they are reliable citizens, remaining eligible for potential future projects. In Purwodadi, Gunawan found, as in many other areas of Indonesia, the jatropha programme mostly failed. Most of the plantations are still there but are left untended. Neither the local government nor the farmers have given up the hope that jatropha will eventually meet some of the initial expectations.

and misuse of funds made sure that investments were withdrawn after only a couple of years.

Widjaja's research leads to the conclusion that innovation in agriculture should take the social, political and cultural context into account. This seems like stating the obvious but, according to Widjaja, most investors have standard assumptions about the people they deal with. "For example, they assume that farmers will gladly work for a fixed fee. In Sulawesi, however, this assumption is wrong. Sulawesi farmers are, as a whole, very independent. Most of them don't want to be employed, and are not keen to participate in a rigid scheme, like contract farming or a plantation. They are market oriented; and they prefer taking entrepreneurial risks over the security of a fixed price. Schemes like the plantation model work much better in Java because of their long existence there."

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Ongoing plant science research will indicate the real potential of the jatropha plant as modern biofuel feedstock, which is just one of the prerequisites for establishing a viable jatropha-biofuel sector in Indonesia (by Roeland Muskens, Sinar Mas, Jatropha Research Centre, Jakarta)

THE SHORT HISTORY OF JATROPHA PROJECTS

Conclusions from the JARAK cluster*

What explains the rise and fall of jatropha as a modern biofuel crop in Indonesia? From 2004 to 2007 jatropha became popular as a solution to many problems. It addressed global concerns about climate change and fossil fuel depletion and national concerns about growing fossil fuel expenditures and energy shortage, while in rural areas it would generate extra income and employment. This convergence of goals was characteristic of the jatropha hype, despite the lack of science-based evidence about the potential of the crop in field situations in Indonesia. Politicians applauded quick solutions for the huge problems they faced. Jatropha's history in Indonesia provides an example of how policy-making becomes steered by hypes, whether the claims about the crop are proven or not. Moreover, global discourse dubbing jatropha a miracle crop encouraged investors and governments to invest their green capital in jatropha projects.

Disentangling the goals from this converged jatropha hype discourse and distinguishing which actors were involved is important for understanding the course of activities in the jatropha sector. The actors involved were plant scientists conducting research and development on the jatropha plant, engineers developing technology for processing seeds into valuable products, journalists reporting about success stories and potential, business people developing project proposals, experts conducting feasibility studies

and government officials making policies and issuing exploration permits. The infant jatropha sector could be seen as a production network with a variety of actors, and many missing links – most notably farmers. After the nationwide campaign in 2006, in which the Ministry of Agriculture promoted jatropha for smallholder cultivation, farmers pulled out when they found there was no market for jatropha seeds.

JARAK's investigation of jatropha's introduction and commoditisation as a biofuel crop in Indonesia reveals that, despite the enabling framework of national policies and intense promotion, jatropha cultivation was concentrated in short-term 'projects' designed to correspond with government and donor agencies' funding periods. We found that most projects took place in offices in towns and cities, or on the Internet, but only few in the fields of the 'marginal areas'. A general lesson here is that a wide variety of actors are involved and needed to achieve a biobased economy; they each perform activities that are only part of the value chain – for example cultivating the crop or developing better machines – that constitute their short-term projects with limited goals. Positive projections of biobased economy potential should

* A popular version of JARAK's research findings is available at <http://jarak.iias.asia>.

therefore carefully assess the implicit assumptions about value chain actors' behaviour. For example, anthropological research near Yogyakarta indicated that farmers often did not intend to cultivate jatropha, but only enlisted as participants so that they would receive benefits, like free inputs and some cash incentives. From the farmer's perspective, jatropha projects fitted in an ongoing series of – mostly government – projects that have created a flow of side income for them. In East Nusa Tenggara, district government officials benefited from contacts with potential investors and issuing permits for jatropha initiatives.

