PLANTS FOR POWER | 2012

Jacqueline Vel & Respati Nugrohowardhani

The potential for cultivating crops as feedstock for energy production in Sumba

Hivos
people unlimited

Colophon

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Plants for power

Table of Contents

List of tables and figures

List of Annexes:

Plants for Power

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Jacqueline Vel and Respati Nugrohowardhani

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Report of a study commissioned by HIVOS

Summary

In November 2010, Hivos initiated a campaign for turning the island of Sumba in the eastern part of Indonesia into 'an Iconic Island for Renewable Energy'.[1] The choice of Sumba was based on the results of a 'preliminary resource assessment' concluding that the island possessed strong potential for various types of renewable energy. Whether biomass from plant material could be a good source of renewable energy in Sumba is the subject of this report. This study was conducted in September–October 2011, and included a short desk study, four weeks' field study in Sumba, a stakeholder meeting in Sumba to discuss results, and a final analysis by the research team. The team consisted of two social scientists, Jacqueline Vel and Respati Nugrohowardhani, both of whom have ample experience with research and rural development work in Sumba. The overall objectives were (a) to describe recent experiences and current cultivation practices of crops that could be used for production of biofuels and electricity generation in Sumba, including the waste streams; and (b) to indicate the potential for increasing energy feedstock production *in a sustainable way*. Hivos asked the team to develop a method to assess which crops, biomass streams, and value chains are suitable for developing into biomass-for-energy production, and to identify crucial factors for success or failure. This method takes into account resources availability in Sumba, general social sustainability, and ethical considerations. Additionally, the team used four pragmatic criteria for reducing the many potential crops to a shortlist for further consideration in this report.

First, this report provides a scheme for grounded assessment of production factor availability for expansion of biofuel crop cultivation in a delineated area. Those factors include land, water, labour, capital, and knowledge. The conclusion for Sumba is that not all resources that are required to increase production are readily available. 'Empty' (uncultivated) land is abundant, but not always suitable or accessible for energy crop cultivation. Traditional land claims make it difficult to know who is entitled to represent the community. Access to water is a greater restriction than land availability. Labour is also a more limiting factor than land. Labour projections for creating rural employment are overly optimistic about the number of people in Sumba, their lack of alternative occupations, and their willingness to work as low-paid land labourers. Biofuel production that needs large capital inputs relies on the private sector because smallholders lack capital and the government allocates its budgets to other purposes. Finally, local participation in decision-making about biofuel developments with free, prior, and informed consent requires better access to information and technologies.

Second, the report explains how social sustainability and ethical considerations concerning food versus fuel play a role in assessing various options for energy feedstock production. Chapter 3 highlights the dilemma of real versus desirable developments. Options for energy feedstock production are considered desirable only if they respect local populations' land rights, do not jeopardise their food security, bring a fair reward for their labour, cause benefits for the local population, and have no negative effect on gender relations.

Third is the report of the field study concerning the crops and wild plants that could be sources of fatty oil feedstock for bio-diesel, sources of sugary feedstock for bio-ethanol, and sources for gasification. The result was a list of 24 crops and plants, of which 15 are discussed in detail in this report. Selection was made following the field study using four pragmatic criteria: sufficient quantity in the short term; spatial concentration of cultivation; potential for commoditisation as energy crop; and cultural factors that might be either serious impediments to or stimulus for turning a crop into energy feedstock. Comparison of potential yield with actual production level in the field leads to the conclusion that for increasing production it would be worthwhile considering improved farming practices rather than expanding the area of cultivation.

A general conclusion from the field data was that there is a pattern in which the options for increasing energy feedstock production are seen as four distinct transition processes: commoditisation of wild plants and trees; introduction of new energy crops for small-holder cultivation; changing the use of existing small holder cash crops; and introducing plantation agriculture. The commoditisation of agricultural waste is also a process of change that is part of the transition towards large-scale production of energy feedstock. This is not regarded as a separate process, because producing waste is per definition linked to cultivating crops for their primary products. However,

[1]For more information see: http://www.hivos.nl/english/About-Hivos/Focus/Iconic-Island-Sumba.

commoditising waste will have its own effects that should not be overlooked. For each of these four categories the team has one or several concrete recommendations.

First, commoditisation of wild plants and trees should not receive priority, not because commoditisation is impossible, but because the transition process is too long, too uncertain, and will not yield as much as the other options.

Second, the success of the introduction of new energy crops depends on who introduces them, and how (term, budget, serious implementation, covering whole supply chain). The team found that the discourse is highly optimistic, but realisation in the field is minimal. Moreover, it takes a long time – at least ten years – to establish a new cultivation sector. This category is therefore not the best potential option for realising (quick) increase of energy feedstock production in Sumba.

Third, producing energy feedstock from specific 'well-established smallholder cash crops' should receive priority. These options score best on all criteria discussed in this report. They include copra (dried coconut) and crumbled candlenut kernels for biodiesel production. For bio-ethanol, small-holder-cultivated hybrid cassava and lontar palm juice are options to be further explored. Cashew apples are primary agricultural residue (waste) that is also a good option for bio-ethanol production. Dried candlenut shells and coconut shells are secondary residues that can contribute substantially to energy production.

Producing energy feedstock from large-scale land schemes has the advantage of large and concentrated quantities. It also usually involves private companies who take care of the organisation and management of the production and supply chain. The scale of the transition from current practices, however, is large, and the social sustainability effects are at best mixed, even sometimes rather negative. The currently developed schemes concern sugar cane, sweet sorghum, and maize.

The fourth recommendation is for Hivos' representatives to act as a matchmaker promoting renewable energy in negotiations being conducted between the government, companies, and the local population. The most urgent items for discussion would be electricity production from the waste product bagasse from the planned 25,000-hectare sugar cane plantation in Sumba Barat Daya, and its social impact. The second issue is the ethanol factory planned in Loli, which will use products from maize (and perhaps sweet sorghum) cultivation as feedstock.

1. Introduction

1.1 Exploring the potential of biofuel in Sumba

In November 2010, Hivos initiated a campaign for turning the island of Sumba in Indonesia into 'an Iconic Island for Renewable Energy'.[2] Sumba was chosen based on the results of a 'preliminary resource assessment' concluding that the island demonstrates strong potential for various types of renewable energy, and biomass for energy is one of the options.[3] Hivos then concluded that the use of liquid biofuels and biomass for energy is prerequisite to achieving the Iconic Island's overarching objective of 100% renewable energy provision in Sumba. Biofuel could replace fossil fuel in 'back up and spinning reserve' diesel generators that constitute an essential part of the power systems on the island.[4] Biomass energy could also contribute electric power to the grid by means of power generation from liquid biofuels or gasification of plant material that is currently considered waste. In isolated areas where people have no access to other renewable energy sources, cultivating crops or using waste is expected to play an essential role in the provision of electricity. Finally, biofuels will be required to replace the fossil fuels currently used in daily means of transport (cars, motorcycles, and boats). This calls for an examination of biomass energy potential on the island of Sumba and a sustainability evaluation of alternative options for the different uses. The 'preliminary resource assessment' about biomass-for-energy concluded that jatropha cultivation is 'technically feasible and on pilot scale successful', that there is a potential for bio-ethanol production on a small scale (for village-based application), and that there is a theoretical (technical) potential for producing bio-ethanol on a large scale. The report insists that 'more detailed analysis and ground truthing is required to further prioritise and optimise the choice of crops'.

As a follow up, HIVOS designed a three-phase approach for identifying biomass-for-energy production potential in Sumba. The first study, entitled *Biofuels Study Sumba*, reviewed technologies that can be applied to produce straight vegetable oil (SVO), biodiesel, ethanol, and syngas, and possible uses. It concluded with a list of crops and waste streams that theoretically and potentially can be used in Sumba as feedstock. The second study centred on field research in Sumba. The first report's list of potential crops was the point of departure for field research, discussions with local stakeholders, and assessing the best biofuel options based on the criteria most relevant in the field. The third phase will concern pilot projects. This report contains the findings of the second study. HIVOS commissioned a team of two 'Sumba experts' – one Dutch and one Sumbanese researcher with expertise in rural economic development, agricultural policy, and local politics in Sumba – for this second study.

1.2 The framework of this study: goals, method, and limitations

This study aimed to describe and analyse crops in Sumba that could be used for energy production, in order to provide input for developing further renewable energy activities there. The overall objectives were:

> (a) to describe recent experiences with and current cultivation practices of crops that could be used for biofuels production and electricity generation in Sumba, including waste streams, and
> (b) to indicate the potential for increasing production of energy feedstock *in a sustainable way*.

Moreover, Hivos asked the team to develop a method to assess which crops, biomass streams, and value chains are suitable for development into biomass-for-energy production, and to identify crucial factors for success or failure. That assessment had to take into account a range of criteria reflecting both technical and socio-economic issues (traditions, land rights, labour and gender situation) and more ethical criteria (food versus fuel considerations).

Because a field study would encounter many issues that are beyond the scope of this document, Hivos defined a set of assumptions that could be used for limiting the questions to be answered by this report. These assumptions are:[5]

1. Energy crop cultivation in Sumba is preferably intended for producing feedstock for local biofuel or electricity production in Sumba to fulfil the 100% renewable energy goal.

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[2]For more information see: http://www.hivos.nl/english/About-Hivos/Focus/Iconic-Island-Sumba.

[3]Winrock International (2010) 'Fuel Independent Renewable Energy "Iconic Island": Preliminary resource assessment Sumba and Buru islands –Indonesia', report of study commissioned by HIVOS. Page 78.

[4] See the Terms of Reference for this study in Annex 1.

[5]During the field study, however, the facts sometimes appeared to contradict these assumptions. The report indicates such frictions when the authors think they are crucial for understanding the potential of certain crops for the renewable energy future of Sumba.

2. Biofuel or biomass-based electricity production will make use of existing technologies that can be applied locally with ‘local management’.
3. The state-owned electricity company PLN and oil company Pertamina will provide continuous demand for feedstock, and establish an institutional arrangement with farmers, government, and other parties guaranteeing a fair price for the primary producers, and a fair distribution of the benefits among all stakeholders.
4. Biofuel and biomass-based electricity can also be used directly by users who are not connected to the electricity grid (cooking, lighting, productive use) without the involvement of PLN or Pertamina.
5. Either the district government, Pertamina, PLN, or private companies will conduct necessary supply chain activities.

As preparation, the main researcher conducted a desk study, the main results of which are integrated in this report. The field study is mostly qualitative, using three types of focus: historical – asking about real experiences; empirical – asking in the field (in Sumba) rather than deducing from theory; and comparative – comparing cases (crops/types of consumers/districts) in the field, and field data with literature. During the field study the main method was triangulation. The team gathered secondary quantitative data when possible, but found that on many issues there are no reliable data available. Moreover, available official statistics were often incomplete or inconsistent. As a consequence, the text always refers to the source of any figure mentioned, and in general these figures should be interpreted as informed estimates. During the field study the team organised a stakeholder meeting to identify the criteria and allocate a certain weight to each factor for the final assessment. The assessment procedure is qualitative, discussing why and how factors and criteria are important. Consequently, the final assessment is a result of weighing incomparable factors based on the team’s efforts to include the grounded perspective of the actors most involved.

1.3 Outline of the report

Chapter 2 discusses the question of availability of production factors for initiatives aimed at increasing production of energy feedstock. Those factors include land, water, labour, capital, and knowledge. The chapter presents a short characterisation of the population of Sumba and their agriculture. The scheme for grounded assessment of production factor availability for biofuel cultivation in a delineated area is then presented and explored. The result is an overview of resource availability in Sumba in general, which serves as background information to consider for all biofuel activities there.

Chapter 3 assesses various energy feedstock production options from the perspective of social sustainability and ethical considerations concerning food versus fuel. It highlights the dilemma of real versus desirable developments. For example, large-scale sugar cane cultivation could provide a large contribution to Sumba’s renewable electricity production, but would probably jeopardise food security and the land rights of local smallholders. Environmental assessment was beyond the scope of this study, but the team included information on environmental issues when encountered. Such environmental assessment is strongly recommended for the next phase in Hivos’ process of initiating biomass-for-energy pilot projects. The second part of this chapter bridges our discussion of issues and criteria for assessment and the actual description of crops in Sumba. Hivos asked the team to concentrate in the report on a selection of ‘most promising crops and waste streams’. We discuss selection (based on current quantity and concentration), the potential for commoditisation as energy crop, and restricting cultural factors. The ‘pragmatic pre-selection’ reduced the list from 24 to 15 crops.

Chapters 4, 5 and 6 elaborate on the 15 selected crops, their traditional farming systems, and the initiatives for large-scale cultivation that are already occurring in Sumba. These chapters are organised per type of energy product – SVO and biodiesel, bio-ethanol, and flue gas – and each starts with the overview of all crops found in the field study and continues with elaborating on those selected. The description includes information on production factors as mentioned in Chapter 2, per crop or case. Attention is paid to the effects of transition from subsistence agriculture to modern commercial agriculture for energy purposes, including consequences for division of labour according to gender and class.

Chapter 7 presents the final conclusions as a priority list of proposals and recommendations to Hivos regarding activities for energy feedstock production in Sumba.

2. Availability of resources for increasing biomass for energy production

Would it be possible to cultivate more energy crops in Sumba? During the field study we were often told that there is plenty of land available there, and anyone travelling across the island can see large areas that are not permanently cultivated. The resources necessary for increasing feedstock-for-energy production are more than just temporarily 'empty' land, however. There is also the quality of the land, and questions concerning water, labour, capital, and knowledge. This chapter starts with a short characterisation of the island's population and agriculture. Next, it includes a schematic overview of assessment issues concerning these production factors (Table 1). That scheme can be used in each specific case as a 'resource checklist' before starting a new biomass for energy activity. The rest of the chapter discusses the issues related to each of the resources in Sumba.

2.1 Population and agriculture in Sumba

Sumba is an island in the eastern part of Indonesia. It has a total land surface of 11,052 square kilometre, which is about one fourth of the size of the Netherlands.[6] Administratively it is divided in four districts or regencies, from west to east: Sumba Barat Daya, West Sumba, Central Sumba, and East Sumba (see the map in Figure 1). These districts are part of the province Nusa Tenggara Timur (NTT).

Figure 1: Administrative map of Sumba

The island has two major 'urban areas', Waingapu in the east and Waikabubak in the west. Since the early 20th century those two towns have developed as the centres of education, administration, and trade. More than a quarter of the population of East Sumba lives in Waingapu, and the rural areas of that district are very sparsely populated. The western part of Sumba is more densely populated. In 2007, West Sumba district was split in three as part of national decentralisation and regional autonomy policies. As a result, there are two new 'district capitals' (Waitabula/Tambolaka and Waibakul). This has stimulated migration from rural areas to these new centres and to areas along the main roads connecting the capital towns. A map showing the settlement pattern in towns and

[6] See Annex 4 for more figures about Sumba.

along the main roads would resemble the map of the island's electricity grid. It would also roughly map the socio-economic classes: the relatively prosperous part of the population lives in areas connected to the grid, whereas the off-grid areas are sparsely populated areas occupied by the rural poor.

These separate economic groups are nevertheless connected through kinship. They belong to clans that each has a village of origin, nearly always in a rural location. In the past, clan leaders founded these villages on hilltops, from which they could oversee their territory and defend their settlements against enemies. At that time only clan members of lower status would live close to the agricultural fields, far from the hilltop villages. They cultivated the fields of their clans (and not their individually owned fields). Clans were autonomous, and only linked with each other through marriage, exchange of goods, and –sometimes –warfare. The colonial government selected some clan leaders as 'local kings' (*raja*), who could act as local representatives in the colonial system of indirect rule.

The heritage of this system is still clear and relevant today, when people in Sumba identify themselves as from a certain 'kingdom' (for example Anakalang, Lewa, or Kodi). The split into more districts and sub-districts is a return to the pre-colonial ethnic division of the population. This affects our study insofar as it explains a basic pattern of differentiation between people from various clans and traditional kingdoms, between rich and poor, decision makers and workers; and it highlights the connection between rural and urban inhabitants. Since the establishment of state and missionary structures in Sumba, people have moved from rural areas to the centres of education, religion, and trade. Those who migrated made a living as teachers, reverends, shop keepers, etc. Their poorer relatives remained in the countryside, worked the land, and guarded the ancestral homes and graves. Children from villages stay with their uncles in town to attend secondary school. Urban relatives go home to their villages for weddings and funerals and to obtain their part of the harvest. A consequence of this system is that decisions about agriculture are often made in town, and those who act as farmers' representatives are often government employees residing in the capital towns.

A typical smallholder 'farm' in Sumba has a wide variety of activities. In the hilly interior, the main activity is wet rice cultivation. Because all the fields have to be planted at the start of the season there is a mutual-support system, in which men help each other to prepare the land and groups of women plant the rice, finishing a whole field in a day and then turning to the next the following day. Such collective work creates mutual obligations and reduces the freedom of each individual to decide on the type and pattern of cultivation activities. Work on dry fields is more individual. The traditional dry land system is shifting cultivation. After a few years of cultivating maize, cassava, other root crops and some vegetables in the dry land garden, shifting cultivators move to another field, leaving the old one to regenerate. Close to the house, women keep small gardens with vegetables and spices.

All households have pigs and chickens, and it is a woman's task to care for such small livestock. Wealthier households have horses, cattle, or water buffaloes. Men care for large livestock and use them for transport, for preparing the land, and as capital (a form of savings). Additionally, livestock is the main exchange object in traditional ceremonies. Traditional wealth is measured in livestock. The richest noblemen used to have thousands of horses and cattle roaming free across the dry lands. Livestock is also the favourite target of thieves, which explains why people in Sumba do not like keeping livestock in stables close to main roads. Cultivating cash crops used to be an additional activity, preferably without investing much labour or money. The most suitable cash crops are trees that grow without maintenance and yield fruits that can be sold as a commodity without any further processing.

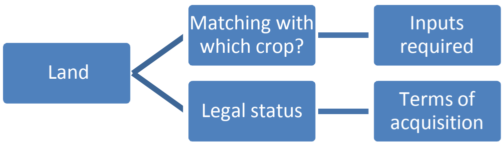
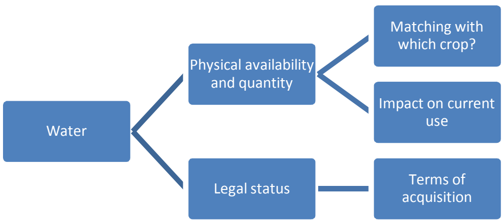
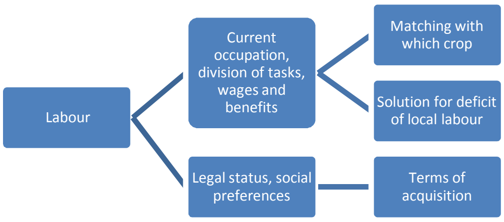
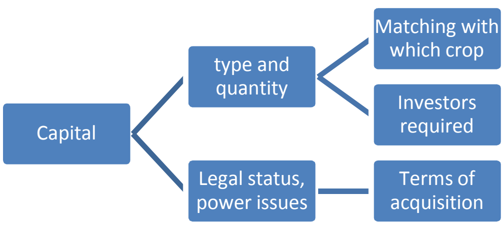
Traditionally, the rural economy in Sumba was a barter economy based on subsistence agriculture and extensive animal husbandry. [7] People from the hill areas would exchange produce for products from the coastal areas, such as salt. Most people in Sumba still prefer to grow their own food. Rural villagers also cultivate food crops for their relatives in town, and in exchange those urban kinsmen pay, for example, school fees of their rural nephews and nieces, who stay with them in town to go to school. Cash money is used mostly for 'industrial' daily household needs (including soap, sugar, and kerosene, but also cigarettes and pre-pay credits for cell phones), hospital costs, education fees, and expenditures for ceremonies.

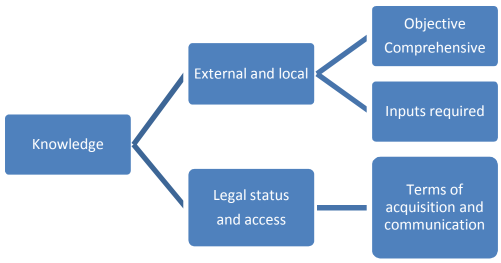
[7]See J.A.C.Vel (1994) *The Uma Economy: indigenous economics and development work in Lawonda, Sumba (Eastern Indonesia)*, PhD dissertation, Wageningen: Wageningen Agricultural University.

In the dry areas of the north and east coast the typical smallholder farm has activities adapted to the dry climate. Sheep and goats are typical. Immigrants from the neighbouring island Savu have lived along the east coast for generations, some retaining the Savu farming system. Central in that system are the *lontar* palm with its nutritious juice, indigenous sorghum, and mung bean. Savunese combine farming with fishing. Sumbanese prefer to live in the hills, where there is more rainfall.

With this background information in mind, we now turn to the question of availability of resources. Table 1 indicates the framework for assessing those issues.

Table 1. Issues for grounded assessment of availability of production for biofuel cultivation in a delineated area

<table>
<tr><th>Assessment issues per production factor</th><th>Explanation</th></tr>
<tr><td>
</td><td>Local or island-wide ‘suitability maps’ and ‘spatial planning maps’ need verification of actual soil and location characteristics. Which inputs are needed? There can also be a difference between formal legal status (e.g.,‘state forest’) and status according to customary law (ancestral lands). Who is entitled to act as landowner, what is equitable compensation?</td></tr>
<tr><td>
</td><td>The issue of water availability and quality is often a secondary concern, but nevertheless very important. How much water does the crop need for production? Where will it come from? What will be the effect on availability and quality of (drinking) water for the local population? Is there any legal protection of water users?</td></tr>
<tr><td>
</td><td>Increasing production requires either increasing input of labour, improving labour productivity, or mechanisation. Which is appropriate? Extra labour input assumes current labour surplus. Is that the case? What will be the effects of these labour changes on gender equality? What is the effect on social differentiation? Terms of plantations in accordance with labour law?</td></tr>
<tr><td>
</td><td>Increasing energy feedstock production requires capital: which type (machines, buildings, roads, inputs, salaries) and how much? Who will supply that capital and on what terms? How does capital input affect power relations? Will farmers be ‘labourers on their own land’? What is the duration of investors’ commitment?</td></tr>
</table>



Knowledge includes information about crops, cultivation techniques, prices, costs, etc. It also includes technical knowledge needed for transforming crops into sources of energy. Some knowledge is local, but most is external. Local actors need this for 'free, prior, and informed consent' about biofuel developments in their area, and for deciding how they can participate in producing renewable energy.