The claims about jatropha that fuelled the hype also assumed that government policies and regulation would support the introduction of the crop. However, JARAK research found that one of the main barriers to good governance and regulation has been the incoherence of supportive economic policy instruments such as subsidies, tax incentives, financial support for biofuel-compatible vehicles, and cheap credit schemes to make the cultivation, processing and consumption of biofuel more economically competitive with other alternatives. These supportive policies did allow researchers, engineers and businessmen to create their own jatropha projects but, at the same time, the commercial viability of jatropha biofuel was ruined by other policies. In particular, the fossil fuel subsidies that the Indonesian government provides to support economic development in general, have set such a low price ceiling for alternative fuels that cultivating feedstock for biofuel production became unattractive. Access to land is another issue that is hard to steer through supporting regulation. The 'marginal land' that national planners indicated as suitable for jatropha cultivation is often customary community land, making it unclear for plantation companies with whom to negotiate, and who is entitled to represent the community and receive compensation payments. It was hard for plantation companies to acquire land with strong legal certainty.

As a consequence of these barriers JARAK research found a large discrepancy between planned jatropha schemes as reported in the media – and referred to in discussions about land grabbing – and the areas being negotiated between project developers and land owners, let alone those that were being cultivated in reality. The autonomy of local governments is another reason why the local political economy is stronger than national policies in governing the adoption of innovations.

While JARAK research focused on the 'failed crop', it led to many insights about processes that occur when policy discourses around global and national crises are translated into activities on the ground. Whether jatropha will get a second chance in Indonesia in the future is a question that confuses means and ends. We should not blame the crop for the failure, but disentangle the goals that actors pursued with jatropha activities. Ongoing plant science research will indicate whether the plant has sufficient potential as feedstock for modern biofuels. Electricity production will focus on other sources of renewable energy. Farmers will prefer to cultivate the cash crop that provides them with the highest returns. Finally, opportunistic entrepreneurs will always find their short-term projects in the next media-hyped innovation sector.



Visit to the Wageningen UR Greenhouse facilities in June 2012. From left to right: Erik Toussaint, Plant Sciences Group Wageningen UR, Dr. Huub Löffler, Director Wageningen International, Prof. Dr. Ir. Gusti Muhammad Hatta, Minister of Research and Technology Indonesia and Mrs. Retno L.P. Marsudi, Ambassador of the Republic of Indonesia to the Kingdom of the Netherlands (by Ben Geerlings)

AGRICULTURE BEYOND FOOD: LESSONS LEARNED

By Cora Govers, Huub Löffler and Sikko Visscher

“Let’s join forces to explore the possibilities of the biobased economy in Indonesia”. This was the call of the Dutch Minister of Education, Culture and Science, Maria van der Hoeven, and the Indonesian Minister of Science and Technology, Kusmayanto Kadiman during the former’s visit to Indonesia in 2007. Facilitated by the Joint Working Committee Indonesia-the Netherlands, committed Dutch and Indonesian scientific organisations, together with research councils and academies, decided to answer the call. Together they launched the Agriculture Beyond Food research programme to explore the potential and threats of using biomass for purposes other than food. Now it is time to reflect on how the programme has worked out, to draw conclusions relevant for policy and practice, and to learn lessons from the set-up and functioning of the programme.

Rapid developments in plant sciences have made it possible for biomass to be used increasingly for the production of a new generation of products, such as biofuels and bio-chemicals. The resulting growth in demand for biomass is spurring agricultural development and can improve the wellbeing of farmers, particularly in Southern countries. Moreover, when biomass replaces fossil fuels this may help to mitigate climate change. The biobased economy thus holds much promise for economy and society. But there are risks, too. Increased demand for agricultural products

could jeopardise food security by competing for scarce resources, and by increasing food prices due to the multi-outlet markets for biomass. It may also lead to deforestation and threaten biodiversity, while land-use changes may nullify the positive effects for the climate. Moreover, economies of scale in the agricultural sector may favour large companies over smallholders. This has given rise to a fierce debate among advocates and opponents of the biobased economy.

The Agriculture Beyond Food (ABF) research programme intended to move beyond this debate by entering into a dialogue. Scientists and other stakeholders were encouraged to explore new possibilities for the biobased economy and to share their research results, views and concerns. It was reasoned that bringing together scientists from different disciplines would enable a broad view on the topic, promoting the design of interventions that are technologically feasible and economically profitable, and which fit societal needs. To reach this goal, the ABF programme aimed at interdisciplinary research by Indonesian and Dutch scientists, working together in three clusters of well-integrated research projects addressing issues of scientific, economic and societal relevance and involving stakeholders. The research projects falling under the programme are soon to be finalised, so it is time to take stock. What has the programme achieved? Have we gained new insights that will help policy to

make evidence-based decisions? And what challenges and lessons learned came out of the interdisciplinary approach and stakeholder collaboration?

Insights for policy and practice

Jatropha and oil palm were a main focus of research in the ABF programme (in two of the three clusters). The research found that, although jatropha had been promoted as a crop that could benefit smallholders, in practice this did not work out as expected. Many jatropha projects adopted a short-term perspective, with unrealistic and unproven expectations about yield levels. The projects were further constrained by insufficient supportive regulations, technologies and infrastructure, and by government policies that lacked coherence. An example of the latter is the government subsidy on fossil fuels, which has hampered the development of alternatives. The success of any innovation thus depends not only on its technological potential, but also on the enabling environment, including appropriate subsidies, tax incentives, and credit schemes aimed at including smallholders. The social and political context needs to be understood and taken into account when introducing any innovation. Moreover, the cultivation of jatropha for its oil is still in a test phase, and genetic improvement has only just started. This means that cultivating jatropha entails higher risks than growing an established crop like oil palm.

The story of oil palm is completely different. Companies and smallholders in the oil palm sector have been able to effectively respond to opportunities and threats. Oil palm serves both the food and non-food market, so it offers producers the choice to target the most rewarding market. The cultivation of oil palm is well established, many new varieties are developed that fit the environmental conditions, and smallholders are increasingly cultivating it independently. The success

of oil palm also has its downsides, as the growing demand for land has negative consequences for those smallholders who lack the formal rights to the lands they use. Moreover, the research shows that the expansion of oil palm plantations comes at a high environmental price and has a negative effect on self-sufficiency in rice production.

ABF research emphasises that further expansion of oil palm should be guided away from natural forests, peatlands and food production areas, and focus on degraded lands. At the same time the social and environmental consequences of converting degraded lands need special attention, as these lands may serve as carbon stocks, can harbour high levels of biodiversity, and may be used by communities, for example to collect wood or fodder, or as pasture or watershed areas. Analysing the ecosystem services provided by so-called degraded lands may reveal agro-systems of high social and economic value, despite a modest yield. The future is in *optimising* rather than *maximising* yields.

The crux of the matter is in smart land-use planning, looking for the best possible trade-offs between conservation and development outcomes. To help governments make decisions about where to plan new plantations, ABF researchers have been working with decision-support tools, based on satellite images and computer models. These tools have been developed to provide insights into the possible negative and positive effects of various land-use choices, and can help decision-makers to balance the environmental and agricultural pay-offs.

The development and application of mobile technologies to produce bio-diesel locally is another angle that the ABF programme focussed on (in a third cluster). Inspired by the adage “if the farmer can’t come to the factory, let’s bring the factory to the farmer”, such technologies can be useful for remote

areas, where communities do not have access to the electricity grid. Based on extensive research in the lab and in the field, ABF researchers found that mobile factories can be used to produce high-quality biodiesel from rubber seeds. Moreover, they took an important step forward in the development of affordable and clean mobile technologies when they managed to use fermented local biomass (ethanol) from waste instead of methanol for the synthesis of biodiesel. Another major breakthrough can be reached in the development of applications for the press cakes, which is a by-product of oil seed pressing. When the cakes are detoxified, they can be used for biodiesel synthesis and for feed, as they contain much protein. Such technologies could be applied for the press cakes of other seeds as well, such as *jatropha* or palm kernels.