2.2 Land

How much land is available for expanding energy crop cultivation in Sumba? Government websites about 'investment opportunities' are usually optimistic. For example, a provincial government website indicated that a total of 2,177,456 hectare would be available for jatropha cultivation.[8] To provide some perspective on this figure, table 2 presents official government statistics about land classification in Sumba and the whole province NTT.[9] In this table there are three categories of land that could be regarded as the 'empty land' plantation companies are looking for; the areas look empty because they are not permanently used. Those categories are, in terms of the statistics book: temporarily unused lands (defined as land usually cultivated, but that is purposely allowed to lie fallow for more than one year);[10] meadows (land used for herding livestock); and a remaining category for 'other dry lands'. Data about forest areas are added because some biofuel production concerns tree crops.

Table 2. Land surface and land use in NTT and Sumba, 2008

In 2008	NTT	West Sumba	Central Sumba	Sumba Barat Daya	East Sumba
Total land surface (ha)	4,734,990	73,742	186,918	144,532	700,050
Classified as (% of total land surface area):					
1. State forest	15	21	26	4	28
2. Private forest (hutan rakyat)	10	16	14	18	4
3. Temporarily unused lands (lahan sementara tidak diushakan)	19	22	12	12	20
4. Meadows (padang rumput)	10	12	16	13	0.5
5. Other dry lands (tanah kering lainnya)	13	1	15	9	16
6. Plantations	9	6	3	10	7
7. Residential areas (house and compounds)	4	1.3	0.8	2.8	11
8. Cultivated dry land fields (non-rice)	18	21	9.6	26	10
9. Rice fields (harvested area)	2.6	10	3.3	2.8	1.3

The sum of the percentages of the three categories of land that is not being used or just for extensive agriculture[11] or herding livestock ranges from 34% in Sumba Barat Daya and 43% in Central Sumba. From these percentages, one might conclude that land for agricultural enterprises is amply available in these districts, but there is an

[8] http://diskominfo.nttprov.go.id/web/produk-unggulan/jarak-pagar.
[9] The data on land use are based on the results of the Agricultural Survey of the Central Statistics Board in collaboration with the Ministry of Agriculture, which is conducted every year in each sub-district, using complete enumeration (FAO 2006).
[10] FAO (Food and Agriculture Organization of the United Nations) 2006 Metadata for agricultural statistics in Indonesia. Rome. http://www.faorap-apcas.org/rdes/PPT/indonesia_metadata.pdf.
[11] Extensive agriculture is a system of crop cultivation using small amounts of labour and capital in relation to area of land being farmed, see Encyclopaedia Brittanica, (http://www.britannica.com/EBchecked/topic/198903/extensive-agriculture).

important question: *why* were these lands not cultivated in 2008? One answer is that some of that land is 'marginal', in the sense that it lacks some of the vital characteristics for being productive: it has poor infrastructure (or none at all), involves undulating terrain, is short of water (no irrigation), or suffers poor soil fertility.[12] Additionally, the marginal lands in Sumba are sparsely populated, which means there is little labour available locally.

Whether land is available for (a specific type of) biomass-for-energy production is also a matter of land suitability, current use, legal status, and available accessibility infrastructure (roads, bridges, etc.). *The suitability of land* in Sumba can be determined in various ways. An elaborate German/Indonesian feasibility study for jatropha cultivation in Eastern Indonesia in 2007 (GFA)[13] considered this issue. Soil characteristics, elevation, and rainfall quantities and patterns are the main variables defining suitability in the GFA study. The conclusions are presented in the form of suitability maps. The maps in Figure 2 were originally produced by the National Jatropha Task Force in 2007, and here copied from the GFA report. The light yellow areas are most suitable for jatropha; the pink areas in the middle are unsuitable (see Annex 5).

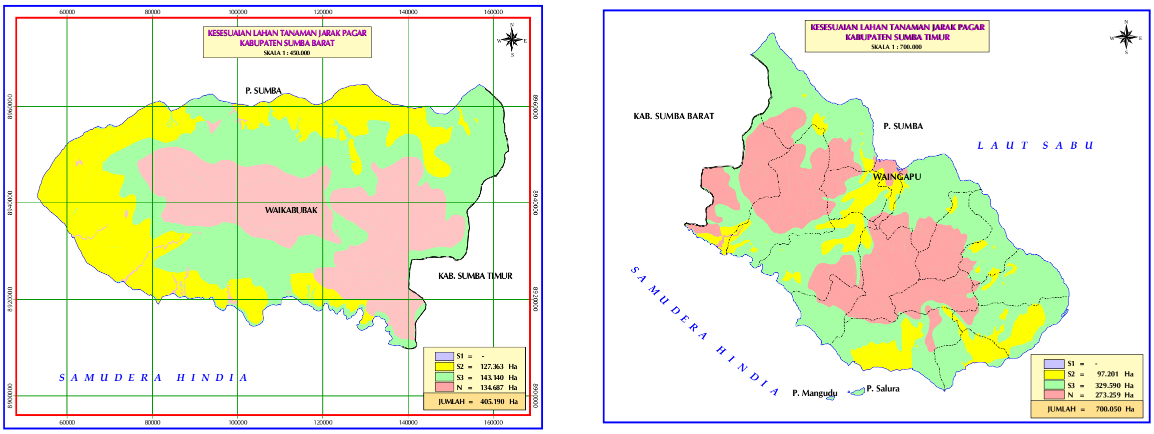


Figure 2: Suitability of land for jatropha cultivation in West and East Sumba (2007)

These maps can be used for planning other crops for which elevation and rainfall are the most important land-suitability factors. This type of map does not mention what the present use of that land is, so that we do not know whether biomass-for-energy produced there will compete with food production or cause deforestation. The 'suitable areas' also include people's houses, gardens, and graveyards. Spatial planning maps provide information on the planned use of zones on the island. Each district government in Indonesia should have such a map. Each type of map is drawn from a particular perspective and provides one answer to the question about suitability of the land for energy crops. It is also necessary to test the theoretical images and planners' intentions against realities in the field. One way is by asking farmers about their experiences of soil suitability and rainfall, and checking the present real use of the land.

The legal system determines whether land is accessible to people or companies who intend to use it for biomass-for-energy cultivation. The questions concern the legal status of the land on which this cultivation is planned, and whether the land is subject to any other claims. Traditionally, land in Sumba is clan property, *tana kabihu*, which is ruled by customary law.[14] Before the introduction of mining and plantations and the establishment of national parks, forests and uncultivated fields were thought of as abundant and used only for gathering, hunting, and grazing herds. These areas were included in the *tana kabihu*. Clan members were free to gather and hunt; outsiders had to obtain permission from the clan leaders to get access. As long as fields only supported local

[12] See feasibility study of GFA Envest (2008) "Development of Jatropha Curcas Oil for Bio-Energy in Rural Areas, Indonesia".
[13] KfW banking group commissioned GFA Consulting group to conduct the feasibility study "Development of Jatropha Curcas Oil for Bio-Energy in Rural Areas in Indonesia" at the request of the Department for Processing and Marketing of Agricultural Products (DPMAP) within the Ministry of Agriculture. GFA, 2007.
[14] For more elaborate information on land law in Sumba, see: Vel, J.A.C. & Makambombu, S. (2010) 'Access to Agrarian Justice in Sumba, Eastern Indonesia', *Law, Social Justice & Global Development Journal (LGD)* 2010(1). http://www.go.warwick.ac.uk/elj/lgd/20010_1/vel_makambombu.

livelihoods there was no need for more regulation. In the past, rules for distributing access to land among clan members were especially important for the types of land that yielded scarce products. Paddy fields and residential plots became ‘individual *adat* land’, and following the government’s introduction of a land tax system, the ‘customary owners’ used the state tax payment documents as a way to ‘register’ their individual claims (against their clan members). Within clans, the traditional stratification distinguished between nobility, freemen, and slaves. The lowest traditional class, the ‘slaves’, never had individual land. They worked as labourers on their masters’ fields. Traditionally, women do not own land since they move to their husbands’ homes after marriage. Women also do not inherit land, even if their fathers control large areas.

Figure 3. North coast landscape near Memboro

The legal status of land can change from customary land to government-registered land owned by people holding titles issued by the National Land Agency. Then it should be clear who among the clan members has a legitimate claim. After such conversion the land can be sold (even to outsiders), which is prohibited by customary law. Obtaining land titles also involves considerable registration costs, except when there are government land registration projects in which whole areas are registered for free or at much lower cost. With increasing differentiation of economic activities and a growing middle class with purchasing power, the land market in Sumba is developing rapidly. Land values are highest in and around centres of economic activity and decrease according to the distance from that centre (physical and ease of access). If it were indicated on a map of Sumba, some high-value land would be found along the main roads connecting the capital towns, with larger areas around the business and administrative centres of these towns. These are areas that individuals have registered as residential plots and paddy fields. Registering low-value land is not necessary since it is not subject to much competition and registration is considered too costly compared with the low yields obtained. The market value of some of this unregistered land has suddenly increased, however, because of plantation developers. Such areas of ‘sleeping land’ (*lahan tidur*) have been or are expected to be turned into centres of economic activity. Because no one had claimed the land previously, it is not clear who is entitled to negotiate about it with plantation companies.

The district government’s important function in the land acquisition process is issuing location permits for companies. If a district head wants to provide land to an agribusiness for plantations, he will issue a location permit (*izin lokasi*) so that the company can commence the procedure to obtain cultivation rights from the government (*hak guna usaha*). Holding this permit allows the company to organise meetings with local landowners. These meetings are called ‘*sosialisasi*’, to put the emphasis on providing information. The meetings include negotiating terms with local landowners for using their land. Use of land should be in accordance with the government’s spatial planning, and this is a condition for issuing cultivation rights to a company.

2.3 Water

Water is an important factor when considering the potential for increasing biomass-for-energy production in Sumba. Water availability varies widely across the island. Waikabubak and south Weejewa, for example, are humid areas with an annual rainfall of around 2,500 mm and more than 100 rainy days per year. The coastal areas in the north and east of Sumba are very dry (see Annex 4 for more figures). The land suitability maps such as those mentioned in the GFA report are based on rainfall data. Large-scale plantations often do not rely exclusively on rainfall only, however: they apply irrigation from ground water or rivers. Data on ground water are not publicly available, and companies do their own exploration. Even more than with land, it is not clear who owns water in Sumba. Customary law is not very adaptable to dealing with new situations in which a resource that was always considered abundant or sufficient is now turned into a scarce commodity. This is an issue of concern that will need the attention of (and regulation by) the district government. For each particular case it should be clear what the source of water for the intended cultivation is, and whether it will affect drinking water availability or food crop production compared to present water use. If plantation companies invest in infrastructure for water for the plantation, they should include water supply for the surrounding population. Fetching water is usually a women's task. In the dry season many women in rural areas in Sumba have to walk for hours to fetch water. If the water in wells and springs decreases, they will face an even heavier burden; if, however, water supply improves along with investments in energy crops, women could benefit from the developments. Lack of water is one major reason why land in the northern and eastern coastal areas is not cultivated.

2.4 Labour

Labour availability depends on the type of labour involved. In poor areas, many people are 'unemployed', but occupied with work that secures their subsistence. They prefer cultivating 'lazy crops' that do not need much labour input, such as candlenut, coconut, cashew, or cassava. Whether people in Sumba will work as contract farmers or labourers for a plantation company depends on the alternatives. The manager of the cotton plantation discussed in chapter 4.6 said that, in East Sumba, the plantation could not recruit enough local labour. He said many people did not want to do this work. Reasons mentioned by the local population were that most young men preferred working in Bali or Java; that wages were not sufficiently attractive and did not include food (lunch); and that the employment was only casual and seasonal. Since this plantation was established in 2006, the only major local labour input was building fences before operations even began. The manager said that by 2011 operations had been completely mechanised, leaving just a few skilled labourers to operate the machines. The regional minimum wage in the province NTT was Rp 850,000 per month, and Rp 35,000 per day in 2011, but no one checks whether employers indeed pay the minimum. A member of the plantation staff in a jatropha plantation said that he received just Rp 400,000 per month and that the rest of his wage depended on the result of plantation operations. By way of comparison: in Central Sumba, the daily wage for rice planters (women) had gone up to Rp 50,000 per day, in addition to a daily meal.

An important reason why it is difficult to hire labour in Sumba is that farming is not completely commoditised. Subsistence agriculture is preferred to land labour. Even people with a permanent job and monthly salary prefer to have their own rice fields; they ask relatives in the village to cultivate the field, and share the harvest. During peak labour periods in rice cultivation there are groups of migrant labourers who can be hired for planting, but that was the only type of hired land labour common in Sumba prior to 2011.

Increasing energy feedstock production could be a way to create rural employment and alleviate poverty, but there is no guarantee it will work. In 2011, a World Bank report argued that large-scale land acquisition can be a vehicle for poverty reduction through three main mechanisms: the generation of employment for wage workers; new opportunities for contract farmers; and payments for the lease or purchase of land. In contrast to its optimistic master narrative, the weight of the evidence presented in the report indicates that poverty reduction is a very unlikely result.[15]In Sumba, it is unclear if sufficient labour is available, and what will happen if it is not. Sumba's rural areas are very sparsely populated. Calculations for jatropha plantations on wastelands in India indicated an average labour input of 200 man-days per hectare during the first year and 50 man-days per year thereafter.[16] If

[15]See Tania Murray Li (2011) 'Centering labor in the land grab debate' *Journal of Peasant Studies* 38-2, pp. 281–298, where she discusses the World Bank's report *Rising Global Interest in Farmland: Can it Yield Sustainable and Equitable Benefits? (*Available from: http://siteresources.worldbank.org/INTARD/Resources/ESW_Sept7_final_final.pdf)

[16] Francis G., R. Edinger and K. Becker (2005).'A concept for simultaneous wasteland reclamation, fuel production and socio-economic development in degraded areas in India; Need, potential and perspectives of Jatropha plantations', *Natural Resources Forum* 29, 12-24. Page 20.

200 man-days per year are delivered by one person, it would mean that for each hectare one labourer should be available. Using these data, a plantation of minimally 10,000 ha would need 10,000 labourers for the first year and 2,500 for each year thereafter. According to government statistics, in Sumba some 70% of the population is economically active (workforce), of which 86% in agriculture. Based on these percentages, the total agricultural workforce of Central Sumba can be estimated at some 35,000 people. It is questionable whether a third of the present local agricultural labour force would shift to energy crop cultivation, and whether they could do so without harming existing food cultivation systems.

Besides these economic and demographic issues, there is also a cultural factor that makes it unlikely that many Sumbanese will work as plantation labourers. Land labour is regarded as low-status work, traditionally the task of the lower class and the poor. The traditional stratification in Sumba between nobility, free men, and 'slaves' is not as strictly applied as in the past, but it still exists – in East Sumba more than in the west of the island. Land labour employment opportunities do not sound very attractive within the cultural context; upward mobility in Sumba usually means escaping from the poverty traps of agriculture and, if possible, obtaining employment as a government official. People sell their livestock – and would sell their land if they could – to pay university fees for their children, hoping they will never become farmers.

At the upper end of the labour hierarchy, involvement of private corporations creates opportunities for local elites and brokers to earn high salaries. One investment proposal that was submitted to a potential jatropha investor by the end of 2011 suggests that salaries for plantation managers and their staff range between US$ 2,250–4,500 per month, whereas the proposed land labourer's wage is only US$ 3.5 per day. By comparison, the district government official in charge of issuing location permits only earns about US$ 330 per month.

Because plantation companies offer only minimum wage, and because of low population density, there will be a shortage of local labour. Labour migration would be one alternative, but this would bring more infrastructure costs, and in many places in Indonesia there is a history of social tensions caused by clashes between indigenous people and migrants. The cotton plantation in East Sumba (see chapter 4) has already shifted from manual labour to mechanisation. If agribusiness companies acquire flat, contiguous areas for their plantations, mechanised planting and harvesting is an option. That applies to most large-scale cultivation initiatives encountered during the field study.

2.5 Capital

Increasing the production of energy feedstock requires capital. Investing in the biofuel sector requires money to buy machines, build roads and buildings, buy agricultural inputs, and pay wages and salaries. Smallholders in Sumba are short of capital. Some have livestock, a house, and land, but usually there is little cash money or monetary savings available. That is one reason why farmers in Tana Righu answered the questions about whether they wanted to use other sources of energy for cooking: 'sure, as long as is does not cost us anything'. It is also a reason why smallholders prefer cash-crop cultivation. For example, candlenut fits well with short-term household expenditures because for more than four months men, women, and children can pick the fruits and sell nuts in quantities according to their needs. Farming is not yet commercial, as it has become, for example, in South Sulawesi, where farmers collectively buy solar panels for their machines because they calculated it would be a profitable investment.

In Sumba, capital for investing in buildings, roads, and agricultural equipment was, as of 2011, nearly always provided by the government. The district government's budget consists for more than 90% of funds from the national government. For example, in 2011 Central Sumba had a total government budget of around Rp 290 billion (US$ 32 million), of which only Rp 12 billion (US$ 1.3 million) was generated locally in the district.[17] Local contractors live from government projects for building offices and roads or other infrastructure. At least two thirds of district governments' budgets are spent on government itself: salaries, allowances, offices, and administration costs. Budgets for agriculture are managed by the Agricultural Service. National and provincial policies largely determine the spending priorities, and the budgeting process follows a fixed procedure so that there is little room for quick initiatives. This means that the government can provide capital needed for investments in new biofuel activities, but only if the amount is limited, if it is in line with national or provincial policies, and if it is applied for well

[17]'DAU Sumba Tengah Rp 207,8 Miliar', available from: http://sumbaisland.com/dau-sumba-tengah-rp-2078-miliar/ (accessed on 20-1-2012). See Annex 4 for more figures. including the government budgets o the other three districts.

in advance. District governments are eager to attract private investment in their areas. Through taxation, corporations bring welcome 'regional revenues' that supplement government budgets. As an indication of the amounts required compared with the size of a district government budget: the sugar mill that is currently planned in West Sumba will cost around US$ 100 million.

The amount of capital and the type of transition process that biomass-for-energy production would involve is not limited to the primary producers, but involves a whole value chain. Local traders are important capital providers in the value chain of smallholder products. For example, traders in Waikabubak provide working capital to village candlenut collectors, and invest capital in storage and in transport to the harbour or even to Surabaya. In cases where agribusinesses are involved, most value chain activities are integrated into the company's operations. When the electricity company PLN eventually buys feedstock for electricity production from farmers, it is unclear who will organise and finance feedstock collection, transport, and processing. Challenges concerning capital – besides the amount and source – include how the return on capital will be distributed among the various capital suppliers in the value chain, and how that relates to the return on labour for farmers and plantation labourers.

Figure 4. New Sumba Barat Daya government offices

2.6 Knowledge

Knowledge about plants, trees, their products, their natural habitat, the suitability of land for a certain cultivation, and sources of water are examples of local knowledge that are very important in the context of increasing energy feedstock production. During the field study, data on energy plants and trees and their habitat were gathered, for example about jatropha seeds and candlenuts – used in the past for making candles. These data, which represent important knowledge from experience, are incorporated in the next chapters.

External knowledge includes information and technologies. In general, there is a lack of both types in Sumba. The information that is required to make well-informed decisions is only available from subjective sources. Only traders know the prices of products in Surabaya or on the world market. Only the companies know for which purposes maize and sorghum produced on Sumba will be used. Many people do not know the difference between food varieties of a crop (for example maize) and the variety for industrial processing used in large-scale cultivation, and thus cannot distinguish between production for food, fuel, or feed. Hardly anyone in Sumba can imagine what 'mechanisation' entails, because the only good example on the island – the cotton plantation – is not publicly accessible. There is no information about the legal aspects of plantation labour, nor on labour relations terms on plantations elsewhere in Indonesia. The team's conclusion is that access to objective information should be facilitated to enable local actors to take part in developments with sufficient knowledge. Internet facilities for NGOs could be a start.

Technologies for improving production, processing the harvest, making oil from seeds, or for ethanol production and gasification exist, but are rarely available in Sumba. Large-scale production by corporations uses technology that is not publicly accessible and often subject to patents. The challenge is to get access to technologies that are genuinely suitable for conditions in Sumba and are not based on promotion by a manufacturer, inventor, or patent holder.

2.7 Conclusion

Would it be possible to cultivate more energy crops on Sumba? The conclusion of this chapter is that not all resources that are required to increase production are readily available. 'Empty' land is abundant, but many parts are not suitable for energy crop cultivation.. There are traditional land claims about which it is unclear who is entitled to act as representative of the community. Access to water seems more restricting than land availability. Labour projections about creating rural employment are overly optimistic about the number of people in Sumba, their lack of alternative occupations, and their willingness to work as low paid land labourers. Biofuel production that needs large capital inputs relies on the private sector, because smallholders lack capital and the government allocates its budgets to other purposes. Finally, participation by local actors in decision-making about biofuel developments with free, prior, and informed consent requires better access to information and technologies.

3.Social sustainability and a pragmatic pre-selection

Is it desirable to cultivate more energy crops in Sumba? The answer will vary depending on whom you ask, and on that person's perspective, interests, or ethical approach. The question is implicit in the second objective of this study, aimed at 'indicating the potential for increasing production of energy feedstock in a sustainable way'. The whole idea of the transition to renewable energy is that it will increase the environmental sustainability of energy consumption. What effect would that have on social sustainability? When plant biomass is the source of renewable energy, this social aspect is important, because the producers of that biomass are (mostly poor) farmers, who will have to change their current practices to contribute to increased energy feedstock production. Will that affect their food production? Will it require more labour input from men, or women? Will it change gender relations? What will the distributional aspects be? In other words, an 'energy transition' is also an inherently social and political process, from origins to outcomes.[18]

The first part of this chapter presents an overview of some of the main social sustainability issues that should be considered before promoting biofuel production. Those issues will return as a subject of discussion in the following chapters. There, we discuss for each crop of the list the social and ethical effects of the transition from current practices to commoditised energy feedstock production that we have witnessed or can predict.