Technologies may, in this way, help to raise the value of crops and waste products. Yet again and again, ABF researchers warn against a one-dimensional application of technology. The possibilities to implement an innovation depend on much more than the technology alone. In the end, innovations affect the lives of local people, who must therefore be engaged in the innovation process. The social, legal, environmental and cultural consequences of innovations must be considered and will determine the success of any technological intervention. This calls for intensive collaboration between scientists from different disciplines, and for simultaneous engagement with stakeholders in the social, political and business spheres.

The Agriculture Beyond Food programme provided 'proof of principle' that such an interdisciplinary approach is possible and successful. Technological innovations were targeted at available (waste) products and existing circumstances. Implementation trajectories were planned and started in close cooperation with local actors. Technological support for policy-makers was grounded in both environmental necessity and

administrative need. Much insight was gained through analysis of the political, social and economic contexts of the introduction of a new biofuel crop (*jatropha*) and the practices and realities of an existing one (oil palm). In all clusters, insights were gained from cooperation with and the dissemination of results to stakeholders in (local) politics and administration, NGOs, local farmers, and companies. The quality of the scientific results benefitted greatly from this dynamic. This book itself is a further attempt to reach a wider audience, not just to inform but to engage and involve more forces in the necessary shifts in policy and behaviour towards a more sustainable future.

Design of the programme

At the end of a research funding period not only the scientific results should be evaluated. It is also a time to reflect on the form and functioning of the programme to see whether lessons can be learned to improve future research activities.

The outline for the Agriculture Beyond Food programme was written by scientists from the universities of Wageningen (WUR), Leiden (UL), Groningen (RUG), Twente (UT) and Utrecht (UU) and the Indonesian Institute of Sciences (LIPI). The resulting call for proposals, published in 2008, intended to combine high scientific quality, societal engagement and interdisciplinarity. The call was published by the Netherlands Organisation for Scientific Research (NWO) and the Royal Netherlands Academy of Arts and Sciences (KNAW), in collaboration with the Indonesian Ministry of Science and Technology (RISTEK).

The programme tried to stimulate collaboration between scientists from different disciplines, based on the idea that interdisciplinary research is the gateway to effective and sustainable innovations. It also combined a number of other goals, such as scientific quality and

originality, international cooperation between the research partners in the Netherlands and Indonesia, and relevance for global development. Different stakeholders had to be involved at all stages of the programme, from inception to dissemination of the results. The involvement of both Dutch and Indonesian researchers and key stakeholders from outside the scientific community helped to prioritise issues and to focus the research. Moreover, the links with multiple scientific and non-scientific stakeholders in the South were vital to disseminating the research results, raising awareness and increasing potential impact. The involvement of researchers from the Netherlands helped gain access to the agendas and networks of international research and policy.

Challenges

The ABF programme intended to stimulate the integration of disciplines within the individual research clusters and also the exchange of ideas and results between the three research clusters. To this end, the programme organised annual workshops for all ABF researchers, mostly accompanied by a public event. During these occasions it became apparent that the involvement of different disciplines not only leads to different research questions and scientific methods, but also implies different ideas about practical approaches, such as the organisation of workshops, the publication of articles or books, engagement with stakeholders, etc. A three-day mid-term review workshop with ABF project leaders, researchers, supervisors and coordinators, revealed many such challenges. One of the things that became clear was that, even though the set-up of the research clusters was interdisciplinary, the individual PhD projects tended to be mono-disciplinary. PhD students need a clear pathway to graduation without too much dependency on results from others. Post-docs are better positioned than PhD students to operationalise interdisciplinarity.

In addition to interdisciplinarity, transdisciplinarity was part of ABF. Transdisciplinarity refers to research that involves non-scientific players (policy-makers, businesses, civil society, farmers, consumers and other end-users) who stand to benefit or suffer from the outcomes of research. To this end, each cluster organised several stakeholder workshops involving local communities, NGOs, government institutions and advisory groups. It did not yet include researchers and stakeholders working together in a consortium and being involved in a process of co-creation of knowledge for innovation, as is current practice at WOTRO, partly based on lessons learned from ABF.

Stakeholder involvement received attention at the mid-term workshop. Two types of stakeholders were identified: those that interact with the clusters and projects, and those that need to be informed about the results of the programme. The first group requires two-way communication, whereas the second group is mostly served by one-way communication, for example through policy briefs. Many stakeholders were identified that could benefit from the aggregated results of the ABF programme, but only a few were identified that interacted at programme level. Although interaction between researchers and stakeholders was considered desirable, in practice such interaction appeared difficult, as this can lead to unexpected changes to the research, and thus demand a great deal of flexibility from researchers.

The ABF experience shows that engaging stakeholders can be highly sensitive, especially when the vested interests of certain actors are at stake. At the same time, it underlines that scientists are bound to lose their trustworthiness when they exclude certain stakeholders from the process. For true 'co-creation of knowledge' stakeholders need to be part and parcel of the project and programme approach. They thus need to be partners in the consortium and play a role in the design,

implementation and execution of the research. This is currently the case at WOTRO, but was not yet included in the ABF programme.

Dealing with dilemmas

Any research in an international setting with the aim of partnering people from various backgrounds faces dilemmas resulting from the different expectations of the people and organisations involved. These dilemmas need to be dealt with in an open and transparent way. A prerequisite is that the financier is clear about its expectations and requirements and that the various research consortia discuss overlapping themes and activities.

The most notable overlap in the activities falling under the ABF programme was the objective to generate results that are not only of a high academic standard but also relevant for society. The traditions and approaches to achieve this, however, appeared to vary greatly between the various research institutions and disciplines involved. These differences resulted in numerous discussions of concepts, methodologies and views, allowing researchers and their institutions to learn from each other and broaden their perspectives.

Another recurring topic of discussion was the tension between the programme's inter- and transdisciplinary goals on the one hand and the various disciplinary demands that exist in the scientific community on the other hand. A related dilemma was that the involvement of non-academic stakeholders took a lot of time, while the clusters are eventually judged by the number of publications and PhD theses. The involvement of senior staff for further outreach and collaboration with international partners and stakeholders was therefore crucial. A similar tension exists between the objective to build capacity and the need to conduct high-quality research. Within the ABF programme, special capacity

building moments were organised in the form of master classes organised by the three research clusters. To overcome dilemmas like those described above, research output needs to be valued not only on the basis of academic publications but also on other types of outputs, outcomes and impacts for society, including capacity building.

The way forward in research and innovation

The term Agriculture Beyond Food implies that agro-production systems have more to offer than food alone. The ABF programme explicitly targeted commodities and waste products that can be used for non-food purposes. It has become increasingly clear, however, that food and non-food markets cannot be separated easily. Most of the expansion of oil palm, for example, is related to the growing demand for food products. Building on the experience and insights of the ABF programme, a new scientific collaboration on the 'Green Economy' can be envisaged. Such a new programme would have to be transdisciplinary and should involve relevant stakeholders from the planning stages onward. It should acknowledge the importance of food, non-food, and their interactions, as well as the importance of ecosystem services provided by agricultural landscapes, and should not just focus on production but also include up-stream processes. Advancing on the achievements of the ABF programme, future efforts should focus on the threats and opportunities for agricultural systems that are resilient and socially, economically and ecologically sustainable.



ABF researcher Yusuf Abduh in the laboratory, University of Groningen (by Miftahul Ilmi)

ORGANISATION OF THE AGRICULTURE BEYOND FOOD PROGRAMME

The Netherlands Organisation for Scientific Research (NWO) and the Royal Netherlands Academy of Arts and Sciences (KNAW) set up and financed the Agriculture Beyond Food (ABF) research programme, in collaboration with the Indonesian Ministry of Science and Technology (RISTEK). The budget was 2.5 million euros for five years (2010-2015). Within NWO the programme is being executed within the framework of the theme Sustainable Earth and within KNAW, as part of the Scientific Programme Indonesia – Netherlands (SPIN).