The second part is the bridge between our discussion of issues and criteria and the actual description of crops in Sumba. Hivos asked the team to take the list from the 'Biofuels Study Sumba' (BSS) as the point of departure for the desk and field studies, expand it with other crops encountered in the field, and elaborate on the best options. That BSS list of 'potential crops' included coconut, jatropha curcas, horse radish, candlenut, and cottonseed as feedstock for biodiesel and straight vegetable oil (SVO); palmyra palm, cassava, sugar cane, sweet sorghum, and nypa as sources of bio-ethanol; and wood chips, rice husks, coconut shells, corn cobs, and elephant grass as material for gasification into flue gas. The result of the desk study on plant statistics from Sumba is the subject of the third section of this chapter, and is rather short because of lack of data. The final section describes how we applied a pragmatic method to reduce the long list of possible options into a more realistic pre-selection of crops with a potential for being used as energy feedstock in Sumba.

As mentioned above, attributing a score and weight to each criterion is subjective. Realising this subjectivity, the team tried to incorporate local voices in the final assessment. The team therefore organised a meeting in Central Sumba at the end of the field study to report preliminary findings and discuss the interpretation with the main field study informants. After presenting the various crops and discussing how they could be used for energy, there was a discussion on the differences between smallholder cultivation and large-scale plantations. The second part of the meeting focused on matrix ranking for assessing the potential of each of these crops for being produced as energy feedstock. The participants were farmers and other local informants, NGO staff from Sumba and from Yogya (Dian Desa), researchers, Hivos programme staff, one PLN staff member, and government officials. A complete list of names can be found in Annex 6. The stakeholder discussion resulted first in a list of eight criteria. When the participants applied the criteria to the crops afterwards, it became clear that some criteria were more important than others, and also that there could be differences of opinion. The issues and arguments mentioned in the discussions are integrated this report.

3.1 Food versus fuel

The first ethical issue to consider for energy crop cultivation is whether it will affect food security in the area of production. A recent CIFOR report explains how biofuel feedstock production, processing, and trade may contribute to food insecurity, and we highlighted this in box 1.

[18]Williams and Dubash, (2004)'The political economy of electricity reform in Asian electricity reform in historical perspective', *Pacific Affairs* 77-3, 403–409.

Figure 5. Farmer Tinus explains score matrix ranking

Box 1. Biofuel feedstock production and food security

Biofuel feedstock production, processing, and trade may contribute to food insecurity in two key ways:

•• Through increased food prices, which may in result from large volumes of food crops being shifted into bio-ethanol and biodiesel production; increased overall demand for feedstock with multiple end-uses; and the effect of these two processes on supply-demand imbalances for substitute foods.

•• Large-scale land acquisitions for biofuel production can displace local food production and productive resources essential to rural livelihoods and purchasing power. They can also divert scarce productive resources (e.g., land, water, labour) from food to biofuel production. These same processes can divert food from the domestic to export markets, thereby increasing the dependency of producer areas on international markets to achieve food security.

Source: German and Schoneveld (2011:8)[19]

During the field study we did not witness the first effect. In Sumba many smallholders are still mainly subsistence farmers who produce their own food, and therefore are not as vulnerable to price developments as long as their food crops are not commoditised. People in Sumba who buy food mainly buy *rice*, the price of which is not directly affected by biofuel production.

The second pathway to food insecurity is likely to occur in Kodi, when the sugar cane plantation will have appropriated 25,000 hectares of fertile agricultural land. The plantation will use ground water for irrigation in the dry parts of the area. The company argues that that irrigation facility can also be used for food crops in the surrounding area, but it is unclear how that would be accomplished.

In the stakeholder meeting there was consensus that food competition is the single first assessment criterion: using food crops for energy is not a good idea. During the discussion it nevertheless became clear that if food production exceeds subsistence needs, the surplus can be sold. The examples mentioned were maize and cassava, in part because in Sumba smallholders are about to enter contract-farming arrangements with maize or cassava companies. The conclusion was therefore that biofuel feedstock production using food crops is possible

[19] German, L. and Schoneveld, G. (2011) 'Social sustainability of EU-approved voluntary schemes for biofuels: Implications for rural livelihoods'. *Working Paper 75.* CIFOR, Bogor, Indonesia.

as long as it does not harm food security. For the team this stakeholder conclusion highlights how little information local actors have about potential negative effects. For smallholders in Sumba, biofuel crops are just a type of cash crop; usually they do not know what the commodities they sell will be used for once they are exported to Java or other areas. The effects mentioned in Box 1 are hard to imagine in relation to energy crops in Sumba, because few plans have been implemented (yet). There was one example of a similar process that had already occurred, however. Some cashew farmers in Sumba Barat Daya complained that, because the canopy of their cashew trees had closed ten years after being planted, they could not grow annual food crops underneath the trees any more. This means they now have to buy food with their cashew income, which is seasonal and depends on international price fluctuations. Cashew farmers and their households are short of cash in the months before the harvest, and that is when they experience food insecurity.

Biofuel crop cultivation does not always have to be a threat to food security. For example, one claim about sweet sorghum is that fuel and food can be combined: the grains for food and the stalks for fuel. A similar way of combining instead of contrasting food and fuel is achieved when using waste products of food crop cultivation for fuel, as in the case of candlenut, cashew, and coconut shells and rice husks. These claims have not yet been verified in Sumba, however. Using stalks for fuel and grain for food is one of the challenges for research to perfect the technologies and reduce the costs of this process.[20] The approach could mean that agricultural waste is no longer available as a cheap form of organic fertiliser, current practice in Sumba.

3.2 Land and resource rights

The main social sustainability principle put forward in various international sustainability standards is the need to recognise and respect local land rights, including customary land rights.

Box 2. Concrete elements of 'respecting local land rights'

- Identification and documentation of all existing ownership and use rights.
- Voluntary, fair, informed, and transparent negotiations whereby all affected land users are to agree whether rights are to be transferred to investors, which rights, how this is to be done, and on what conditions.
- Fair compensation for all foregone rights.
- Establishment of independent grievance mechanisms for negatively affected parties to raise concerns.

Source: German and Schoneveld (2011:7)

Chapter 2.2 already provided information on how access to land as a necessary production factor is organised in Sumba, and how various types of maps indicate the 'suitability' of areas on the island for energy crop cultivation. When the criteria in box 2 are compared with the current land rights situation in Sumba (see section 2.1) it will be clear they are not (yet) met. Regarding the third criterion of fair compensation, it remains unclear which actors are entitled to receive compensation. Do clan leaders have the authority to allocate a certain area for biomass-for-energy production, and how do they distribute the benefits and costs of such land alienation? This is especially relevant when external actors pay compensation for the use of land. The 'clan leaders' who claim they can represent their clan and act as land owners often pocket the benefits for themselves (money, motorcycles, trips organised by plantation companies, company jobs, etc.), whereas the actual farmers and land labourers never receive any benefits, except the promise that they can become plantation labourers.

It is not easy to identify who or which institution could improve the land rights situation for the local population. A representative of the sugar company said that the company offered a certain amount of compensation per hectare, and that they left it up to the village leaders 'to sort it out among themselves' who would receive which part of the compensation. The company made the actual payments at a public meeting in the village so that everyone could

[20] D. Graham-Rowe (2011) 'Beyond Food versus Fuel'. *Nature* 474 (23 June 2011) S6–S8.

witness, and if necessary, object to the payments. This example indicates how differentiation among the local population can make the introduction of new cash crop schemes a source of social injustice for the poor.[21]

3.3 Labour and gender impacts

Chapter 2 already discussed the availability of labour as a necessary condition for increasing energy feedstock production in Sumba. International labour sustainability standards refer mostly to the rights of workers, in this case plantation labourers. There are not many plantation labourers in Sumba yet, but those who are present should be paid and treated in accordance with labour laws. Another issue that is very relevant in the context of Sumba is the prohibition of compulsory or child labour. Collecting wild fruits and shelling candlenuts, for example, are tasks excellent for children: 'we can send our children to do that'. Promoting the use of these products for energy feedstock will likely increase child labour.

Labour issues are also hidden in the contracts between companies and smallholders about contract farming. With the contract the company makes claims not only on smallholders' fields but also on their labour. This can concern the duration of the contract, the extent to which conditions of loans or terms of payment are made transparent in the contracts, how prices – and implicitly the return on labour – are being determined, and the extent to which household labour (by children, women, slaves) is employed on the farms.[22] This is or will be a relevant issue for maize and cassava contract farming in Sumba.

Gender effects are likely to occur when plantations use local labour for planting and harvesting. Women will be drawn more into agricultural work, either replacing men in subsistence food cultivation, or as female land labourers. Sugar company staff interviewed said that on their plantations in Vietnam, mostly women are employed as land labourers. More demand for products from smallholders, such as copra, can lead to more work and income for women. The NGO Satu Visi's research on the household effects of the candlenut trade indicated that when products are no longer sold in small quantities on local markets but instead in larger volumes, men obtain a larger share of the income and spend it in a different way (more on cigarettes and mobile phones) than their wives (more on food). Another type of gender effect is described in the next box.

Box 3. Gender issues and spending money on (energy for) improved technologies

Gender refers to an ascribed role in society. In Sumba not only the difference between men and women matters for which type of role or work an individual does, or her rights and obligations, but also a class difference. Traditionally there is a division: nobility; free (wo)men; and slaves. Agricultural manual labour and household chores are typically the type of work for the lowest in the hierarchy: women lower than men, slaves lowest in terms of class and younger lower than older. Spending money is a privilege of those who have a higher position in that hierarchy.This is important when introducing an improved technology for household labour or energy: who will benefit in terms of less (stressful) work enjoying the new equipment, and who will pay for it?

[21] Vel, J.A.C. & Makambombu, S. (2010) 'Access to Agrarian Justice in Sumba, Eastern Indonesia', *Law, Social Justice & Global Development Journal (LGD)* 2010(1). http://www.go.warwick.ac.uk/elj/lgd/20010_1/vel_makambombu.

[22] German and Schoneveld (2011:6-7).

Figure 6. Children in Weeluri shelling candlenuts

3.4 Local benefits

During the final meeting of the field study, participants argued for 'local benefits' as criteria for assessment. They argued that even if a crop performs very well and produces feedstock for renewable energy, if all income and profits are likely to be appropriated by actors from outside Sumba, it would be wrong to classify that cultivation as a 'best potential' crop. The bargaining power of smallholders depends on the manner of collaborating with other actors in the value chain. Box 4 explains the two main plantation business models.

Box 4. The plantation model versus contract farming

Large quantities of energy feedstock can be produced by smallholders or plantation companies. Plantations are generally organised as public-private partnerships. An agribusiness company looking for land to grow a certain crop meets district governments in search of private companies that are willing to invest in their district. The Investment Board (BNPM) and the Board for the promotion of research and technology (BPPT) play an intermediary role in channelling investors to the regions. The general pattern is that agribusiness companies from outside Sumba seek to acquire land (several thousands of hectares) for their plantation, negotiate a location permit with the district government, conduct 'sosialisasi' providing some information and settling the terms on which landowners allow the company to use their land. The two most common plantation models are referred to as 'nucleus'('inti') and 'plasma'. The inti-plantation is owned and managed completely by the company; it can hire labourers or opt for mechanisation. For the inti-model, the company needs a land use permit (*hak guna usaha*, HGU) that is now usually valid for 35 years. The alternative plasma model does not require land acquisition, because local farmers will cultivate the company's crops on their own land under a cultivation-contract system. As a compromise, most often plans mention a combination of inti and plasma. Especially for food crops like maize, sorghum, and cassava, it is politically more acceptable for agribusiness corporations to propose the plasma-system, whereas the inti-system is more acceptable for crops that the government has designated as plantation crops.

The discussion during the final meeting also included two arguments regarding price. First, the representative of national NGO Dian Desa proposed taking the relative price of biomass feedstock against the price of diesel (fossil fuel alternative) as a criterion for assessing potential or feasibility. This proposal reflects the perspective of the feedstock buyer, and eventually of the energy consumer. Buyers and consumers are worried about the price of fuel for energy consumption. Farmers focused more on the price for their product by itself, or compared with alternative crops they could grow. Farmers see themselves as producers rather than consumers of biofuel. Their motivation for cultivating energy crops is to earn money, and not to produce renewable energy. If a non-energy crop would yield a better income, they will switch to that cultivation.

It is therefore very important that the price paid to farmers for their energy feedstock is high enough. This is currently a problem in Indonesia, where the government subsidises the consumer prices of fossil fuels, but not of biofuels. Under such conditions, it is hard to produce biofuel in a competitive way. Experience with jatropha in Central Sumba indicated that when the subsidised diesel price is the basis for calculating the prices that are paid to farmers, the result is so low that farmers were not willing to cultivate the crop. It seems as if the government policy is changing, however. In December 2012, the Renewable Energy Directorate of the Ministry of Energy and Mineral Resources announced that the price index for biofuels will be revised. The Ministry installed a team to propose a new formula for determining the prices for bio-ethanol and biodiesel.[23]

The list of social sustainability issues could be expanded, but that would be beyond the scope of this study. Social sustainability issues will be incorporated in the description of selected crops in Chapters 4–6.We now turn our attention to the way crops have been selected for this study.

3.5 Selecting best crops from plant statistics

During the desk study the team first tried to assess the potential of crops for energy production using data from the Indonesian Statistics Agency, based on surveys by the Ministry of Agriculture and Plantations. Regional differentiation over the sub-districts provides information on where actual cultivation of the crop is concentrated. These statistical reports include data mentioned above, but only for crops regarded as sufficiently important for Sumba.[24] Many crops in Sumba are not cultivated on any commercial scale, which could be the reason they are not mentioned in the statistics. There are also no statistical data on waste streams. Table 3 compares the figures of real average production levels in Sumba with the theoretical level of production of the same crops as mentioned in the BSS study.

Tabel 3 Potential biomass for energy crops and their actual yield levels in Sumba in 2009, data BPS

Name crop		Average yield (ton) per hectare in 2009				
English	**Indonesian**	**'Biofuels Study Sumba' (data literature)**	**Central Sumba**	**West Sumba**	**Sumba Barat Daya**	**East Sumba**
Cassava	*Singkong / ubi kayu*	25 to 30	6.8	7	6.6	10.6
Coconut	*Kelapa*	20–24	0.5	1.28	0.8	0.7
Jatropha curcas	*Jarak pagar*	4–8	0.34	0.36[25]	0.38	0.15
Rice[26]	*Padi*	Data on husk (3–4 ton/ha)	3,280 (grain)	2,086 (gr)	4,202 (gr)	3,564 (gr)
Maize	*Jagung*	Data on cobs (3.46 ton/ha)	2,658 (grain)	2,660 (gr)	2,979 (gr)	2.566 (gr)

The official statistics show a real production level that is only a fraction of the theoretical production level (total yield/productive area). Official statistics also indicate that of all hectares registered as land under a certain cultivation, only a part is productive, for example only a third of the coconut area. This suggests that for increasing

[23] Tim Harga Bahan Bakar Nabati berdasarkan Keputusan Menteri Energi dan Sumber Daya Mineral No. 1319 K/73/MEM/2011.
[24] The statistics books are available for each of the four districts, beginning in 2007, and published online: http://www.ntt-academia.org/statistik-ntt.html. Before 2007, Central Sumba and Sumba Barat Daya were part of West Sumba, and West Sumba's statistics books included (and unified) the figures of all three present districts.
[25] http://www.ntt-academia.org/files/sumbabarat2009.pdf, page 254.
[26] There are no statistics about waste products; instead the table shows the figures for average yield of grain per hectare per year, from which crops experts could estimate the size of waste streams.

production it would be worthwhile considering improved cultivation practices rather than expanding the area. For all other crops mentioned in this study there are no official statistical data available.

The lack of data underscored the need for field research, but a relatively short study cannot provide all the missing figures. During the field study the team assessed the criteria for each crop through field visits and discussions with farmers, NGO staff and government officials, and some traders. The team also inquired about additional crops that could be sources of fatty oil feedstock for bio-diesel, sources of sugary feedstock for bio-ethanol and sources for gasification. The result was a list of 24 crops and plants.

3.6 A pragmatic pre-selection

From the list of 24 crops the team made a first selection of 15 crops to be discussed in more detail in this report. The selection took place after the field study, using four pragmatic criteria: sufficient quantity in the short term; concentration levels of cultivation; potential for commoditisation as energy crop; and cultural factors that might be a serious impediment, or rather a stimulus for turning the crop into energy feedstock.

Sufficient quantity

For each crop, the study investigated production quantity. Some data are available from the governments' statistics surveys; otherwise, the team made an estimation. The team established a relative ranking concerning the quantity of production of each crop, with a relative score on a scale varying from 1 (very small quantity/rare) to 5 (very large quantity). The assumption is that, when current production is already substantial, it will be easier to use (part) for energy purposes, rather than to establish a whole new cultivation and supply chain from scratch.

Concentration levels of cultivation

The team assumed that concentration of a certain cultivation is a logistical advantage for increasing production. Such 'natural concentration' identifies areas that are most suitable for targeting activities for increasing production and establishing processing facilities, for example the southern and eastern coastal areas for coconut production. On the other hand, when crops can only grow in very specific habitats, there is a smaller chance of increasing production areas. This the case of nypa, which grows only in brackish water, of which there is little in Sumba.

Potential for commoditisation as energy crop

When a plant has not been commoditised yet, the whole supply chain needs to be established. This is not impossible. New crops can be commoditised based on promising information about the crop (for example from scientific research), when there is a market demand for the product, or when there is promotion of cultivation, including subsidies and budgets for seeds, agricultural extension, and land acquisition. Jatropha is the best-known example of such a crop. The best proof of the potential for commoditisation is that a corporation engages in the development of the crop concerned. In contrast, if a crop is already fully commoditised as a well-established cash crop, it means that production already takes place and that a supply chain is already working. In such cases energy production competes with the alternative use that determines the current prices for the crop. In some cases the value of the alternative use might be too high, for example when the oil can be used for cosmetics. Using the product for energy feedstock locally eliminates transport costs to Surabaya, however, making a higher off-farm price possible.

Cultural factors concerning using crops for energy purposes

Some crops, especially the most valued food crops, cannot be used for energy purposes for cultural reasons. Another cultural factor that hampers the development of biofuels on the large dry coastal plains is the habit of burning the fields at the end of the dry season(although this is not just cultural but also part of the very labour-intensive farming of those dry areas). Supportive cultural factors are also present, for example in areas where the custom of making strong alcohol from palm juice makes the transition to producing bio-ethanol a shorter process than in areas without such practices.

The next chapters are organised per type of energy product –SVO and biodiesel, bio-ethanol, and flue gas; each starts with the overview of all crops found in the field study and continues with elaborating on those selected. From those descriptions it will be clear that some crops are primarily cultivated by smallholders, whereas other crops are plantation crops. The transition from small-scale production by smallholders to a system that increases production of feedstock can change the way in which production is organised.

4.Crops for oil and biodiesel

4.1 Overview and priority selection

During the field study the team found 13crops with fatty seeds or fruits that could be suitable energy crops. Table 4 summarises the main characteristics of these crops that were used for making a priority ranking.

Table 4. Potential sources of SVO and bio-diesel in Sumba

	Name crop		**Wild and cultivated in Sumba per October 2011**				
	English and Latin	**Indonesian (in Sumba)**	**Characteristics, current use, cultural factors in Sumba**	**Concentrated in**	**Quantity Ha or ton, and score***	**Commoditisation potential as energy crop**	**Selected in this report**
1	Coconut (Cocos Nucifera)	Kelapa	Food, cooking oil, building material and cash commodity; extensive cultivation, building material	All over, best quality along the coast	4 36,505 ha	Established cash crop: copra. Price fluctuations; increasing demand coconut timber	yes
2	Physic nut/ Jatropha curcas	Jarak pagar/ damar	Traditional lamp oil – not used now; fencing plant; plantations since 2006	All over the island in fences	3 4,453 ha	Government promotion, high claims about crop	yes
3	Jatropha gossipifolia	Damar merah	Traditional lamp oil – not used now	Weed all over the north coast	4	Fruits do not contain much oil	no
4	Candlenut (Aleurites Moluccana)	Kemiri	Traditional lamp oil, Spice, kernel is cash commodity	All over hilly and humid part of island	5	Kernels well-established cash crop; broken kernels energy potential ; dried shells potential for gasification	yes
5	Horse radish tree (Moringa Oleifera)	Kelor	Survival food, leaves, vegetables	All over the island	4	Logistics problem (dispersion) and return on labour=?	no
6	Castor (Ricinis Communis)	Jarak Kepyar	Medicinal use	Rare, both in east coast interior Lewa	1	Possible see FFI in Lombok	no
7	Kusum (Schleichera Oleosa)	Kesambi	Firewood, host for shellac, fruits can be eaten	Dry areas all over the island	4	Possible, companies interested, but labour productivity=?	yes
8	Patchouli (Pogostemon Cablin)	Nilam	High quality oil for perfume	Lewa	1	High market demand for cosmetic sector	no
9	Cotton (Gossypium Hirsutum)	Kapas	Weaving, textile industry, cotton for lamps; plantation increasing	Plantations in East Sumba; plans every district	2 (4)	Seeds as waste product of plantation;	yes
10	Kapok (Ceiba Pentandra)	Kapok	Pillows and mattresses	All over the island, close to houses	4	Logistics problem (dispersion) and labour productivity=?	No
11	(Aleurites Trisperma)	Kemiri Sunan	Not yet cultivated. One of 4 bio-energy commodities prioritised by Ministry of Agriculture	One tree in front of government office	1	Not sure at all, many unknown factors	no
12	Pongamia (Pongamia Pinnata),	Malapari	Not yet. Often mentioned as a successor of jatropha.	Trial in Memboro	1	Not sure at all, many unknown factors	no
13	Nyamplung (callophyllum inophyllum)	Nyamplung	Not yet. Promoted as part of a programme by the Ministry of Forestry.	Not yet	?	Not sure at all, many unknown factors	no

* Hectares or production in tons in 2009 according to BPS statistics; relative score on a 1–5 scale: 5=very large, 1= very rare

Oil palm is by far the largest oil-producing crop in Indonesia, but is not mentioned in this list of crops that could be used for biodiesel production in Sumba. The first reason is that the tree is not cultivated in Sumba. The tree preferably grows in wet tropical lowlands.[27] It needs a humid climate without a long dry season. The climatic conditions in Sumba's flat lowlands are therefore not suitable. The only parts of the island where water requirements could be met are in the interior mountainous area, but nearly all the flat land with good soils in the island's interior are already used for rice cultivation. Modern oil palm cultivation also needs considerable labour input, which is not available in Sumba. The third reason for not considering it is that introducing oil palm to the island seems undesirable based on the negative environmental and social consequences that have already been experienced in other parts of Indonesia and the world.[28]

Before elaborating on the five most promising crops mentioned in Table 4,we will explain why the eight others receive less attention.