The scientific coordinators are Dr. Huub Löffler from Wageningen University & Research centre (WUR) and Prof. Enny Sudarmonowati of the Indonesian Institute of Sciences (LIPI). Cora Govers (NWO-WOTRO Science for Global Development) is the programme coordinator, in collaboration with Sikko Visscher (KNAW). Programme officers are Nada Marsudi and Tri Sundari (both in RISTEK) and Guus Derks (Netherlands Enterprise Agency, RVO).

The programme comprised the following Integrated Projects (clusters):

- **JARAK**: the commoditisation of an alternative biofuel crop in Indonesia
Prof. J.M. Otto (Leiden University, Van Vollenhoven Institute) Prof. Yunita Winarto (Universitas Indonesia, Department of Anthropology, Faculty of Social and Political Sciences)

- **Breakthroughs in Biofuels**: mobile technology for biodiesel production from Indonesian resources
Prof. H.J. Heeres (University of Groningen, Chemical engineering) Dr. Robert Manurung (ITB, Plant science and biotechnology)
- **Sliding from Greasy Land?** Migration flows and forest transformation caused by palm oil expansion in Riau, Sumatra and Berau, East Kalimantan
Prof. E.B. Zoomers (Utrecht University, Geography) Dr. Sofyan P. Warsito/Oka Karyanto (Gadjah Mada University, Forest resource economics)

ABF has been awarded four DIKTI scholarships (from the Directorate General for Higher Education, DIKTI) by the Indonesian Ministry of National Education and Culture which are utilised in the Breakthroughs in Biofuels and Sliding from Greasy Lands? clusters.

The Programme Committee, which decided on the set-up of the ABF programme and the allocation of funding, consisted of the following members: Rik Leemans (chairman, WUR), Leo de Haan (ULeiden), Prem Bindraban (WUR), André Faaij (UU), Joris van der Voet (VROM) and Rued Ruben (RU).

The planning and execution of programme activities was the responsibility of the coordination team, which included: Suraya Afiff, Paul Burgers, Cora Govers, Eric Heeres, Oka Karyanto, Huub Löffler, Togar Simatupang,

Enny Sudarmonowati, Tri Sundari, Jacqueline Vel, Sikko Visscher and Tim Zwaagstra.

Governance

Decisions were taken by the Steering Group of the Sustainable Earth theme of the Netherlands Organisation for Scientific Research (NWO), composed of representatives of the boards of NWO Earth and Life Sciences (ALW), NWO-WOTRO Science for Global Development, NWO Social Sciences (MaGW), the Ministry of Housing, Spatial Planning and the Environment, and a member of the executive board of the Royal Netherlands Academy of Arts and Sciences (KNAW). It was mandated by the boards of the financing organisations to make decisions on budgets and financing.

The Programme Committee was installed by the Steering Group to supervise the ABF programme, established at and supported by KNAW. The Programme Committee issued a call for proposals, was responsible for the independent assessment of the research proposals, consulted with the Indonesian-Netherlands Joint Working Committee for research cooperation (JWC) and drafted a funding recommendation for the Steering Committee.

A Scientific Coordinator from Wageningen University & Research centre (WUR) was appointed by the Steering Committee, who worked closely with a counterpart from the Indonesian Institute of Sciences (LIPI). The Coordinator has been responsible for the scientific interaction and synergy within the programme and for the execution of the complete set of coordination and research activities.