The horse-radish tree is a big tree with fine leaves that are used as vegetables.[29] The leaves are nutritious, and rich in protein. The seeds can be eaten as well, but it takes a lot of time to pick the pods and clean the seeds. The trees grow all over the island, but never in large quantities. Some trees are cultivated (sown, planted), typically as a tree for the home yard. To collect and transport horse radish seeds would be a challenge, and there is no demand for or information about prices that would convince smallholders that investing their labour in the collection of the seeds could provide sufficient returns.

Red jatropha is a wild shrub that grows all along the north coast, including in Waingapu. It is a persistent weed that sometimes grows in quantities that make it look as if it is being cultivated. In 2011 it was not used for any purpose. By contrast, castor is rare in Sumba. It is just occasionally used as home medicine. The team found a plant close to Lewa in the forest area, and one close to the sea in East Sumba, which gives the impression that castor might grow well in the various climatic zones of the island. Castor also had no known demand in Sumba as of October 2011; the seeds are therefore not generally considered worth collecting.

Kapok seeds also do not qualify as an energy commodity for smallholders because the quantity per smallholder is very limited, and there is no demand. Kapok seeds are not very productive sources for biodiesel, and so it is unlikely that any company would invest in production.[30]If a processing technology were found that used these seeds in combination with others as feedstock to produce economically feasible biofuel, it is worthwhile remembering that these trees are common all over Sumba.

Patchouli oil is too valuable to use for energy purposes, and the patchouli field that the team found in Lewa was just a trial plot. In a similar case, we did not find any example of tree crops that are often mentioned in Indonesia as promising sources of biodiesel or plant oil. What these tree crops have in common is that they are known elsewhere in the world, notably in India, for successfully producing oil, and are promoted by plant science or process technology researchers and sometimes mentioned as an option for Sumba. Pongamia could provide an alternative for jatropha curcas, or as a complement to more regular supplies to processing units. Preferred habitats include coastal and riverine habitats, primarily in humid tropical and subtropical areas (500–2,500 mm rainfall per annum). There has been a trial for setting up a Pongamia plantation in Memboro by the company Equitech. The owner of that company said that the plantation 'never got off the ground', but did not explain why.[31]
Nyamplung is another oil-producing tree. It has been promoted by the Indonesian Ministry of Forestry since 2008. A kilogram of dried *nyamplung* fruit could produce some 0.4 litres of oil. The claims regarding this tree are that utilisation of *nyamplung* as biofuel has an advantage compared to jatropha and palm oil. *Nyamplung* seed oil has good viscosity and the oil content reaches 50–70%. Other claims include that it can bear fruit throughout the year,

[27]See FAO document on modern oil palm cultivation for a list of practical requirements. Available from: http://www.fao.org/DOCREP/006/T0309E/T0309E01.htm.
[28]F. Danielson *et al.* (2008) *Biofuel Plantations on Forested Lands: Double Jeopardy for Biodiversity and Climate*. http://www.globalbioenergy.org/uploads/media/0811_Danielsen_et_al_-_Biofuel_plantations_on_forested_lands.pdf; M. Colchester *et. al* (2006) *Promised Land, palm oil and land acquisitions in Indonesia: implications for local communities and indigenous peoples*. Available from: http://www.forestpeoples.org/sites/fpp/files/publication/2010/08/promisedlandeng.pdf.
[29]http://www.reclaimaustralia.net/Herbs_are_special/DRUMSTICK%20TREE.pdf.
[30] http://www.lppm.itb.ac.id/wp-content/uploads/2011/03/IKR_ASEANENGINEERINGJOURNAL.pdf.
[31]Skype conversation with J. Vel.

the cultivation process is easy, and the process does not compete with the interests of their use as food. This tree is not yet cultivated in Sumba.

Among the recently promoted crops for biodiesel production is *kemiri sunan*. It is about to be introduced to Sumba, and the first sign was one, newly planted tree in front of the office of the SBD Agricultural Service in Tambolaka. Examples from Java promise a very high oil production per hectare: 10 tons per hectare per year. If the tree is indeed closely related to the common *kemiri* (candlenut), it has a good chance of growing well in Sumba. Kemiri sunan is one of the four official biofuel crops mentioned in the Ministry of Agriculture's Strategic Plan for 2010–2014, besides oil palm, coconut, and jatropha. *Kemiri sunan* trees take eight years to reach full production, however, which is why the crop has not been prioritised here.

Box 5 provides some relevant background information on the promotion of these crops.

Box 5. Plant politics and promotion of crops

Nyamplung, kemiri sunan, and *pongamia* are often mentioned as successors of jatropha, after jatropha fell out of grace and acquired a bad name because of poor performance in the field and disappointing results. The four successor crops have a similar organisational pattern of introduction and dissemination as jatropha. The trigger for promotion of the crop is a combination of the global debate around climate change and renewable energy, with the challenge for technical researchers (process technology, plant science) to test their laboratory findings in the field. The result is often an overly optimistic discourse of promises and claims. In fact, there is too little well-researched information about the crops, and there are no guarantees about performance in areas other than the original habitat. Through a variety of political networks, the positive discourse is translated into policy. For example, from 2004–9 the Ministry of Agriculture promoted jatropha, and since 2009 *kemiri sunan* has become fashionable. A policy comes with a budget, and many research institutes and lower bureaucracy of the Ministry are financially dependent on such budgets. After the programme period is over, the subsidy dries up, and the sector will only survive if it is truly economically viable. In the case of jatropha, nearly all activity ended after the Ministry's programme stopped; however, for some reasons, the crop is again one of the four bio-energy crops in the 2010–2014 Strategic Plan.[32] Indonesian bureaucratic logic also explains why some crops are propagated by the Ministry of Forestry and others by the Ministry of Agriculture. Bureaucratic interests require an on-going positive discourse, which cannot be understood as objective information. Some Indonesian and foreign companies use this positive discourse to attract international investors. These companies are sometimes just brokers, in search of short-term profits or a good salary for a few years for a couple of employees.

The next sections focus on crops that show better potential. The descriptions focus on current smallholder cultivation, processing, and marketing practices in Sumba; initiatives for increasing production, including plantations; and availability of resources for expanding cultivation, including labour issues and gender aspects.

4.2 Coconut

Coconut palms grow all over the island. It is a smallholder crop for household use and for earning some cash income. The trees are cultivated extensively, generally with no external input.
Consequently the yields are low. The BSS study mentioned a potential average yield of 20–24 tons per hectare on Sumba, whereas government statistics show average levels of 0.5 ton in Central Sumba to 1.28 tons in West Sumba in 2009.Women use coconuts for cooking, coconut oil for frying and for hair oil, and men and women use the leaves for thatching roofs and making brooms; sometimes they use husk as firewood, or as small brush, or as protection for small seedlings. The empty shells are sometimes used instead of firewood. The tree makes fine building material. The products that have cash value are young coconuts (for drinking), mature fresh coconuts, copra (dried coconuts), and homemade coconut oil. The best coconuts – in terms of high oil content – grow in the coastal areas. Several informants said that production of coconut in Sumba is declining. The main reason is that many coconut trees have been logged for timber. Timber demand is booming in Sumba due to fervent building activity following the influx of money from Jakarta after West Sumba split into three new districts. Meanwhile, government recently started strict enforcement of national park boundaries, limiting access to forests for logging.

[32] Peraturan Menteri Pertanian 15/Permentan/RC.110/1/2010, available from: http://www.deptan.go.id/renbangtan/Renstra%202010-2014%20-%20ISI%20view.pdf, page 248.

The market for copra is constant, but prices fluctuate. In September 2011 farmers in East Sumba (Waijelu) received Rp 4,000 for one kilogram of copra, whereas it has been double the amount in the past, so that farmers think the current price is very (or even too) low.

Coconut is a 'lazy crop'. Planting and picking fruits from the tree is men's work. In the villages, processing coconuts into coconut oil is more a women's task, as is selling nuts in small quantities. There are several initiatives for increasing production or increasing added value for smallholders. Yayasan Bintang Sumba/Bintang Belanda in collaboration with Yayasan Donders in Weetabula has a programme for increasing coconut production and processing it into high-value virgin coconut oil. Their website explains that

> the coconut project was launched in 2007, with the coconut plantations being turned into cooperatives. When their harvest is successful, the government gives the farmers fallow land to set up new plantations on. The VCO (virgin coconut oil) has been certified as Indonesia's highest quality oil! There is a huge demand for VCO both in Asia and in Europe, which means this product can be marketed on an international scale. The foundations are hard at work mechanizing the factory to increase production, which will in turn allow more coconut farmers to get a decent price for their produce and thus create more jobs.[33]

The programme will be further expanded with 'empowerment' and 'microcredit' in 125 villages in Sumba Barat Daya.[34]In Weetabula there was some VCO available in shops, at a price of Rp 25,000 per 100 ml. If the plans are implemented as announced, lower quality oil and waste products could be used for energy.
A larger initiative is the coconut biodiesel project of the Sumba Foundation, an NGO working in Wanokaka, West Sumba.[35] It is a USA-registered social foundation committed to poverty reduction in Sumba, founded by the owner of the luxurious Nihiwatu Resort. The resort consumes around 13,000 litres of diesel a month; this project aims to replace that fossil diesel with biodiesel made from locally produced copra. According to their website, the biodiesel project

> started constructing a production facility in July 2007 with a generous grant provided by the French cosmetics company Sisley. The construction and fit out of the factory was completed by April 2008 and in May we started production under the guidance of Martin Tobias. Martin was the former CEO of Imperial Oil, the largest bio-diesel producing company in the USA. Martin formulated the mixtures we needed for producing high quality bio-diesel from coconuts and trained our production staff. The operations of the production facility are now managed and staffed by The Sumba Foundation. Most of the processing is fully automated, but we do employ five staff from nearby villages. The equipment maintenance is provided by Nihiwatu Resort mechanics.

The same website claims the project could 'restore the local market for copra when they buy the harvest from an estimated 9,000 trees that are needed to produce up to 1,000 litres of bio-diesel daily'. Recently the Sumba Foundation bought copra for a price of between Rp 3,000 and Rp 5,000 per kilogram and sold the diesel for a price varying between Rp 7,000 and Rp 13,000 per litre to the resort.[36] Because copra is only produced in the dry season, the resort relies on common diesel during the rainy season. This project is very atypical, and can only be replicated when similar conditions apply. The capital and technology have been provided by the Foundation, the initial investments were subsidised, and the whole value chain is covered by one organisation, while the associated resort is the permanent buyer, at subsidised rates. The project nevertheless shows that biodiesel production in Sumba is possible. Within the framework of the Iconic Island Initiative, it would be recommended to explore options for using the same technology in other areas of Sumba where there is ample supply of coconuts. Rather than producing the diesel in the rural areas where there are no large consumers such as the Nihiwatu Resort, the technology could be applied by (or in collaboration with) traders who have already collected copra if a large buyer such as PLN or Pertamina would guarantee demand and a stable price. The government will likely support developing coconut biodiesel initiatives because coconut is one of the four bio-energy commodities in the National Strategic Plan for 2010–2014.

[33]See the 'projects' page on the Yayasan Bintang Belanda website: http://www.bintangsumba.org, accessed on 20-1-2012.
[34]Personal communication with Mrs Li Wong of Bintang Belanda in Weetabula, 30-9-2011.
[35]http://www.sumbafoundation.org/index.php/community_development_program/employment_and_economic_growth/the_biodiesel_project/.
[36] Information provided by Eco Matser from interview with Sumba Foundation on 1-2-2011.

Figure 7. VCO from Sumba sold in Weetabula SBD

4.3 Candlenut

The candlenut tree is a big multi-purpose tree native to the Indo-Malaysia region. Due to its many traditional uses and its role in ecosystems, candlenut is the official state tree of Hawai'i.[37] Forest officers of the Dutch colonial government already recognised the effectiveness of candlenut cultivation in the reforestation of former swidden sites in the 1920s.[38] In the 1970s and 1980s the government continued that colonial policy and supported candlenut cultivation by providing subsidies and seedlings for planting, and NGOs joined in promoting the tree. More than 20 years later the result is visible: in the moist areas of Sumba, it is a widespread tree. The total number of trees or hectares is not mentioned in government statistics; the only figures available concern annual total production: 800 tons in Central Sumba, 310 tons in West Sumba, and 710 tons in East Sumba.[39]The field study made it clear that these figures are in fact too low. The total production in one area in West Sumba collaborating with Satu Visi was already 585 tons/year, which exceeds the official production figure for the whole district (see Fig. 3 below). Moreover, the Head of Plantation Service in Sumba Barat Daya said that the highest total candlenut production is found in his district, but was not yet included in the statistics. The trader in Waikabubak who is the main buyer and exporter of candlenut estimated annual export from the three western districts in Sumba at around 3,000 tons.

Candlenut trees grow in home gardens, in and around farms, and along streams, gulches, and valley slopes. The tree is easily recognised by its characteristic silvery grey-green foliage. People in Sumba do not really cultivate candlenut (no particular care or inputs) but just gather the fruits that have dropped from the trees. Weeluri village in West Sumba even imposed a regulation that candlenut fruits may not be picked from the tree, in order to prevent premature harvesting. The season for harvesting is from early September to the end of December. 'It is a lazy crop,' according to the Head of the Agricultural Service in Central Sumba, who added that it is therefore very suitable to Central Sumba. Every member of the household is involved in candlenut activities. Women and children mostly do the gathering. The nuts have to be dried first. Children, women, and elderly people (whoever is at home as has nothing else to do) crack the nuts. The challenge is to keep the kernels intact, because broken kernels have lower market value.

During the harvest season candlenut can be sold every day, and can also easily be stored, depending on the household's needs for cash. Yayasan Satu Visi collaborates with candlenut-farmers groups in the Tana Righu sub-

[37]http://www.agroforestry.net/tti/Aleurites-kukui.pdf.

[38] See Tanaka Koji (2002) "Kemiri (Aleurites moluccana) and Forest Resource Management in Eastern Indonesia: An Eco-historical Perspective", http://www.asafas.kyoto-u.ac.jp/publication/pdf/no_02/p005_023.pdf, page 15.

[39] Figures from 2010 district reports of Badan Pusat Statistik, available from http://www.ntt-academia.org/.

district. This NGO conducted a household economy survey among famers and found they spend their candlenut income mostly on food, while male members of this group spend a large part on cigarettes and cell phone credits. When farmers collectively sell a product such as candlenut to a trader from town (who is then willing to send his truck to the village), the role of men in selling candlenut becomes larger than when the kernels are just sold in small quantities (but frequently) to village collectors. There is an important potential gender effect when increasing production and further organising the supply chain should candlenut be used for energy feedstock. Candlenut income is very important because it is earned during the planting season for food crops, which is usually the period of food shortages.

Traders buy the kernels for Rp 16,000–17,000 per kilogram, and a large trader in Waingapu said he bought broken kernels for Rp 8,000 per kilogram. The price of candlenut has been rising over the last few years and does not fluctuate the way copra prices do. The price in Sumba is determined by delivery contracts between industry on Java and traders in Sumba, and fluctuates during the harvesting season, with a peak in the first weeks when traders are eager to secure part of their contract obligations. The NGO Satu Visi monitored the quality, quantity, and prices of candlenut production among the farmers groups with whom they collaborate in West Sumba (see Fig. 3);80% of the kernels were whole, 15% broken, and 5% crumbled.

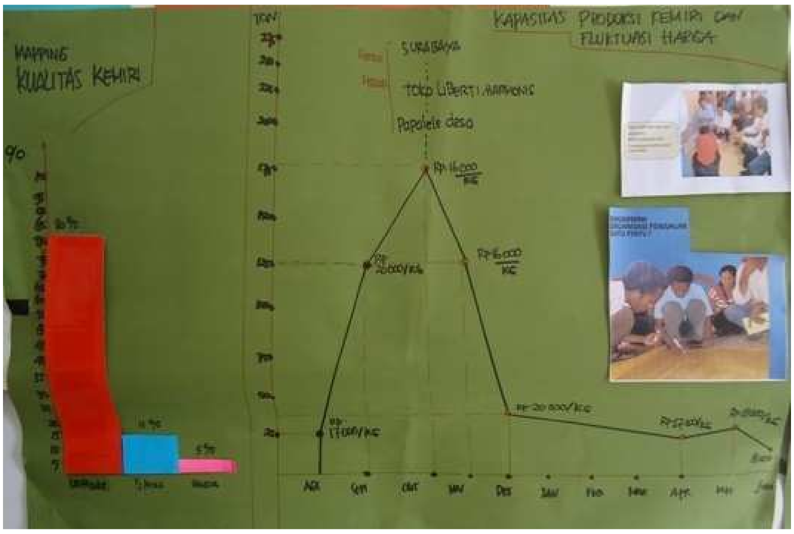


Figure 8. Yayasan Satu Visi's chart of candlenut production and prices from data of the farmers groups in their programme in Tana Righu, 2010-2011

In 2011 for the first time there was a market for dried shells. This will be further discussed in Chapter 6.5, where waste products that can be used for gasification will be discussed.

In general, farmers do not know what their candlenuts products are used for once they have been transported to other areas, nor what they *could* be used for. For example, a shop in Waikabubak sold candlenut hair oil for Rp 5,000 per centilitre, but it was produced in China. There is no candlenut processing on Sumba yet. As far as the producers in Sumba are concerned, they could just as well sell their candlenuts to a company for energy production, as long as they would get the same price as or a higher price than they receive now. Technically, biodiesel production from candlenut is possible. A study of the quality and processing options for candlenut oil concluded that it has a high iodine number (more than 125), and contains more than 7% free fatty acids. That would require an acid catalysed pre-treatment process with subsequent water separation steps for reducing the free fatty acids and water concentration to below the threshold limit.[40] Such technology is not currently available in Sumba.

[40]Hary Sulistyo, Suprihastuti S. Rahayu, I M. Suardjaja and Umar H. Setiadi (2009) "Crude Candlenut Oil Ethanolysis to Produce Renewable Energy at Ambient Condition", Proceedings of the World Congress on Engineering and Computer Science 2009 Vol I WCECS 2009, 20–22 October 2009, San Francisco, USA. http://www.iaeng.org/publication/WCECS2009/WCECS2009_pp85-88.pdf.

Broken and crushed kernels, as well as dried shells, have good potential as feedstock for energy production in Sumba, depending on the price. Traders in Waikabubak and Waingapu might be interested in any offer to sell both commodities to parties in Sumba, as it would eliminate the bulk of transport costs. Flora and Fauna International has a technology for using candlenut shells for renewable energy that they apply in Lombok.

4.4 Kesambi

Kesambi is a savannah tree found all over the island. According to LIPI research, there are approximately 24 million *kesambi* trees in the NTT province, and each tree should produce 10 kilogram of wet seed per year. That research argued that *kesambi* in East Nusa Tenggara has the potential to be developed for biodiesel, calculating that four to five kilograms of dry *kesambi* seed could produce one litre of biodiesel oil. Additionally, Antara News reported in January 2011 that a Japanese investor (Bec Japan) was interested and collaborating with the Bogor-based company Bogor Agro Lestari. The report claimed Bec Japan 'is ready with an investment of approximately Rp 50 billion.'[41] In March 2011 Deputy Governor of NTT Foenay said that in the Bolok industrial zone, the Department of Industry and Trade would start a trial for processing *kesambi* fruits with pressing machines that were formerly used for jatropha, and would buy the fruits from farmers for Rp 500 per kilogram.[42]

Kesambi used to be popular as a host for lac insects that produce valuable shellac (*kutu lak*). Because of bad harvests in India in the early 2000s demand and prices for shellac increased, and it turned into a boom commodity in Sumba. Only the branches with lac insects' nests should be harvested, but often people cut down whole trees in their rush to harvest the valuable commodity. The *kutu lak* boom in Sumba ended around 2008, when prices had fallen again, and *kesambi* trees could recover. The fruits can be eaten, but in Sumba they are mostly a survival food when nothing else is available. From the 18th century the oil from the seeds was known as 'Macassar oil', and used as hair oil. The ad in Fig. 4 is from 1895, and praises the oil as 'the best and safest preserver and beautifier of the hair, by far preferable to other hair restorers; it preserves and beautifies the hair, arrests baldness, removes scurf, and is the best Brilliantine'.

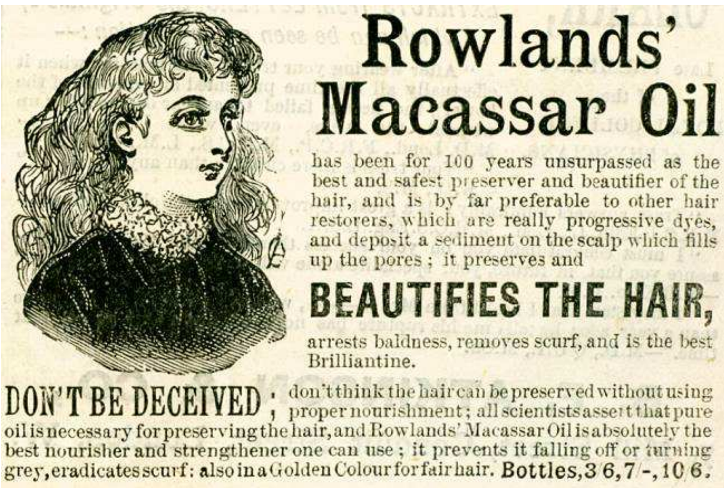


Figure 9. Kesambi oil advertisement.[43]

Kesambi seeds could be gathered in Sumba in large quantities. This is not just theoretical; it was also a concrete suggestion of one of the farmers attending the final field study discussion meeting. Whether people would be willing to gather the seeds depends on their assessment of return on labour compared to other activities. Gathering such seeds can be done by all household members, including women and children; commoditisation of *kesambi* seeds could therefore stimulate child labour. The result in terms of gender effects could be negative, increasing women's work burden with extra time gathering seeds. It could also be positive, insofar as revenue from *kesambi* seeds increases their income. The potential is still very uncertain, however, given that plans to develop the sector have only recently been announced in the media but yet not implemented, that there is no clear demand on Sumba, and that the technology for processing into biodiesel is not available yet.

[41] http://www.antaranews.com/en/news/67368/japan-interested-in-kesambi-oil-investment.
[42] http://bantenexpo2012.blogspot.com/2011/10/lipi-dan-ipb-lirik-biji-kesambi-ntt.html.
[43] http://www.historyworld.co.uk/advert.php?id=359&offset=0&sort=0&l1=Hair+Care&l2=Hair+Restorers.

4.5 Jatropha curcas

Whenever during the field study the team raised the issue of plants for energy production, jatropha would be the first example people mentioned. Next, they would tell why it had failed on Sumba. It was introduced to Sumba around 2005 through the Agricultural Service/Ministry of Agriculture as a crop for producing energy (and nothing else). Jatropha curcas (*jarak pagar*, or *damar*), is found all over the island, but mostly in the coastal areas, and planted as a hedge to keep the animals out of gardens. The leaves and seeds are sometimes used as home medicine. In 2006–7 many people planted seeds from wild shrubs because they heard they would get a good price for the crop. It turned out differently: at that time the only price that had been offered was Rp 500–750 per kilogram dried seed. One litre of oil needed 4 to 5 kilograms of seed. Mr Sulaimon of the PLN Persero in Waingapu tried to set up smallholder jatropha curcas production in Central Sumba, but found it was economically not feasible (especially given the subsidised price for diesel).

Since 2006 there have been various other initiatives for jatropha plantations. In Central Sumba, PT Cecilisara Abadi had been active for several years, but due to lack of investment capital the plantation never became a reality, although the company had produced seedlings in their nursery in Tana Modu in 2009.[44]

During this field study we particularly studied the PT Australasia Biofuel plantation, located in Memboro. There is a wide discrepancy between the plantation as described in the company's business proposal to the local government and what the team saw in the field and heard in interviews with main stakeholders. The plantation was planted in December 2010, and currently counts about 100 hectares. We visited at the end of the dry season, which is the worst period for such plantations. We saw a wide area planted with around 20 cm long sticks that appeared to be jatropha seedlings. There were about three or four local employees around when we visited. They said that the best part of the plantation, 'that was just about to be harvested', was burnt the week before because a bushfire had spread to the plantation. The plantation has a large nursery area, but there were hardly any plants in the nursery.

Figure 10. Australasia jatropha plantation Memboro

The land of the plantation is a flat, dry, and stony plane that was formerly used as an area for (extensively) herding livestock only. According to the 'local director', the company did not have much knowledge about how to grow jatropha, nor how to manage a plantation. Therefore they signed an agreement for collaboration with the Indonesian Center for Research and Development of Estate Crops (ICRDEC) in January 2010 in Bogor. The press announcement on the ICRDEC website said the institute would carry out training on Standard Operating

[44]For more information about this plantation plan see Vel, J.A.C and S. Makambombu, 'Access in Land Disputes Arising in the Context of Commercialization of Agriculture in Sumba (Nusa Tenggara Timur)'. Access to Justice in Indonesia Working Papers, Van Vollenhoven Institute Leiden University. http://media.leidenuniv.nl/legacy/a2jworkingpaper-jacqueline-en-stephanus.pdf.

Procedures related to jatropha cultivation and supply improved seeds.[45] The agreement also covered the establishment of Product Processing Unit to produce crude Jathropa oil, biodiesel, and other high-value products. It also promised that ICRDEC would 'prepare a jatropha agribusiness development model for NTT Province, as well build capacity of staff for implementation'. As of October 2011, however, there had been just a single visit by an expert from Bogor, who only took some measurements. The 'local director' said the company really needs good technical advice on cultivation and management of the plantation.

The team's visit to the site in Memboro and the additional information from interviews lead to doubts about whether this company is really serious about cultivating jatropha. The stories about it suggest it is a success, but there are rarely outside visitors who check the plantation site, because it is far from the main road. The team gathered some background information that could explain why there was not yet any sign of serious cultivation, in spite of the optimistic stories that we heard about it in offices. The summary of that information is that there is a pattern concerning non-implementation of plantation plans. There is never hard evidence, but many informants shared a similar analysis concerning practices of broker companies involved in starting plantations in Sumba. The land permits for plantation companies provide access to bank loans, and even only plans for jatropha cultivation can be sufficient to receive subsidies from a government or international donor agencies. When the plantation subsequently turns out to be a failure, the companies disappear, and so does the capital they received from banks, investors, or donor institutions. There is even a local term for this phenomenon: 'PT Akan', companies with (only) nice promises but no implementation.[46]

A different situation is found in Tana Rara (West Sumba), which was positively assessed in Hivos 'Preliminary Resource Assessment'. The trees there had been planted in 2004–5 by the Agricultural Service, and now looked really big and strong. It is not a common plantation but a '*kebun induk'*, a 'garden of origin' to keep the original high-quality plant material intact, with which the promotion campaign of the Agricultural Service started in 2005.This garden presents evidence that jatropha can grow well in Sumba.[47]The hilly areas of West Sumba are fertile and receive sufficient rainfall. At our visit in October 2011 the jatropha garden looked abandoned, but that could have been caused by the timing of the visit, at the end of the dry season.

In contrast to its poor performance in the field, jatropha still provides inspiration for inventing new technologies and depicting scenarios in which the crop is a source of a variety of products.

[45]http://iaard.go.id/news/one/44.

[46]J.F. McCarthy, J. A.C. Vel and S. Afiff (2012)'Trajectories of Land Acquisition and Enclosure: Development Schemes, Virtual Land Grabs, and Green Acquisitions in Indonesia's Outer Islands', *Journal of Peasant Studies*, 39 (2) pp.1-29.

[47]However, vegetative growth is not similar to productivity in terms of seed yield and oil content.

Box 6. New technologies and jatropha dreams

In Sumba, jatropha curcas is only known as a hedge plant and as an energy crop for producing plant oil or biodiesel. But in other parts of the world researchers are developing new technologies for producing more jatropha products than just oil or biodiesel from the seeds. In general, the idea behind these technologies is referred to as bio-refinery.[48] For example, a Yale study[49] calculated that with a feedstock of 177 kilograms of dry fruits (seeds and husk) oil extraction and refining would produce 46.7 kilograms of semi-refined oil, 51.3 kilograms of seed cake, 7.1 kilograms of residual oil and 65.5 kilograms of husk. A few technologies *–as described below in terms and arguments used by entrepreneurs seeking investors–*sound very promising:

(a) *Jet fuel* could be a high-value niche market for jatropha oil (but the idea of using jatropha for aviation fuel is also strongly criticised[50]). In the calculation above, the claim is that the 46.7 kilograms of semi-refined oil could produce 26.6 kilograms jet fuel.[51]One jatropha entrepreneur explained his plans for jatropha plantations in Central Sumba, using drip irrigation with water from 1,200 water wells in Memboro. He envisaged processing jatropha into semi-refined oil in Sumba, with a processing plant that produces 20,000 tons biodiesel/oil per year (using its capacity at a minimal economical scale). The entrepreneur claimed a production of 8 tons jatropha fruits per hectare, and he said he could produce for US$ 70 per metric ton, whereas the selling price was now US$ 700 (as of August 2011).The oil would then be exported as raw material for the jet-biofuel market (aviation) in Indonesia. Pertamina in Cilicap on the south coast of Java already produces 2% of the world supply of aviation fuel. In Memboro the department of transportation is working on a concrete jetty in the harbour where trucks can drive up to the ships that will transport jatropha oil to Java.

(b) *Jatropha can produce organic fertiliser* when the biomass from its fruit shells, seed cake, and plantation trimmings are converted into compost. The entrepreneur with the plans for Central Sumba said that when that compost is dried it naturally detoxifies. He was planning to ship organic fertiliser pellets for domestic sales to the Indonesian state-owned companies that have the licenses as fertiliser producers and distributors. Demand for this jatropha waste product is likely to increase, because new government policies have set a target of 40% fertiliser production coming from organic, renewable sources starting by 2015. The jatropha entrepreneur said that Pupuk Gresik already had offered him US$ 130 per metric ton waste in 2011.

(c) *Animal feed from kernel meal proteins* is an even more advanced product from jatropha curcas. At the International Conference on Jatropha Curcas in November 2010 in Groningen, Prof Harinder Makkar of the University of Hohenheim explained how the press cake of jatropha that remains after oil extraction contains a high percentage of protein.[52] His company secured an international patent on a method for detoxification of Jatropha curcas seed cake, kernel meal and protein isolate. These Jatropha products are destined for use as a protein supplement in feeds for fish, shrimp, aquaculture, pig, poultry, turkey, cattle, buffalo, sheep, goats, or other domestic livestock species. The detoxified jatropha kernel meal and protein isolate have protein contents of 60% (25% higher than soybean meal) and 90% (double of soybean meal), respectively. Prof Makkar said that 'detoxified jatropha protein isolate can replace 75% fishmeal protein without compromising growth and nutrient utilization in common carp'. This finding is important because it positions jatropha not only as a biofuel crop, but also as an animal feed crop. If produced in Indonesia, the oil products could be targeted at domestic consumption, whereas the kernel meal or protein isolate would be exported to international markets. The economic value of jatropha would increase dramatically, and the prices for jatropha seeds would no longer only depend on world crude fossil oil prices, but also on world

[48] Biorefining refers to the separation of biomass into distinct components which can be brought individually to the market either directly after separation or after further (biological, thermo-chemical/chemical) treatment(s).See also: http://www.biorefinery.nl/background-biorefinery/biorefinery-concepts/.

[49]R. E. Bailis and J. E. Baka (2010) Greenhouse Gas Emissions and Land Use Change from Jatropha Curcas-Based Jet Fuel in Brazil. Environmental Science and Technology, 2010, 44 (22), pp 8684–8691.

[50]Friends of the Earth strongly objects against this idea in the report "Biokerosene: take-off in the wrong direction", available from: http://milieudefensie.nl/english/biomass/biokerosene.

[51] Bailis and Baka, page 8686.

[52] http://www.jatrosolutions.com/index.php?option=com_content&view=article&id=91&Itemid=103&lang=en.

feed/food prices.

These new technologies have not been implemented outside the laboratories yet. Their success depends on many context factors that are often not (or very optimistically) considered in the calculated projections of their proponents. All these technologies are subject to intellectual property rights, which renders them publicly inaccessible. Jatropha jet fuel meets moral objections.With these considerations it is not very likely that in the short term these technologies and processing options plus marketing channels will become available in Sumba.

The conclusion is that as of October 2011 there had not yet been any serious jatropha production in Sumba. Smallholders produced a considerable amount in 2006, but became disappointed because the price for one kilogram was just Rp 500–700, too low in terms of return on labour. The price of jatropha is directly linked to the price of diesel, which is now Rp 4,500 per litre for household consumption (subsidised). The non-subsidised price is Rp 11,000 per litre, which would create an option to raise the price for farmers considerably. If an institutional buyer of feedstock (PLN or Pertamina) would secure a steady demand at a good price, smallholders would be more willing to grow jatropha. In that case it would have to be decided who would organise collection and processing. Large-scale production on plantations can only have a positive perspective if the jatropha agribusiness is no longer dominated by 'PT Akan'.

4.6 Cotton seeds

Cotton seeds contain oil, which, according to a review of alternative crop for biodiesel feedstock, can yield 340 kilograms oil/hectare.[53] Cotton is traditionally cultivated in Sumba for its fibres, and not for its seeds. Cotton is the basic material for the famous Sumba *ikat* cloths, but over the last century home-spun cotton has been partly replaced by imported machine-spun yarn. Where weaving is an important economic activity and source of income for the household,people are more likely to cultivate cotton for own use. Weaving and spinning is traditionally women's work. Because the woven cloth is very important in ceremonies, and additionally is a popular commodity for tourists, the sector remains important (albeit small). East Sumba is the centre of textile made from home-spun cotton. In smallholder cotton cultivation for weaving, the seeds could be regarded as waste products.

PT Ade Agro has a cotton plantation in East Sumba where the cotton seeds are not waste, but the main product. The only waste products are the dry plants that remain after harvesting the cotton. The plantation was set up in 2006, and after a difficult start it now produces high-value cotton seeds. According to the manager, the conditions on Sumba are excellent for cotton and the result is high-quality seed. The market value of cotton seeds is at least Rp 35,000 per kilogram.[54] The seeds are for domestic use in Indonesia and, the manager added, are not genetically modified. The Ministry of Agriculture's Plantations Department has chosen Sumba as the National Cotton Centre (Pusat Kapas Nasional), where farmers from all over Indonesia will be trained in high-tech cotton cultivation.

The national government supports cotton cultivation in order to reduce the country's dependence on imported cotton. PT Ade Agro is a subsidiary company of PT Adetex in Bandung, a textile company that needs large quantities of cotton. The plantation in Sumba is part of an integrated value chain owned by one company and its subsidiaries. The company cooperates with investors from Australia, and with such Australian seed-breeding research institutions as the Cotton Research and Development Centre (CRDC).[55] PT Ade Agro has three plantations in East Sumba, located on the flat lands along the east coast: the first, and at around 6,000 hectares the largest, is situated in Laipori (sub-district Pandawai), a second in Ngohung (sub-district Kahaungu Eti), and a third in Lawila (sub-district Pahunga Lodu).

[53]Razon, L.F. (2009) Review: Alternative crops for biodiesel feedstock. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 2009 4, No. 056, page 6. Available from: http://www.cabi.org/cabreviews.
[54] Price mentioned by farmers in Lombok. Dewanto Lestari (2011) 'Benih karisma harapan baru mutu kapas' Antara News 24-11-2011.
[55]http://ditjenbun.deptan.go.id/semusimbun/semusim/index.php?option=com_content&task=view&id=137&
Itemid=37 (accessed May 23, 2009).

Figure 11. Mechanised cotton cultivation at PT Ade Agro's plantation in East Sumba

During the field visit in October, a wide area of cotton in Ngohung was being harvested with a harvesting combine. The plantation thus offers a view of the large-scale mechanised agriculture that is so hard for Sumbanese farmers to imagine; unfortunately, the plantation is not open to the public. Besides the harvesting machines, the plantation also uses large centre-pivot irrigation equipment, which uses water pumped from several bore-holes. The manager told us that not every hole they bored touched ground water, but in the middle area it was sufficient for irrigation this season. In the processing hall they have a machine for cleaning cotton and separating the seeds. Originally this plantation promised employment opportunities for the local population, but the manager now admitted that they had problems in attracting local labour, so that they decided to move to full mechanisation. The effect is that there is little benefit for the local population in terms of income generation.

There are plans for establishing more cotton production areas in Sumba, including in West Sumba (Lamboya), where cotton will be intercropped with maize. As long as the cotton seeds are the cultivation's highest value commodity, using them as feedstock for energy production will not be a feasible option.

4.7 Conclusion

Among all the crops on Sumba that could be used for SVO or biodiesel production, coconut and candlenut stand out as the best potential options. *Kesambi* is widely available but gathering and organising the supply chain still presents an important challenge. Jatropha curcas has a recent history of failure and only if steady demand and a fair price for farmers are secured will smallholders be willing to cultivate the crop. Large-scale jatropha initiatives so far have not produced any successful implementation. Cotton seed production is concentrated in several areas, but currently the seeds are sold as seed material (for sowing) at such a high price that biodiesel production from cotton seeds is unfeasible.

5.Crops for bio-ethanol

5.1 Overview and selection

During the field study the team found nine crops that could be suitable for bio-ethanol production. Table 5 summarises the main characteristics of these crops that were used for making a priority ranking.

Table 5. Potential sources of bio-ethanol in Sumba

	Name crop		**Wild and cultivated in Sumba per October 2011**				
	English and Latin	**Indonesian**	**Characteristics, current use, cultural factors in Sumba**		**English and Latin**	**Indonesian**	**Characteristics, current use, cultural factors in Sumba**
1	Sugar palm (Arenga pinnata)	Enau/ Aren	Wild, not tapped, sparsely: black fibres for roof thatching or brooms	Found close to Lewa (Tana Rara)	1	Highly promoted,and success in Java and Kalimantan	Yes
2	Palmyra palm (Borassus flabellifer (Linn.)	Lontar	Building materials, juice, sugar, alcohol; extensive cultivation; cultural connection with Savunese	Along the east coast	3	Established cash crop for sugar and alcohol (illegal)	Yes
3	Nypa (Nypa Fruticans)	Nipah	Leaves for roofs; wild palm tree, rare	Brackish water: Wanokaka, Lenang	1	Scale too small, suitable locations limited	No
4	Sweet potato (and other tubers)	Patatas	Subsistence food, leaves as vegetables; pig feed	In the hilly part of Sumba	2	Priority for subsistence food crop	No
5	Cassava (Manihot Esculenta) (a) local (b) industrial varieties	Ubi kayu	(a) Subsistence food, pig feed, leaves as vegetables; (b) Cultivation industrial varieties developing	In the hilly part of Sumba	3 16,381 ha		(a) No (b)Yes
6	Sorghum (a) traditional (b) sweet sorghum (Sorghum bicolor (L.) Moench)	(a) Jagung rote (b) Sorghum manis	(a) Food in dry coastal areas, 'poor man's food'; associated with Savunese, and with poverty (b) Large scale smallholder cultivation promoted by Agricultural service	(a) Dry coastal areas (b) East Sumba (Haharu) and Central Sumba	2	Potential for sweet sorghum; in Oct 2011 just plans. Corporations interested.	Yes
7	Maize (a) local variety (b) hybrid (for industrial processing)	Jagung (a) lokal (b) hybrida	(a) Important food crop, some for animal feed (b) Cash crop, increasing corporate involvement. Waste could be used for energy as well	(a) Island-wide (b) Island-wide	5 37,398 ha	(a) Subsistence crop (b) highly promoted by government, corporate involvement	(a) No (b) Yes
8	Sugar cane (Saccharum spp)	Tebu	Traditional candy, animal food; advanced plans for huge plantation. Waste product bagasse for energy	All island garden crop; plantation in Kodi	1/ 5	National priority crop for sugar consumption, Government promotion, corporate initiative. Bagasse for energy.	Yes
9	Cashew apples *Anacardium occidentale* L.	Buah Jambu Mente	Waste product of cashew nut cultivation.	Most in Sumba Barat Daya and East Sumba	3 29,461 ha	Cashew nuts have well established supply chain; potential depending on logistics and processing cost.	Yes
* Hectares or production in tons in 2009 according to BPS statistics; relative score on a 1–5 scale: 5=very large, 1= very rare							

Before elaborating on the most promising crops we first give some explanation why four crops receive less priority.

Nypa palm grows in brackish water, and is the only palm considered to be a mangrove tree. According to secondary information

> Nypa palms produce large quantities of a sugar-rich sap that can be used for ethanol production. Nypa palm has been reported to have ethanol yields ranging from 6480 to 20,000 liters/ha, which makes it several times more productive then the sugarcane. Nypa palms can be tapped after they are 5 years old and continue to produce until they are about 50.[56]

During our field study we encountered nypa trees twice: close to the beach in Wanokaka, on the south coast, and in a coastal marsh close to Lenang in the north coast of Central Sumba. The trees are rare and not cultivated in Sumba. The leaves are sometimes used for thatching roofs. In East Sumba there is still a considerable area of mangrove along the east coast, but we did not have opportunity to check if it included nypa trees. There is no use of this tree at the moment, and no organisation that supports cultivation in any way, so the process of commoditisation would involve a major transition process. The tree only grows in brackish water. Because conservation of still-existing mangrove is important as nature conservation and protection of the coastal environment (including protection against tsunamis), replacing existing mangrove trees with nypa does not seem a feasible option.

Sweet potato (and other roots and tubers), local cassava, and local maize are not selected as a priority crop for a very different reason. Smallholder food crops are in principle not suitable for energy production, because they provide food security. There is a distinction between the local, traditional varieties of these crops, and new high-yielding varieties for industrial processing. Often the difference is not very clear to smallholders in Sumba because companies proposing contract farming do not provide information about the food characteristics of new varieties, nor the purpose of the products. Maize and cassava are discussed below, not because we intend to promote their use for energy purposes, but because large-scale schemes are currently being developed in Sumba and might even include ethanol production on the island, or in other parts of Indonesia.

5.2 Sugar palm

Sugar palm is currently just a wild tree in Sumba. Locally it is called *enau*. With the plant expert from Yayasan Sumba Sejahtera, I.G. Made Raspita, we searched and found a few trees in Tana Rara, not far from and southeast of Lewa, close to a spring and in a small forest. The local population there does not use the tree. Local informants said the fruits itch or cause blisters when touched. In other areas of Indonesia the tree is popular for sugar or alcohol production. A success story of a sugar palm farmer in the district Garut of West Java indicated that it is possible to sell Rp 2,8 million worth of sugar palm sugar *per day*, as a product of just 40 trees. That West Javanese farmer could continue tapping during 11 months of the year, every day. [57] Moreover, a recent report by Ecofys and Winrock indicated that:

> Although a limited number of scientific studies are available on sugar palm, they all suggest that under the right conditions sugar palm can be very productive, with ethanol yields even exceeding those of sugar cane. Furthermore, sugar palm is praised for requiring little maintenance and growing in harmony with other natural forest ecosystem components (including valuable timber trees and food crops such as bananas, cocoa, vanilla and cloves) which can generate additional incomes to the farmer from the same piece of land.[58]

In Sumba sugar palm apparently already exists, which suggests that climatic and rainfall conditions could be favourable in Lewa, but conditions in coastal areas need to be examined. The success story in West Java is in a district with average rainfall of about 2,600 mm per year, in a mountainous area. Additionally, 'the right conditions' also means the right economic and social circumstances. In the West Java case, Bandung is close by and the vicinity of large cities implies a stable and continuous market for sugar palm sugar. In Sumba, those conditions are

[56]http://www.bioenergywiki.net/Nypa_palm.

[57]Faiz Yajri (2011) 'Aren mesin uang', *Trubus* 550 (December 2011) 142-3.

[58] Sugar palm ethanol: Analysis of economic feasibility and sustainability, Ecofys and Winrock, commissioned by Agency NL, October 2011. http://www.agentschapnl.nl/sites/default/files/bijlagen/Ecofys%20and%20Winrock%20-%20Sugar%20palm%20ethanol%20-%20August%202011_1.pdf.

not yet present. The transition from nearly no trees to commoditised production on a scale large enough for processing will be significant. If sugar palm could be intercropped with *lontar* palm, the transition would be not as large. *Lontar* has similar product and processing characteristics, and is already well established in Sumba. However, sugar palm 'thrives best in a warm tropical (equatorial) climate with plenty of sunshine and abundant rainfall'.[59] That means it is not suitable in the dry coastal areas where Savunese cultivate *lontar* palm. The option that Savunese – skilled palm juice tappers –would move to the mountainous inland areas is unlikely, because their livelihoods are based on combining fishing with *lontar* tapping, and they usually do not have access to land in the interior.