The role of the Programme Committee to facilitate the execution of ABF was taken over by the coordination team. The coordination team held meetings twice a year,

where possible with the Indonesian members. Each research cluster was led by two Principal Investigators – one in Indonesia and one in the Netherlands – who ensured the proper execution of the research activities and were responsible for scientific supervision within their research clusters. The coordination teams organised most of the mutual activities, including the kick-off meeting in 2010, the researchers' day in 2011, the mid-term review workshop in 2012, participation in the Open Science Meetings of 2011 and 2014, the final conference in 2014 and the organisation of a master class by each cluster. Two matchmaking events between science and business were organized jointly by RISTEK and the Netherlands Enterprise Agency.

Administrative support and the monitoring and evaluation of the projects were executed by the bureaus of NWO (Programme coordinator) and KNAW, in collaboration with the Indonesian Ministry of Science and Technology (RISTEK).

Further information and contact

Sliding from Greasy Land? research cluster:

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JARAK research cluster:

Jacqueline Vel (j.a.c.vel@law.leidenuniv.nl),

or see <http://jarak.iias.asia>.

Main ABF programme activities

- A matchmaking event for Indonesian and Dutch parties in Bogor, Indonesia (November 2008);
- A matchmaking meeting for ABF and Dutch companies, organised in the Netherlands by Agency NL (February 2009);
- Programme launch in Jakarta, co-organised with RISTEK (April 2010);
- A matchmaking meeting for ABF and Indonesian companies, organised in Jakarta, Indonesia by Agency NL after the launch of the ABF programme (April 2010);
- A researchers day in Wageningen, the Netherlands (March 2011);
- Master class on social sustainability in biomass production for non-food purposes by the JARAK cluster in Bogor (December 2011);
- A session during the Sixth Open Science Meeting Rise to the Water Challenge in Jakarta, Indonesia (28-29 November 2011);
- Presentation of ABF during the 10th anniversary of the Scientific Programme Indonesia-Netherlands (SPIN), Amsterdam, the Netherlands (19 June 2012);
- Discussion on the preliminary research results with Prof. Gusti Muhammad Hatta, the Indonesian Minister of Research and Technology, during his visit to Wageningen, the Netherlands (20 June 2012);
- Presentation of ABF research during the 10th Triple Helix Conference in Bandung, Indonesia (August 8-10, 2012);
- The mid-term review workshop took place in Yogyakarta, Indonesia, co-organised with Gadjah Mada University (October 2012);
- Master class on 'Oil palm and sustainable land use planning' by the Sliding from Greasy Lands? cluster in Yogyakarta (October 2012);
- Concept to Reality: C2R master class 'Technology Introduction in Rural Areas' by the Breakthroughs in Biofuels cluster in Makassar (January 2014);
- Presentations during the Seventh Open Science Meeting Science and Society in Makassar, Indonesia (27-28 January 2014);
- Final ABF symposium in Jakarta, co-organised with RISTEK (25-27 November 2014);
- Each of the clusters organised their own regular workshops and participated in national and international workshops and panels.



Agriculture Beyond Food – Experiences from Indonesia

Indonesia strives for green development and the ‘biobased economy’ is an important component of this ambition. It implies that biomass instead of oil is used as a base for fuels and products, resulting in decreased dependence on fossil fuels. The development was initially greeted with much enthusiasm, as it would help to mitigate climate change and provide new opportunities for farmers. But NGOs and researchers also started expressing concerns that the increasing demand for non-food agriculture would push up food prices and threaten remaining natural areas.

Indeed, the growing importance of agriculture for non-food purposes triggered many complex questions; questions that could only be answered on the basis of robust and high-quality research. The Agriculture Beyond Food (ABF) programme has attempted to provide just that. Under its umbrella, Indonesian and Dutch researchers have conducted extensive research to shed light on the opportunities and threats for local communities and the environment.

Through this book, the ABF programme intends to share the research findings with a wider audience. It provides the answers to some of the key questions surrounding agriculture beyond food as well as stories from the researchers in the field, and general lessons for policy and practice. The book offers an invaluable resource for researchers, policymakers and practitioners interested in understanding the possibilities of green development in general and the biobased economy in particular.