5.3 Lontar

Lontar (Palmyra palm) is a palm tree that grows along the northeast and east coast of Sumba. The main product is the sap obtained from tapping the inflorescences, which can be consumed immediately, be processed into sugar, or be allowed to ferment for a few hours to becomea toddy. It is typically associated with the Savunese. In his classic book *The Harvest of the Palm*, James Fox describes the traditional *lontar* palm culture and economy on the islands of Savu and Rote, where the palm traditionally is a major source of food. In Sumba the Savunese – who often have lived there for generations –are the ones who use the tree and harvest its sap. They are often not the owners of the land, however, and can at best be called tree-share croppers. Men tap the trees, women cook (desiccate) the sap into palm sugar, and both men and women collect firewood for cooking. If the sap is kept overnight it will turn into toddy, a light alcoholic drink locally called *duwe* or *tuak*. Some specialised cottage-breweries distil *tuak* into arak (local: *peneraci*, or *peci*) and so gain added value.

Figure 12. Tapping lontar juice

The district governments in Sumba declared production and selling alcohol above 8% as illegal; however, that has not ended production or trade, but in fact created an opportunity for police officers to get involved in *peci*-trade. It did not end consumption either, and alcohol has become a problem in Sumba.[60]*Peneraci* is a traditional form of bio-ethanol. The tappers sell the products locally, and this petty commodity trade is not mentioned in district statistics. Total lontar production in Sumba is zero, according to the provincial statistics about plantations, probably explained by the fact that *lontar* is classified as an 'estate crop', but is not cultivated in Sumba on estates. With our own eyes we saw many trees cultivated by local people, and an Indonesian study published in 2010 estimated that there were 1,1 million *lontar* trees in East Sumba, of which a third are sap-producing.[61]

[59] Ecofys and Winrock, 2011 page 10.
[60]See many newspaper articles about '*miras'* (strong alcoholic beverages), for example: http://www.tribunnews.com/2011/02/18/bupati-sumba-tengah-musnahkan-350-liter-miras.
[61]Parlindungan Tambunan (2010) Potensi Dan Kebijakan Pengembangan Lontar untuk menambah pendapatan penduduk (The Potential and Policy for Lontar Development to Increase the People's Income), *Jurnal Analisis Kebijakan Kehutanan* 7(1), April 2010: 27–45.

The transition from a low-external-input, smallholder, Savunese share-cropping farming system to a commercial activity will imply changes in many respects. If juice tapped from the trees is sold directly for ethanol production, the income generating activities of sugar production (women) and alcoholic drink production (some specialists, men) will no longer exist. There is also the question of what will happen if people can no longer buy the local *peci*? How the benefits of the ethanol production will be distributed among tappers and tree/land owners is another question to be answered. Still, the option of *lontar*-based bio-ethanol production is worth exploring for the east coast of Sumba. However, neither the Plantation Service, private companies, nor NGOs are active in exploring the potential of *lontar* in Sumba (yet).

5.4 Cassava

Cassava is a traditional food crop. With maize it is the most common crop that people in Sumba grow in their dry land gardens, and often close to their houses as well. Cassava leaves are used as vegetables, and for pig feed. The roots are a staple food, but not as appreciated as rice: poor people who cannot afford to eat rice eat home-grown cassava. It is typically a food security crop: it can be left in the garden until there is no other food left. It is a subsistence crop, with an average yield in Sumba between 6,800 and 10,600 kilograms per hectare, according to government statistics from 2009. It is generally not commoditised. It is a crop cultivated by the poor, and most tasks are performed by women.

Cassava cultivation for industrial processing uses a completely different system. The variety is different, with higher content of starch and lower protein. The yield per hectare can be many times more than the current volume, but that also requires external inputs. The theoretical yield level that the BSS mentioned was 25 to 30 tons per hectare. 'Industrial cassava' is less suitable for human consumption. It requires a well-established supply chain, with a steady demand and fair prices for smallholders. There is no company on Sumba yet that buys cassava for animal feed and ethanol production. Smallholders would become contract farmers, and perhaps earn more income, but commercial cassava farming would also increase their dependence on price fluctuation of products and inputs. A predictable gender effect is that men will be engaged in commercial cassava cultivation rather than their wives, with a contract with the cassava company in the husband's name.

It might be worthwhile to explore the options for cassava as feedstock for ethanol production, but there is a food security risk. In Sumba Barat Daya, especially, surplus production seems feasible as additional smallholder activity. Cassava cultivation is traditional, it is a 'lazy crop', and, according to farmers in Waijewa, they would like to plant more if they could get a good price for it. Smallholders would have to be fully informed about the differences between traditional and industrial cassava. By way of comparison: in the commercial smallholder farming system of South Sulawesi this crop does not need any promotion by government, just a steady demand with a fair price is sufficient to convince farmers. The Head of the Agricultural service SBD is currently designing a policy to promote this production, and has been in contact with cassava corporations.

5.5 (Sweet) Sorghum

Sorghum (*jagung rote*) and maize (local variety) are traditional food crops in Sumba. The characteristics are different from those of the varieties cultivated on plantations, just as in the case of cassava. Plantation varieties are selected for industrial processing for food products, non-food products and ethanol, and production for animal feed. The plantation companies do not explain this difference between local and industrial varieties in Sumba, but speak about sorghum and maize in general. Because these crops are food crops, the companies involved prefer the plasma model, which is politically more appropriate than the *inti*-model (see Box 4), and if smallholders cultivate the crop for a company on their own land there is no need for corporate land acquisition. From various interviews concerning on-going negotiations with companies, we concluded that the basic model is contract farming, but adapted to existing social organisation and hierarchy.

Sorghum is an alternative to maize that yields better in dry areas, especially if there is no irrigation available. Sorghum cultivation in Indonesia has been constantly decreasing since 1989 because the price of sorghum was lower than that of maize, no government programme focused on intensive cultivation of the crop, and the grain is susceptible to storage insects. Sorghum grain may be a substitute for maize in animal feed. In Sumba, *jagung rote* grain is rarely sold in the market, and if so as food for race horses. Women in Haharu said they prefer other food to this local sorghum because preparing a meal of sorghum takes a relatively long time.

Sweet sorghum (*sorgum manis*) is a type of sorghum that is cultivated because of the high sugar content of the stalks. That makes it very suitable for ethanol production. The Dutch Ministry of Economic Affairs (Agency.nl) supports the development of sweet sorghum as a source of bio-energy, because

> research in India shows that sweet sorghum offers commercially attractive and sustainable bio-ethanol. So far, it has hardly been used as a source of bio-ethanol, but only as cattle fodder. Since you cannot make sugar from sorghum, cultivating it for bio-ethanol doesn't compete with food production. More research is needed, however, before it can be cultivated on a large scale.[62]

The grains, which account for about 10% of the harvested crop, can still be used for food, while the stalks are processed for ethanol. The waste product can be used afterwards as well. Proponents not only mention the positive food security aspect of the crop, but also the fact that it is drought resistant, needs about a third of sugar cane's water requirement, and costs much less than sugar cane in terms of external inputs.[63] If all these claims are true, it would be the best potential crop for the north coast of Sumba. Figure 7 shows a diagram from by the Nimbkar Agricultural Research Institute (NARI) in India explaining which products can be made from sweet sorghum.

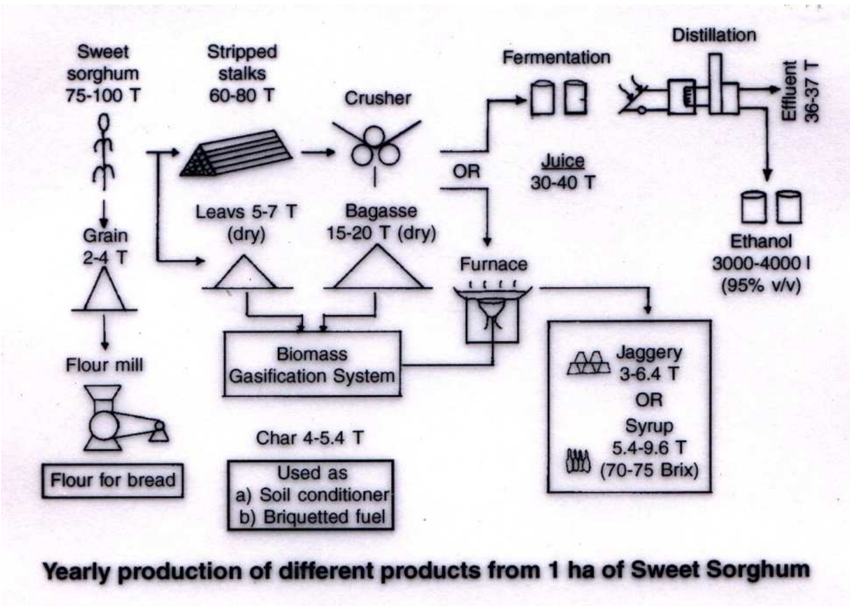


Figure 13. Sweet sorghum processing and products[64]

In East Sumba we found plans to cultivate sweet sorghum on the plains along the northeast and east coast. We saw freshly ploughed fields in Haharu, waiting for the first rains to be sown with sweet sorghum. The Head of the East Sumba Agricultural service interestingly pointed at the long standing Sumba-Savunese traditions of cultivating this crop (*jagung rote*), whereas the Service is promoting *sweet* sorghum as a commodity. In Central Sumba, the Head of the Agricultural Service told us about a plan to grow sweet sorghum on the rice fields during the dry season. Those plans have not been realised as yet. In Central Sumba, the company PT Kairos Sumba Lestari was granted a location permit for sorghum cultivation and a sheep ranch in Memboro in 2009, but it never materialised.

Sweet sorghum cultivation in Sumba shows very good potential on paper. Ethanol production will require that a company set up production and organise processing and marketing. For smallholders – if they are to be involved – it will be a totally different farming activity than their former traditional sorghum cultivation.

[62]See http://www.agentschapnl.nl/programmas-regelingen/search-best-sweet-sorghum, accessed on 22-1-2012.
[63]Belum V S Reddy, A Ashok Kumar and S Ramesh (2007) Sweet sorghum: A Water Saving Bio-Energy Crop, available from http://www.icrisat.cgiar.org/Biopower/BVSReddyetalSweetSorghumWatersavingJan2007.pdf
[64]http://www.nariphaltan.org/nari/technology_agri_2_sorghum.php, accessed on 22-1-2012.

5.6 Hybrid maize

Maize is widely cultivated in Sumba. It is an important food crop, especially for people who cannot afford to eat rice three times a day. Farmers cultivate it on the dry land, usually two crops per year: from the first rains in October or November until February, and then a second crop from the end of February until May. Maize is an indigenised crop, and has been on the island for at least several hundred years. The local variety is tasty, and farmers keep a number of ears as seed for the next year, storing it either in a tree or under the highest part of the roof, where the smoke from the cooking fire will preserve the seeds and protect them from insect infestation. Traditionally, maize is not a commodity but a subsistence crop. Women provide the larger part of labour in maize cultivation. Crushing maize manually is a lot of work for women; a maize mill (using energy) would help lessen the burden.

Figure 14. Storing maize seed in a tree, Lenang, Sumba

Farmers on Sumba differentiate between hybrid maize (alien cash crop, to be treated commercially) and local maize (sacred food crop, used in rituals, important for food security). Studies about the adoption of hybrid maize by smallholders have shown that the transition for subsistence maize cultivation to commercial cultivation of hybrid maize 'tends to reduce women's share in crop management and decision making, independent of the farm size', and that men shift their activities towards this cash crop cultivation and receive the larger part of the income earned.[65] Hybrid maize cannot be stored well, and therefore it is not possible to keep seeds for the next season. Instead, farmers have to buy seeds each season. Hybrid maize requires external inputs: fertiliser and, if necessary, pesticide. It also requires good land and sufficient water. Consequently, improved maize will not be cultivated in marginal lands but on good quality agricultural land. If not all good quality land is already cultivated, there is a potential for adding maize plantations or extra smallholders' gardens to existing food crop cultivation.

Hybrid maize has been known in Sumba for at least 10 years, and propagated by the district government in collaboration with a number of companies. Since 2009 there has been a province-wide programme for increasing maize production.[66] The goal is 6% growth of production in the province per year up to a total production of more than 1 million tons maize (dry seeds) by the end of 2013. The increased production is meant for industrial processing in food products, animal feed (50–60% of total), and for bio-energy, according to the website of the Ministry of Agriculture in NTT. In Central Sumba the term in 2009 was *jagungisasi* (maize promotion) in which every household was urged to plant (at least)1 ha with maize.

[65]S.K. Kumar (1994) Adoption of Hybrid maize in Zambia: Effects on gender roles, food consumption and nutrition. Research report 100, Washington DC: International Food Policy Research Institute.
[66]See http://www.nttprov.go.id/distanbun/index.php?option=com_content&task=view&id=22&Itemid=36.

The Provincial government of NTT has announced its priority to make NTT 'The Maize Province', following the example of Gorontalo in Sulawesi. In September 2010 the NTT government allocated Rp 1 billion of the 2011 annual budget for stimulating maize cultivation.[67] The Agricultural Service and Plantation Service are the institutions which take a lead in that programme (and in spending the budget). The provincial government's vision is that NTT should produce maize commercially, for export to other parts of Indonesia, and for other purposes than food only. Using maize for ethanol production fits in with that policy. There is also direct support for growing hybrid maize from the national level of the Ministry of Agriculture. The Head of the SBD Agricultural service told us that each year the district receives high-yielding variety maize seed 'from Jakarta'. The Service distributes it to farmers, who have to repay at harvest time on a 1:1 ratio. The repayments form a source of income for the district government. In contrast to the provincial policy, the district government explains the maize policy as support for food production in poor parts of the country. It is common knowledge, however, that hybrid maize is sold for export to other areas in Indonesia. Figures on the total volume of exports to other islands are not available.

During the field study, staff of the Agricultural Service in Waikabubak (West Sumba) told us about collaboration with PT Pangan Agro Nusantara. In September 2011, the company applied for a location permit of around 2,000 hectare close to the capital town Waikabubak, and West Sumba's Bupati had already replied positively. The Agricultural Service staff said that the company would cultivate maize as feedstock for ethanol production, and that it would build an ethanol factory in Loli. It is hard to assess whether this is really a serious plan. The company PT Pangan Agro Nusantara is – according to its letterhead–a subsidiary of the Sampoerna Agro group, a large Indonesian oil palm company. It seems that this company has not been active in maize cultivation before. One reason for this plan in Sumba could be that this company is looking for land as a capital investment.[68]Additionally, this oil palm company aims to become a multi-plantation company. The head of investor relations said about a sago plantation acquisition, "in the long term there is a possibility to convert the acquired business into a biofuel producer, but now we are still focusing our business on palm oil."[69] The Agricultural Service staff said that Pertamina would buy the ethanol produced in Loli. When the team checked this information with the Pertamina head office in Waingapu, the director did not know about such a plan. He added that he does not have the authority to decide about buying such feedstock, because he is in charge of fuel distribution in Sumba only. It would be good to ask the Pertamina Head Office in Jakarta for more information, because – if really implemented – this plan would fulfil part of the Iconic Island goals.

In Central Sumba and East Sumba we obtained information about another company, PT Pramana Celebes Agri Resources (PCA). PCA obtained a location permit for 500 hectares in sub-desa Wai Manu, Central Sumba, on 1 November 2010, and as of October they had acquired 65 hectares. According to the District Government of Central Sumba, the company intends to work according to the inti-plasma model.[70] Interestingly, PCA is approaching smallholders for collaboration through the institutional and social network of the Protestant Christian Church, which is an island-wide organisation covering about 60% of the population. If members of Church congregations would plant as little as half a hectare per household, the total area could reach more than 50,000 hectares. In return, the company provides the Church with some financial assistance. The company's brochure identifies the main activity of the company as 'Green Commerce', explaining that:

> In promoting better community living standards the company works hand in hand with surrounding communities and governments, to develop plasma farmers. The corporation provides price guarantees and collects all harvest into its central warehouse. These product are then promoted and traded globally. A portion of the profits generated are reinvested into the system to develop more plasma farms. Having signed MoUs for prospective Integrated Green Industries Locations (Lokasi Industri Ramah Lingkungan Terintegrasi), the corporation has the largest land bank in the eastern part of Indonesia.

From this quote it seems PCA is above all a trading company that will export maize produced in Sumba to destinations outside the island. The team could not find information on the Internet about this company.

[67]http://nttprov.go.id/provntt/index.php?option=com_content&task=view&id=1873&Itemid=1.
[68] http://www.agroasianews.com/news/corporate-news/11/07/18/sampoerna-agro-push-capex-spending-second-semester.
[69] http://www.thejakartaglobe.com/business/sampoerna-agro-mulls-making-biofuel-from-sago/369093.
[70] See also http://sumbaisland.com/pca-resources-kembangkan-jagung/.

5.7 Sugar cane

Sugar cane is a tall perennial grass of the genus *Saccharum*. Is has been common in Sumba for a long time, used for chewing (local type of candy) and occasionally as cattle fodder. According to the linguist Onvlee there was an expression in local ritual speech saying “sugar cane on the mountain ridge, bananas at the boundary”, referring to a separating fence, and is a metaphor for a mediator between two contesting parties.[71] The expression suggests that sugar cane was not a crop for the dry coastal plains, but rather cultivated in the mountains where there is more rainfall. Nowadays, people in Sumba always buy sugar and it is an important daily household expenditure. Sugar cane is not an important crop in the traditional farming system.

As of 2011 there have been plans for turning a large part of Kodi (the very western part of the island) into a sugar cane plantation. PT Wilmar will cultivate sugar cane on at least 25,000 hectares, and build a US$ 100 million sugar-processing factory. The factory could provide a large amount of renewable energy. During the field study, Australian technicians with the company estimated that the factory in Sumba could deliver up to 30 Megawatts to the electricity grid, which exceeds the current capacity of the electricity grid in West Sumba many times. Proponents of these plantation plans argue that it will bring prosperity to the population: employment, electricity, services, and compensation for their land. These assumptions might be overly optimistic, however, and a negative impact on local food security is likely.

The legal status of the land on which these developments are planned is rather unclear. Before 2005, a large part of the planned sugar cane area in North Kodi was (extensive) grazing land for livestock, and it was partly used as a cattle ranch by a Chinese entrepreneur from Waikabubak. When Sumba Barat Daya was about to become an autonomous district, a group of people who are currently SBD government officials took the initiative to start cultivating the area, as private activity. This can be seen from the rectangular plots, prepared using big, government-owned tractors. As of late 2011, they were still cultivating maize in those fields.

The plantation plans started this year, when PT Wilmar’s quest for land in Indonesia brought it to Sumba. PT Wilmar is Asia’s leading agribusiness group, with headquarters in Singapore (see box 7). In Sumba they operate through their subsidiary company PT Gunung Madu Plantations (GMP) with technical input from an Australian sugar company, Sucrogen, that is also a part of the Wilmar conglomerate. Two technical staff told us that the climate and soil conditions in Kodi are suitable for cane. In Kodi the sugar content was 21% in the trials, which is very good (highest in Australia is 26%). Water availability may not be sufficient throughout the planned area, however, especially in the north. In October 2011, company teams and local government conducted *sosialisasi*, familiarising the local population with crop and plantation plans ‘from the top to the village level’. In July 2011, PT Gunung Madu Plantations organised a trip for 70 important stakeholders from Sumba Barat Daya to visit its plantation and factories in Lampung, accommodating them at a fancy hotel and flying them with a chartered airplane. A smaller group, including the Bupati and the main heads of services and departments, were invited to Australia in August to visit the factory’s activities there. These trips convinced the SBD government that the company is really serious. In October 2011 we saw the draft location permit concerning 25,000 hectare, but the company’s technical staff told us that PT Wilmar intends to get at least 50,000 hectare in Sumba.

[71] L. Onvlee (1984) Kamberaas (Oost Soembaas)-Nederlands Woordenboek. Leiden: KITLV. Page 492 ‘tibu’.

Box 7. A self-porttret of two parts of a sugar conglomerate -

Sucrogen Limited is the largest raw sugar producer in Australia, the second largest exporter of sugar globally, and the seventh largest producer globally. It owns seven sugar mills capable of producing in total 2.1m MT of raw sugar per year. The mills also produce by-products including molasses, which is used to produce ethanol and is also sold as stock feed. Sucrogen generates electricity from cogeneration operations at each of its seven sugar mills and is Australia's largest renewable energy generator from biomass, with a total cogeneration capacity of 171 MW. Through its interest in Sugar Australia and New Zealand Sugar Company, Sucrogen is the largest sugar refiner in Australia and New Zealand with its three sugar refineries capable of producing 970,000 MT of sugar annually. Sucrogen is Australia's largest producer of sugar-based ethanol, which is used as an additive in fuel and for a range of industrial purposes. Sucrogen produces fertiliser using by-products from its sugar milling and ethanol distillation processes.

Wilmar International Limited, founded in 1991, is today Asia's leading agribusiness group. It ranks amongst the largest listed companies by market capitalisation on the Singapore Exchange. Its business activities include oil palm cultivation, edible oils refinery, oilseeds crushing, edible oils processing and merchandising, specialty fats, oleochemicals and biodiesel manufacturing, and grains processing and merchandising. Headquartered in Singapore, its operations are located in more than 20 countries across four continents, with a primary focus on Indonesia, Malaysia, China, India and Europe. Backed by a multi-national staff force of more than 80,000 people, over 300 processing plants and an extensive distribution network, its products are sold to more than 50 countries globally. Over the years, it has established a resilient integrated agribusiness model that captures the entire value chain of the agricultural commodity processing business, from origination and processing to the branding, merchandising and distribution of a wide range of agricultural products. Through scale, integration and the logistical advantages of its business model, it is able to extract margins at every step of the value chain, resulting in significant operational synergies and cost efficiencies.

Source:http://www.wilmarinternational.com/news/press_releases/Wilmar_SGXNet_press_release_05072010.pdf.

The company's negotiations with the local landowners about compensation for land use began in October 2011. We heard that the price for land use (*sewa lahan*) varied between Rp 6,5 and 7 million per hectare, but it was not clear to all informants whether this amount would be paid annually or just once for the whole 35 year period. Company officials said the company had to make a socially accepted deal with the population because they could not afford the risk of land conflicts around a sugar factory worth 100 million dollars. A farmer told us that he does not like the prospect of losing his land sovereignty, but that it is difficult for the common farmers (but not government officials/land owners) to voice their interests. When 25,000 of the 60,000 hectares of suitable land for agriculture in the whole district (according to the head of Agricultural Services) will be used for sugar cane cultivation, that cultivation will probably have a negative effect on food production in this most densely populated district of Sumba, with around 400,000 inhabitants.

PT Wilmar's head of sugar estates explained that the company's sugar operations use a 'flexible model' of combining manual labour with mechanisation, depending on the availability and cost of labour compared with mechanisation. In Australia, work in the field is completely mechanised, in Java it is all manual. Labourers in Sumba will be hired for Rp 850,000 per month, the official minimum wage in NTT. In Australia, labourers in rural areas can earn AUS$ 150,000 per year (in 2011)[72]; hence there is a lot of mechanisation. If the 25,000 ha would be operated solely with manual labour, they would need around 10,000 people, about a third of whom could work all year round. The rest would be seasonal work in the crushing season.

According to PT Wilmar's head of sugar estates, it takes at least three years to start operations. First the plant material needs to be produced and checked whether it is disease free. It also takes two years to design and build a sugar factory. When the plantation is in full operation, the cane will be cut every year. New cane will grow from the roots that remain in the soil. That cycle lasts for a period of five years. Then the company ploughs the fields and cultivates a nitrogen-fixing plant for half a year, for example mungbean, or peanuts. A new five-year cycle

[72] The exchange rate for 1 Australian dollar was around Rp 9500 in November 2011.

follows. Shorter periods are not feasible because planting cane is very expensive. This means there will be no rotation system, as was common in the past in Java.

The processing factory will produce sugar, ethanol, and bagasse as waste product. The latter is used to produce energy, first of all for operating the factory itself, as well as electricity for the whole plantation complex. In October 2011 the company planned to make pallets of bagasse for export because of demand on the world market for this renewable energy feedstock. Another option would be to supply to the electricity grid in Sumba. From the point of view of the company, the feasibility of supplying to the PLN depends on the price for electricity per KW hour. The head of sugar estates explained that sugar mills are not 100% reliable electricity providers. Usually they only supply electricity during the dry months, which in Sumba conditions would be about five months, from July–November. If they would store fibre, they could provide electricity for eleven months, but that is more costly. The company usually takes the 'black energy value' (=from coal) as alternative when calculating whether their energy production from sugar is feasible. During the field study we noticed that there had not been any discussion between the government, the company, and PLN about this option for electricity production.

For the Iconic Island initiative sugar cane is an important biomass for energy activity, because of its enormous scale. There might be an opportunity for Hivos to act as a facilitator of discussion about producing energy from sugar cane waste. Ethical questions regarding food security and land sovereignty must nevertheless be taken into consideration. Interestingly, the head of the Agricultural Service in Central Sumba declined proposals for sugar cane plantations in 'his' district for those reasons, arguing that sugar cane needs first class soils, which are also the best for food production.

Figure 15. Farmer shows sugar cane field trial

5.8 Cashew apples

Cashew is a tree that is cultivated for its nuts. The nuts have been a main commodity for Sumba since the end of the 1990s. The cashew apple is an accessory fruit (sometimes called a pseudo-carp or false fruit) (see Figure 9). It is pear-shaped and ripens into a yellow or red structure about 5–11 cm long. It is edible, and has a strong 'sweet' smell and a sweet taste. The pulp of the cashew apple is very juicy, but the skin is fragile, making it unsuitable for transport.[73]

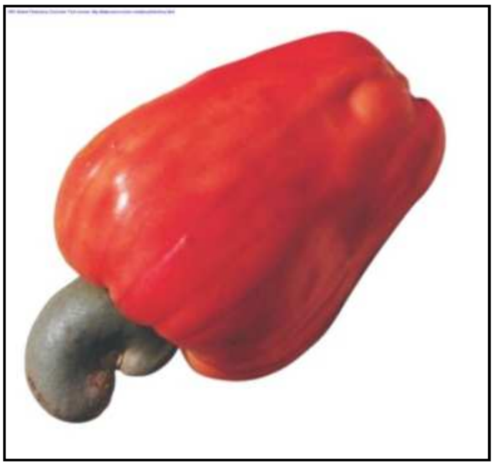


Figure 16. Cashew apple and nut[74]

Cashew production takes place all over Sumba, but is mainly concentrated in East Sumba and Sumba Barat Daya. In the early 1990s the government stimulated cashew cultivation and provided free seedlings to smallholders. Initially, just a few farmers planted cashew trees, but when the cultivation turned out to be profitable, more followed. It is a smallholder cash crop; mostly they cover between 1 and 3 hectare, with an average of 100 trees per hectare.[75] In 2009 the total production according to the official government statistics was around 2,000 tons of unpeeled nuts in East Sumba and 6,000 tons in Sumba Barat Daya.

The crop promotion in the 1990s included the promise that there would be a factory in Sumba for processing so that the farmers were assured that there would be a steady demand for cashew, but the factory never materialised. There are minor initiatives for processing in Sumba, and some shops in Waingapu sell locally-produced cashew nuts for consumption. Sumba's smallholders are primary producers of raw (unpeeled) cashew nuts. There is a well-established supply chain for cashew nuts. Village collectors transport the nuts to Waikabubak and Waingapu; there the nuts are dried and exported from the island to Surabaya. Then a part continues the journey to India for further processing. The majority of consumers are in Europe and the USA. The apples remain on Sumba as waste.

Cashew apples are sweet. Around 10% of their weight consists of carbohydrates.[76] In Goa, India, the cashew apple is mashed, the juice is extracted and kept for fermentation for two to three days. Fermented juice then undergoes a double distillation process that results in an alcoholic beverage of about 40%.[77] Cashew apples thus have a potential as feedstock for bio-ethanol. This option was also proposed by one of the farmers from Kodi who attended the final meeting of the field study.

When cashew apples are used for processing on a larger scale, some of the main challenges are to motivate cashew farmers to collect the apples (offer a price that is high enough), and to organise transport (the fruit is highly perishable and its skin fragile). Perhaps there are small-scale options for bio-ethanol use from cashew apples,

[73] http://en.wikipedia.org/wiki/Cashew
[74] Image from: http://img.21food.com/20110609/product/1306582318463.jpg
[75] Data from pre-study about the cashew value chain by Kornelius Bale Mema.
[76] Morton, J. 1987. Cashew Apple. p. 239–240. In: Fruits of warm climates. Julia F. Morton, Miami, FL.
[77] http://en.wikipedia.org/wiki/Cashew.

using a technology similar to that now being developed for other waste fruit.[78] Another characteristic of cashew apple production is that it is seasonal, with a peak at the end of the dry season. The consequence is that processing facilities cannot be supplied year round with this feedstock.

5.9 Conclusion

Among all the crops in Sumba that could be used for bio-ethanol production, there is not one single outstanding option. Every crop seems to have arguments in favour and against being produced as energy feedstock. In the final chapter we indicate which of the bio-ethanol options above we think should be prioritised for further action. Together with the local smallholders and traders organising ethanol production from cashew apples and *lontar* sap, there are options to explore. When large-scale schemes for sugar cane, maize, sweet sorghum or cassava are implemented – for other reasons than producing renewable energy in Sumba – we recommend initiating discussions with the government, companies, and other relevant authorities to explore the options of using (part of the) production for renewable energy generation in Sumba.

[78] S. Kusumaputri, A. Titisari and D.D. Tanjung (2011)'Salak jadi bensin', Trubus 505 (December 2011) pp 136–7.

6. Feedstock for gasification

6.1 Overview and selection

During the field study, the team found six types of feedstock for gasification. Five of these are waste products that remain after the harvest or after processing. Table 6 summarises the main characteristics of these crops that were used for making a priority ranking.

Table 6. Potential feedstock for gasification in Sumba

	Name Crop and waste product		**Wild and cultivated in Sumba per October 2011**				
	English and Latin	**Indonesian**	**Characteristics, current use, cultural factors in Sumba**		**English and Latin**	**Indonesian**	**Characteristics, current use, cultural factors in Sumba**
1	Maize (Zea Mais) Stalks and empty cobs	Batang dan tongkol jagung	(a) Waste of smallholder cultivation (b) Waste of large-scale cultivation	1	Maize (Zea Mais) Stalks and empty cobs	Batang dan tongkol jagung	(a) Waste of smallholder cultivation (b) Waste of large-scale cultivation
2	Rice (Oryza Sativa) Husks	Sekam Padi	Rice is top food crop, cultivated wherever possible in valleys. Threshing and winnowing in the field, husks are burnt afterwards. One or two harvests a year	2	Rice (Oryza Sativa) Husks	Sekam Padi	Rice is top food crop, cultivated wherever possible in valleys. Threshing and winnowing in the field, husks are burnt afterwards. One or two harvests a year
3	Coconut (Cocos Nucifera) Shells	Tempurung kelapa	Household use as alternative firewood; otherwise just waste	3	Coconut (Cocos Nucifera) Shells	Tempurung kelapa	Household use as alternative firewood; otherwise just waste
4	Wood chips	Potongan Kayu	There are no permanent saw mills on Sumba. Custom to saw timber at building site, thus wood chips are dispersed	4	Wood chips	Potongan Kayu	There are no permanent saw mills on Sumba. Custom to saw timber at building site, thus wood chips are dispersed
5	Elephant grass (Pennisetum purpureum)	Rumput Gaja	Some is grown for animal fodder close to dry land gardens. Culture of burning fields in dry season	5	Elephant grass (Pennisetum purpureum)	Rumput Gaja	Some is grown for animal fodder close to dry land gardens. Culture of burning fields in dry season
6	Candlenut(Aleurites Moluccana) Dried shells	Kemiri: kulit kering	Waste; replacing firewood or charcoal; since 2011 commodity for export to Lombok	6	Candlenut(Aleurites Moluccana) Dried shells	Kemiri: kulit kering	Waste; replacing firewood or charcoal; since 2011 commodity for export to Lombok
* Hectares or production in tons in 2009 according to BPS statistics; relative score on a 1–5 scale: 5=very large, 1= very rare							

Wood chips and elephant grass were on the list of potential gasification feedstock in the 'Biofuels Sumba Study'. Wood chips are the waste product of sawmills, or more generally, sowing timber. In Sumba most timber is sown by specialists who own sowing equipment (chain saw). People who are building a house or need wood for any other purpose usually buy timber trees and then hire a wood sawyer. During the field study we did not hear of any sawmills where wood chips could be found in sufficient quantities to turn into feedstock for gasification.

A second item on the list of the 'Biofuels Sumba Study' was elephant grass. Whenever smallholders cultivated this type of grass in Sumba it has been for animal fodder and erosion prevention, in their dry land gardens. The quantities are small, and elephant grass is not commoditised yet.[79] There is not yet much experience in the world with elephant grass as energy source, and Sumba does not seem to be the best place to start the experiment.

[79] Information from Petrus Pandanga of YSS, 14-2-2012.

Elephant grass needs quite a lot of water (like sugar cane) and thus cannot grow in dry areas.[80] If the land, water, and labour were available, smallholders would prefer either food crops or cash crops with the highest return on their labour. The data for this calculation were not available. In general, larger-scale grasses cultivation is vulnerable when located in areas where people usually burn the field in the dry season. That happens in many 'idle lands' because it is a labour-saving technique for clearing the field of old grasses and making way for fresh sprouts that is good fodder for livestock.

The other four types of feedstock all concern crop cultivation waste products. Below we will mention what we learned about the current use of waste products, and give an indication of the available quantity and where on Sumba the largest quantities are concentrated.

Box 8. What is waste?

Using waste streams to generate energy is the basis of the idea of 'third generation' biofuels, which do not compete with food production (first generation) and require no extra land for their production (second generation). By using the entire plant and not just the edible parts, a large volume of biomass becomes available as feedstock for energy production – but what is to be considered 'waste'? For the cases we consider in this report the term 'agricultural residue' would be more correct.[81] That refers to all the organic materials produced as the by-products of harvesting and processing agricultural crops. These residues can be further categorised into primary residues and secondary residues. Agricultural residues generated in the field at the time of harvest are defined as primary or field-based residues (e.g., rice straw, sugar cane tops), whereas those co-produced during processing are called secondary or processing-based residues (e.g., rice husk and bagasse). It is a matter of perspective whether agricultural residues are waste or useful by-products. For example, maize stalks have other uses as cheap organic fertiliser or cattle fodder. If the agricultural residues are removed from the fields and used as energy feedstock, there should be a solution for the alternative purposes that can no longer be served. Additionally, when agricultural residues are commoditised, they can no longer be considered 'waste' because they have a market value. The residues can even become more important that the original commodity, as in the case of the cotton plantation, where the main product is no longer the fibre but the seed. The on-going development of new technologies can turn the priority ranking of products made from one single crop upside down. Jatropha was introduced as a biodiesel energy crop, but new technologies are being designed for making protein-rich animal feed out of the press cake, which could render biodiesel a side product from jatropha as food crop.

6.2 Maize stalks and empty cobs

In section 5.6 there is a description of traditional maize cultivation and the programmes for large-scale maize production that are currently being planned in Sumba. Basically, both types of maize cultivation system could yield waste streams that are valuable sources of energy.

In traditional cultivation, empty cobs and dry stalks are considered waste, but in practice they often have a purpose. When available, women use corncobs in cooking as replacement of (or in addition to) firewood. Technology for using corncobs in an efficient way is not yet available in Sumba. The stalks that remain in the field after harvesting the cobs are often used as fodder for cattle and water buffaloes. Collecting dry maize stalks from the fields seems impracticable, because the fields are scattered throughout the hills, which makes collection and transport costs high.

Collecting maize waste in centres of large-scale cultivation is more feasible. Then it depends on what parts of the plant the business plan considers waste. In the current proposals for maize plantations, it is not clear what kind of technology for harvesting and processing will be used, and what kind of and how much waste will remain in Sumba. For example, when maize is harvested mechanically for animal feed, the whole plant, including the cob, is cut and processed into feed. In that case there are no stalks and empty cobs left. When the maize is cultivated for

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[80] M. Osava (2007) 'Elephant Grass for Biomass', IPS News, available from: http://ipsnews.net/news.asp?idnews=39592, accessed on 18-1-2012.
[81] This definition and explanation is a quote from J. Singh and S. Gu (2010) 'Biomass conversion to energy in India—A critique', *Renewable and Sustainable Energy Reviews* 14 (2010) 1367–1378, p. 1372.

its grain, a special combine known as a 'picker-sheller' could be used, which removes the ear from the plant, removes the husks from the ear and shells the grain by removing the kernels from the cob. The remaining biomass could be used for energy production. The prices and production costs of the alternative use of maize stalks will decide the feasibility of the energy option.

When maize companies in Sumba contract farmers to cultivate maize (grain) for the company according to the plasma model, empty cobs and stalks will remain in Sumba. Naturally, the same logistical problems exist as for traditional maize cultivation.

6.3 Rice husks

Rice is the number one food crop in Sumba. There is a distinction between dry land rice (*padi ladang*) and wet rice (*padi sawah*). The best quality rice according to many people in Sumba is the famous dry rice from Kodi. Productivity is relatively low, however, and cultivation is gradually declining. In contrast, farmers will cultivate wet rice wherever possible. Across Sumba are valleys with rice fields. In rain-fed areas, there is usually only one crop per year. Where the rice fields can be irrigated from a river or a spring, there are two crops a year. Three crops per year, known in areas, such as Bali, with abundant rainfall, is very rare in Sumba. In the dry season most springs and rivers do not have enough water for irrigating fields. This means rice harvests in Sumba are seasonal, and concentrated in July and August. The availability of waste from rice cultivation is therefore also seasonal.

Threshing and winnowing is traditionally done in the field, and the remaining husks are burnt in the field afterwards. In some reports the term 'husks' also implies the waste product from rice mills (or from pounding rice at home). That type of husk also contains parts of the grains, and thus has nutritional value. In Sumba such waste is used for animal feed; chicken and pigs eat what remains after pounding, and some people buy husks from rice mills (*dedak*) to feed their pigs and horses, especially in the dry season, when fewer fodder grasses are available.
Compared with the circumstances in some areas in India and China, where rice husks are successfully used for energy generation, conditions on Sumba are less suitable, especially because of the seasonality of supply, the dispersion of the fields, and alternative uses of rice mill waste.

6.4 Coconut shells

In section 4.2 there is a description of coconut cultivation and current programmes for processing coconut into bio-diesel and virgin coconut oil. Coconut shells are sometimes used as alternatives for firewood, or as material for cups and spoons, but mostly they are just waste – waste which could be used for energy production. Because the largest quantities of coconut shells are concentrated in centres of copra production, it would be logical to set up facilities for energy production from shells in those centres as well, if the energy is used for local energy requirements. If, following the assumption of this study, this feedstock would be used by Pertamina or the electricity company PLN, a follow-up study should specify minimum scale, appropriate logistics, and economic conditions under which this option would be feasible.

6.5 Candlenut shells

In section 4.3 we described the current farming system and supply chain for candlenut products. The main commodities that smallholders sell in Sumba are the nuts and the kernels. These smallholders who sell kernels produce shells as by-product. Until 2010 the shells were merely waste. Parts used to be dried and stored, and used in the rainy season for cooking, when firewood does not burn well because it is wet. Farmers in Weeluri in West Sumba said the shells are also currently used as building material: mixed with cement they make strong material.

In 2011 there was a market demand in Sumba for dried candlenut shells, for the first time ever. The off-farm price in West Sumba was Rp 200 per kilogram, whereas the main trader in Waikabubak told us that he would sell to traders outside Sumba for minimally Rp 500, because otherwise it would not cover his costs. A village trader in Weeluri in West Sumba said that a company from Java had ordered 2,000 ton from Sumba, whereas the trader mentioned 'Lombok'.[82] The shells are used as energy feedstock, replacing or in combination with charcoal, and they last much longer than charcoal. If this demand persists, it will be an extra stimulus for smallholders to sell

[82]The NGO Flora and Fauna International has been buying candlenut shell in Lombok for Rp 1200 per kilogram (source: Rafiastanto, Andjar (2011) 'Developing Candlenut and Castor bean supply chains in Lombok Island, Indonesia', presentation at Master Class Agriculture beyond Food, Cipayung 1 December 2011). This could have caused or raised demand in Sumba as well.

kernels instead of whole nuts, and sell the shells as well. Because women (and children) do most of the shelling a gender effect of increased demand for dried candlenut shells can be that women will have an extra work burden.[83] This feedstock for energy is in many ways similar to the case of coconut shells. Here too, a follow-up study should specify minimum scale, appropriate logistics and economic conditions under which this option would be feasible, if - following the assumption of this study - this feedstock would be used by Pertamina or the electricity company PLN.

Figure 17. Candlenut shells collected by Toko Liberty Waikabubak

6.6 Conclusions

This chapter provided an overview of five waste streams and one crop that could be used as feedstock for gasification. It was not possible to assess the real potential of using these waste products as energy feedstock in Sumba based on the current field study because there are no data on waste streams, and the options are still rather hypothetical. There are nevertheless three general observations. First is that it will be very important to pay continuous attention to how the plantations now being planned in Sumba will use waste products once implemented, and to discuss that with companies and government. Second, coconut and candlenut shells are already amply available for use for energy purposes. Increasing demand for candlenut shells might have negative gender effects, because it would increase the workload for women. Third, we would like to stress that context characteristics are very important for success or failure of the application of technologies for turning agricultural waste into electricity or gas. For example, whether the technology is applied in an area with intensive farming systems, good roads, and high population densities – as in Java – or in sparsely populated areas without infrastructure, as in Sumba. The context affects the cost of applying the technology and thus its feasibility. There are not many roads and their quality is low, and smallholder fields are scattered all over the area. This will increase transport costs from the farmers' fields to collection and processing centres. The question remains: who will organise the value chain for waste products from smallholder cultivation? Assumptions 3 and 5(see chapter 1) render this question beyond the scope of this study, however.

[83]J. Rosser (2005) 'Community and Gender Aspects of a Proposed Candlenut Oil Processing Facility in Timor-Leste'. USAID. Available from: http://pdf.usaid.gov/pdf_docs/PNADC642.pdf

7 Best options for increasing energy feedstock production

In this final chapter the team presents a priority list of 'best options' for increasing production of energy feedstock in Sumba. The options are phrased as proposals and recommendations to Hivos. The team took all the considerations mentioned in the previous chapters into account, trying to make a synthesis based on criteria that actually cannot be measured by one single standard. While reflecting on all those considerations after the field study and presentation of preliminary results, we saw a pattern that helped us draw conclusions and identify best potential options. The next section first presents that pattern; then this final chapter continues with the best smallholder production options, and the options linked to large-scale agricultural schemes.

7.1 Patterns of change towards energy feedstock production

When the team organised the list of plants and trees found in the field study, it used the classification according to types of bio-energy products. That is also the structure of Chapters 3–5 in this report. After the field study and writing the report, however, we concluded that there is a pattern to what we regard as best options. Table 7 presents the pattern as a rubric in which four categories of agricultural change are subject to four considerations for assessing their potential as energy supply sources.

Table 7. Comparison between processes of change involved in transition towards large-scale production of energy crops.

	Change proces	**Size Transition**	**Quantity of feedstock in short term**	**Social sustainability**	**Serious plans/ implementation**
1	Commoditisation of wild plants and trees	Large	Small	?/+	No
2	Introduction of new energy crops (to smallholders)	Large/medium	Small	?/+	No
3	Change of use of existing smallholder cash crop cultivation	Small	Medium	?/+	Yes
4	Introduction Plantation agriculture a) smallholder contract farming - 'plasma' (b) inti-plantations	Medium Large	Large Large	?/-+ -	Yes Yes

For the commoditisation of wild plants and trees in Sumba, we can take the example of *kesambi* and sugar palm. The idea of using these trees for biofuel production originates in research institutes and application in other places in Indonesia or other countries. Neither is part of the existing farming systems and therefore the transition to commercial production will be significant, including allocating labour, organising collection of products, finding technology, etc. Although the theoretical production potential of wild crops might be large, we assess that their contribution to energy feedstock production in Sumba will be small, most of all because of lack of labour, knowledge (technology), and infrastructure. Plans for commoditisation of wild plants and trees sometimes exist, but as of October 2011, they remained vague and unimplemented. Our conclusion is that this whole category should not be prioritised, not because commoditisation is impossible, but because the transition process is too long and uncertain and will not yield as much as the other options. In the example of sugar palm, there are hardly any sugar palm trees yet, they grow in (humid) areas without a culture for tapping palm juice, and there are no current initiatives for introduction. Every aspect of cultivation and supply chain would have to be set up from scratch.

In the change process of introducing new energy crops in Sumba there is always an actor actively promoting this crop. The hope or assumption is that, if provided with information on cultivation practices and technology (and usually also seed or planting materials), smallholders will adopt this new cultivation and start producing. Other positive assumptions concern social sustainability: that land and labour are available, and that prices for farmers are high enough to make cultivation profitable. In the past this was successful for candlenut and cashew, but recently it failed in the case of jatropha. If the new crop is similar to currently cultivated cash crops, the transition process might not be overwhelming. For the energy crops that were considered newly introduced during the field study, we did not find any serious plans yet. Examples were *nyamplung, pongamia*, and *kemiri sunan*. In general, it takes a long time to set up a new cultivation sector –at least ten years. Candlenut and cashew are now well-established cash crops and thus part of the next category.

The third category concerns well-established smallholder cash crops. Currently, they are produced for export from Sumba to other parts of the country, because there is no consumer demand in Sumba. If there would be demand for the same products for use in Sumba – in this case as energy feedstock – it would likely entail economic improvement for farmers. There would be fewer transport costs in the supply chain from farmers to end consumers. There is an ethical issue, however: whether cash crops from Sumba that are processed into food for consumption elsewhere in Indonesia can be used for energy production on the island. Coconut and candlenut are examples of such cash crops that are used in Java for cooking oil and cooking spices, respectively. Waste products from these established cash crops can be used for energy production much more easily without provoking such ethical dilemmas. Coconut and candlenut shells and cashew apples are examples.

The last category of change in agriculture occurs when plantations are introduced. As explained in box 4, a plantation can either use the plasma system of collaborating with smallholders, or the nucleus (inti) system of having one large plantation operated by the company, or a combination of both. Compared with independent smallholder cultivation, the transition process to producing energy feedstock using the plantation system is large. Plasma systems are less threatening to social sustainability than nucleus plantations, because the land remains the property of smallholders, whose collaboration with the company will generate income. It all depends on the terms of contract farming what the effect will be on food security, freedom of smallholders to decide what to grow and how to do that, vulnerability to price fluctuations, and gender division of labour. If people in Kodi work as plantation labourers in the sugar plantation they will earn the minimum wage during the labour season, and become dependent on the market or their relatives for food. We therefore assess a serious chance that the social sustainability of such plantations will be negative. By contrast, in terms of energy feedstock production, the plantations are the most important suppliers in Sumba. There, production – and waste–is concentrated in large quantities, and there is a serious company organising production and the rest of the supply chain. That company could act as a supplier of energy feedstock to Pertamina or the PLN. It depends on the weight attributed to social sustainability whether these plantations should be seen as positive or negative developments.

The commoditisation of agricultural waste is also a process of change that is part of the transition towards large-scale production of energy feedstock. This is not regarded as a separate process, however, because producing waste is per definition linked to cultivating crops for their primary products. Commoditising waste will nevertheless have its own effects that should not be overlooked. For example, creating a market demand for dried candlenut shells will reduce the availability of the shells for cooking (as replacement of firewood), and increase the amount of household labour for shelling (mostly women and children), but also will raise smallholders income (men and/or women).
With this pattern of change processes and assessment criteria in mind, we have made a priority list for Hivos to discuss with authorities and local stakeholders, and for follow-up activities.

7.2 Best potential smallholder energy crops

In general, producing energy feedstock from the crops that we categorised in Table 6 as 'well-established smallholder cash crops' should receive priority. These options score best on all criteria discussed in this report.

Coconut: copra and shells

Coconut seems to have the best options as smallholder energy crop in Sumba. Current production levels are quite low, however. Stimulating better cultivation practices would be a better way to increase production than expanding the area planted with coconut. Assuming that Pertamina or PLN will provide a steady demand at a good price, there are several options and challenges for increasing production. One challenge is finding an alternative for coconut timber, so that nut production will no longer decline as the trees are logged for timber. Another challenge is to upgrade production levels without increasing labour input too much. The opportunities for coconut as energy feedstock are considerable because supply chains for copra and fresh coconuts are already well established. The transition from production for export to production for local energy requires reorganisation of the supply chain, and thus negotiations with collectors, traders, and processers in Sumba. The technology for producing biodiesel from coconut is available from the Sumba Foundation, and the challenge is to upscale this model for wider use. That technology could be applied close to (or in collaboration with) traders who currently collect and produce copra in Sumba. The waste products from copra production can become a valuable source of energy. One option concerns using the waste and lower quality products from projects for producing virgin coconut oil, which are being organised by Foundation Bintang Sumba and Yayasan Donders in Weetabula. The NGO Satu Visi is also a good partner for further developing plans regarding coconut, because their experienced local staff have been working with coconut farmers for years. In East Sumba there is well-established, high-quality production, too, but there is no NGO involved in supporting farmers to upgrade production.

Candlenut: crumbled nuts and dried shells

There is a large production of candlenut in Central Sumba, West Sumba, and Sumba Barat Daya. Candlenut is purely a smallholder commodity, without government programmes supporting it; the supply chain is organised by local traders. The NGO Satu Visi is already collaborating with candlenut-farmer groups in Tana Righu, West Sumba. With a current off farm price of Rp 16,000 per kilogram kernels, biofuel production from candlenut kernels does not seem feasible. Using broken or crumbled kernels that have a lower market value (around Rp 8,000/kilogram) could be an economical option for biodiesel production. The main traders in Waikabubak and Waingapu are the key actors for starting biodiesel production from crushed candlenuts. Because supply of this feedstock is seasonal, biodiesel processing would be more economically feasible if there were an additional feedstock available in the other months of the year (January–July).A second energy product from candlenut is the dried shell. Experience in 2011, when there was market demand for dried shells for the first time, indicated that smallholders are willing to sell the shells, even if the price is low (Rp 200/kilogram off-farm in 2011). Currently the dried shells are exported from the island and there is no available improved or modern technology for processing them into energy. The owner of Toko Liberty in Waikabubak is a key actor when discussing and organising a candlenut shell supply chain. Candlenut shell production is seasonal as well, and it would therefore be advisable to explore how they can be processed together with coconut shells, which are produced year-round (but also mostly in the dry season, from July– December).

Cashew fruits

The option for using cashew fruits (apples) for ethanol production needs further exploration, especially in Sumba Barat Daya, where cashew is the major cash commodity. Currently the fruits are mainly a waste product of cashew cultivation; any use that would create value for cashew fruits is therefore an economic advantage for farmers. The production is seasonal, with its peak at the end of the dry season. There is an established supply chain for cashew nuts, but not yet for fruits. There is no NGO involved, and technology to produce ethanol from these fruits is not available in Sumba. The volume of this waste stream is (seasonally) quite large, but transport is a challenge because the skin is fragile and the fruit highly perishable.

Cassava

Cassava cultivation is traditional. It is a 'lazy crop' mostly cultivated by women as security for when there is nothing else to eat. According to farmers in Waijewa, they would like to plant more cassava as a cash crop if they could get a good price for it. That is why we included this option here. In Sumba Barat Daya especially, surplus production seems feasible as additional smallholder activity. Smallholders would have to be fully informed about the difference between traditional and industrial cassava, so that they could make an informed decision without risking food security. The Head of the Agricultural Service SBD is currently designing a policy to promote production, and has been in contact with cassava corporations. There is no company on Sumba that buys cassava for use in animal feed or ethanol production. Smallholders would become contract farmers, and get the opportunity to earn more income, but this would also increase their dependence on the price fluctuations of products and inputs. A predictable gender effect is that men will be engaged in commercial cassava cultivation rather than their wives, with a contract with the cassava company on the husband's name.

Lontar (palmyra palm) for ethanol

Lontar sugar, palm wine, and arak are commodities for the domestic market. These products could be used for ethanol production. An Indonesian study published in 2010 estimated that there were 1.1 million *lontar* trees in East Sumba, of which a third were sap producing. The transition from low-external-input, smallholder, Savunese share-cropper farming system to a commercial activity will imply changes in many respects. If sap tapped from the trees is sold directly for ethanol production, the income generating activities of sugar production (women) and alcoholic drink production (some specialists, men) will no longer exist. How the benefits of the ethanol production will be distributed among tappers and tree/land owners is another question to be answered. Still, the option of *lontar*-based bio-ethanol production is worthwhile exploring for the east coast of Sumba. Neither the Plantation Service, private companies, nor NGOs are currently active in exploring the potential of *lontar* in Sumba. The option of intercropping *lontar* with sugar palm seems impossible because of the varying rainfall requirements of the two tree crops.

7.3 Best options for energy feedstock from plantations

In general, producing energy feedstock from large-scale land schemes has the advantage of large and concentrated quantities. It also usually involves private companies who take care of the organisation and management of production and supply chains. The size of the transition from current practices is large and the social sustainability effects are mixed at best, and can be also rather negative. The next 'best options' have a high average score, but they still can have effects that many people (including smallholders, poor women, and lower-class rural inhabitants in Sumba, but also biofuel and gender activists, and critical scholars) would regard as undesirable.

Sweet sorghum

Official discourse about sweet sorghum presents it as a smallholder crop. We consider it in fact a plantation crop because of the requirements of scale for processing. The grains, which account for about 10% of the harvested crop, can still be used for food, while the stalks are being processed for ethanol. The waste product can be used afterwards as well. Proponents not only mention the positive food security aspect of the crop, but also the fact that it is drought-resistant, requires about a third of sugar cane's water requirement, and costs much less than sugar cane in terms of external inputs. If all these claims are true, then it would be a best potential crop for the north coast of Sumba. Ethanol production will require that a company be seriously involved in production and organise processing and marketing. For smallholders – if they are to remain involved – it will be a totally different farming activity than their former traditional sorghum cultivation. Our recommendation for Hivos would be to discuss the option of ethanol production on Sumba for local use with the companies that have obtained permits from the government to organise sweet sorghum cultivation.

Sugar cane

The most important development, in terms of quantity, concerns a 25,000 ha sugar plantation that is planned in Kodi (see Chapter 5.7). The Singapore-based palm oil and sugar company PT Wilmar and its subsidiaries are serious about implementing these plans, and so is the government of SBD. If realised according to current plans, the sugar factory would be able to produce sufficient electricity for all of Sumba from the waste product, bagasse. For this option the main stakeholders organising the production are the company PT Wilmar (PT Gunung Madu Plantations and Sucrogen from Australia), and the Plantation Service in SBD. PLN is important for implementation because this electricity company owns the grid, and would act as a buyer of the sugar cane electricity. As of October 2011 PLN in Waingapu had not yet been informed of these plans, however. The fact that this is a serious plan which will result in large quantities of renewable energy feedstock is counter-balanced by likely effects on the livelihoods of local farmers, or negative effects on the environment. The food versus fuel debate is especially relevant – but also more complicated – in this case, where thousands of hectares of good agricultural land will be used for sugar cane. It is complicated because the sugar can be used both for sugar (food) as well as for ethanol (fuel), and the waste product could yield additional fuel, but sugar cane cultivation will dispossess local smallholders. The team assesses that the developments around this plantation are beyond the influence of Hivos. As we think it is very likely that at least part of the plans will be implemented, we nevertheless recommend discussing the option of bagasse for electricity with the relevant stakeholders.

Maize

There are many plans for large-scale (hybrid) maize production. The volume of energy feedstock that could be produced in this way is large. Stimulating commercial maize production has been provincial government policy for a number of years. The food security issue is most important in this case, because maize is traditionally a main staple crop. Maize as cash crop is mostly exported to other areas. There are no reliable figures on how much is exported. It would be a positive development for the economy in Sumba if more added value would remain on the island. It is a unclear, though, whether agribusiness companies are willing to invest in ethanol factories in Sumba, and whether it is profitable. The most concrete plan for maize-based ethanol production comes from the company PT Pangan Agro Nusantara, a subsidiary of the Sampoerna Agro group, a large Indonesian oil palm company. It entails maize plantations in West Sumba and an ethanol factory in Loli. The ethanol would be purchased by Pertamina. Another big maize scheme is being proposed by PT Pramana Celebes Agri Resources. It concerns an island-wide plan for smallholder (hybrid) maize production, which uses the social organisation of the Protestant Christian Church as a vehicle for recruiting contract farmers. If implemented, this plan could result in large quantities of production. At this stage of negotiations with the company, the local government and the church institution that communicate with PT Pramana could set the local use of waste products as a precondition for collaboration.

7.4 Making best options come true

The final recommendation to Hivos is to support a multi-stakeholder forum in Sumba in which the developments that concern the renewable energy future of Sumba can be discussed. We found that information on biofuel (crops, technologies, prices, politics) was limited, not just for farmers but also for NGO staff and even for government staff. Additionally, there seem to be few opportunities to spread information about on-going developments in Sumba. The recent split of West Sumba into three districts has only aggravated the barriers to island-wide collaboration and information because attention is completely focused by district. Furthermore, the assumptions for this study concerning the role of the government, PLN, and Pertamina are highly optimistic. In reality, sector policies of ministries or state-owned companies do not fit as nicely as assumed, unofficial interests play a role in decision-making, and other priorities might conflict with the goal of increasing renewable energy production and consumption. There are therefore many more negotiations and discussions needed to make the best options identified in this study come true.

During the field study we found that this Hivos programme creates an excellent opportunity for such communication, because ‘Sumba, the Iconic Island for a renewable energy’ is an appealing unifying theme. During the final field study meeting, several NGOs showed their interest in collaborating on this theme, and the government of Sumba Barat Daya explicitly invited Hivos (and the research team) to join in discussions about renewable energy production. These invitations enable Hivos representatives to perform a role as matchmaker for promoting renewable energy during negotiations currently underway between the government, companies, and the local population about cultivating energy crops. The most urgent items for discussion would be electricity from bagasse (sugar cane) production in Sumba Barat Daya and its social impact, the ethanol factory plans in Loli and food security, and the options for an all-Sumba coconut forum that brings all the actors mentioned above and the government from four districts together to discuss the establishment of this new sector.

List of Annexes:

1.Terms of Reference
2.Time schedule of field study (available from the authors)
3. List of informants during field study
4. Some key figures about Sumba's districts
5. Jatropha land suitability classification and mapping
6. Participants of the final meeting in Waibakul, 19 October 2011.

Annex 1. Terms of Reference for phase 2 biomass research

Introduction

Phase 1 describes the possible options for biomass use in Sumba. It gives an overview of technologies that can be applied to produce SVO, biodiesel, ethanol, and syngas, and possible uses in Sumba. It concludes with a list of crops and waste streams that theoretically have the potential to serve as feedstock in Sumba. They are listed below.

Bioethanol Feedstock

Crop name			Source of	Edible /	Crop yield	Bioethanol yield		
Botanical name	English	Indonesian	bioethanol	non edible	ton/ha/yr	Liter/ton	Liter/ha/yr	
Borrasus flabellifer	Palmyra palm	Lontar	sap of flower	E	12 -15	100	1200 - 1500	a)
Manihot esculenta	Cassava	Singkong	starch	E	25-30	180	4500 - 5400	b)
Sorghum bicolor	Sweet sorghum	Sorgum manis	stalk	E	70 - 80	100	7000 - 8000	c)
Nypa frutican	Nypa	Nipah	sap of flower	E	27	93	2500	d)

SVO and Biodiesel Feedstock

Crop name			Source of oil	Oil content	Edible/	Crop yield	SVO	Biodiesel	
Botanical name	English	Indonesian		% dry basis	non edible	ton/ha/yr	Liter/ha/yr	Liter/ha/yr	
Cocos nucifera	Coconut	Kelapa	Kernel	60 – 70	E	1 - 3	2400 - 2800	2240 - 2615	a)
Jatropha curcas	Physic nut	Jarak pagar	Seed kernel	40 – 60	NE	4 - 8	1350 - 2000	1270 - 1890	a)
Aleurites moluccana	Candlenut	Kemiri	Seed kernel	57 - 69	E	16	3685	3500	b)
Moringa oleifera	Horse radish	Kelor	Kernel	30 - 49	E				c)

Fluegas Feedstock

Feedstock name		Harvest yield	Volatile matter	AVG HHV*	Kg feedstock	Ton feedstock	
English	Indonesian	ton/ha/yr	% dry	MJ/Kg	/kWh	Per MWe/day	
Rice husk	Sekam Padi	3 - 4	60	15	1.6 - 1.8	38.4 - 43.2	a)
Woodchips	Potongan Kayu	n/a	70-80	20	1.3 - 1.5	31.2 - 36	b)
Coconut shell	Tempurung Kelapa	n/a	79	20	1.3 - 1.5	31.2 - 36	c)
Corn cob	Tongkol Jagung	3.46	n/a	14.7 -18.9	1.6 - 1.8	38 - 42	d)
Miscanthus	Rumput glagah	40 - 50	70 -90	17.5	0.55	13.2	e)

Objective of phase 2

The overall objective is to describe recent experiences and current cultivation practices for crops that could be used in biofuel production and electricity generation in Sumba, including waste streams, and indicate the potential for increasing energy feedstock production in a sustainable way.

Method:

The research will be a combination of desk research (part 1); interviews and site visits in Sumba (part 2); and writing a report (part 3). The visit to Sumba will include interviews with local experts. Existing reports and comparable projects on biofuels/biomass will be used and will provide important insight and information for this study. Conclusions and recommendations will be based mostly on qualitative information and expert judgements.

Content of the study:

1. Researcher will develop method to assess which crops, biomass streams, and value chains are suitable for developing into biomass-for-energy production, and identify crucial factors for success or failure.
2. In this assessment a range of criteria will be taken into account, e.g., soil and climate suitability, land availability, the socio-economic situation in Sumba (traditions, land rights, labour and gender situation),

and more ethical criteria (food vs. fuel considerations in Sumba). Researcher will propose the means of evaluation.

3. Information on the current practices and recent local experiences of cultivation, processing, marketing, and consumption of the crops concerned in Sumba will be gathered as input data for indicating whether or how these crops could become feedstocks for sustainable energy production in Sumba.
4. Information (qualitative and quantitative) obtained from literature but also (and probably most valuably) from experts, organisations, or companies working in this field will be documented for later use by HIVOS or other stakeholders. The researcher can use the information for writing (semi-) academic articles.
5. Overall conclusions and recommendations concerning which crops are probably best suitable in Sumba, and description of value chain connected to these feedstocks.

Assumptions:

6. Crops will preferably be used for biofuel production and/or electricity production in Sumba itself (aiming at 100% RE).
7. Technologies applied will be existing technologies that can be applied locally with 'local management'.
8. We assume in this study that PLN (and Pertamina) will provide continuous demand for the feedstock, and establish an institutional arrangement with farmers, government, and other parties that guarantees a fair price for the primary producers/fair distribution of the benefits among all stakeholders.
9. Biofuels and electricity can also be used directly by users outside the grid (cooking, lighting, productive use) without involvement of PLN and/or Pertamina.
10. Regarding the institutional context, it is assumed that either district government or Pertamina/PLN or private companies will conduct necessary supply-chain activities.

Result:

The main result is an English-language report with recommendations for and conclusions on the most promising combinations of crops and technologies for biofuels and electricity production in Sumba. This selection can be used for further, more in-depth research, and development of pilot studies (project identification notes). Report can be relative short (approx. 20–30 pages) if supporting information is attached in annexes.

Deliverables:

1. After the initial desk study, the researcher will present a more elaborate methodology of the study, assessment model, and an outline of the final report.
2. After desk and field study in Sumba, the researcher will present and discuss conclusions and a draft report (English) for review in Jakarta with HIVOS.
   Final report will be produced for HIVOS.

Annex 3- Contact persons field study

No	Name	Function/institution	Address	Main crop or issue discussed
1	Adi Lagur	Coordinator Biogas program Hivos in Sumba	Weetabula	biogas
2	Yohanis Yakob Sigakole (Yoga)	Quality Inspector NTT program BIRU (biogas)	Weetabula	biogas
3	Pater Michael Keraf (Mike)	NGO Yayasan Sosial Donders	Centre of the Redemptorists in Weetabula	coconut
4	Pater Willy Ngongo	Diocese Catholic Church www.cssr.com	Weetabula	sugar cane
5	Rofinus D. Kaleka	Kepala Bidang Organisasi Kabupaten SBD (ex camat Kodi utara)	Kadul	sugar cane maize
6	Agustinus Wakur Kaka	Maize farmer/petani teladan dari SBD	Desa Mangganipi, Kodi Utara	sugar cane maize cashew apples
7	Ir. Yakobus Bulu, MMA	Head Agricultural Service SBD	Kadul	maize cassava
8	Ir. John Oktavianus, MM	Head Plantation Service SBD	Kadul	sugar cane coconut cotton
9	Martin van Leeuwen	Sustainable Social Technology, www.sst-betterplanet.org	Nieuwkoop, Netherlands	coconut
10	Li Wong	Dutch NGO Stichting Bintang Belanda	Netherlands	coconut
11	Dominggus Bulu	Head of Planning Agency Bappeda SBD (from Tosi)	Kadul	district planning
12	Franky U.H.Hudang, SE, Msi	Head of Economy Department (Kepala Bagian Ekonomi) Central Sumba	Makatul	investors permits
13	Umbu Sappi Pateduk	Bupati Central Sumba	Makatul	Water and energy
14	Farida Padu Leba	NGO Yayasan Wahana Komunikasi Wanita	Desa Umbu Mamijuk	labour issues
15	Rambu Niwa (Mia)	Journalist Sumba Pos (Central Sumba)	Desa Umbu Mamijuk	Hivos in news
16	Leslie and Janice	Plantation manager stevia plantation - PT Agrifert	Tana Modu – Central Sumba	stevia plantation
17	Ir. Martinus Jurumana, Msi	Head of Agriculture, Plantation and Forestry service in Central Sumba	Waibakul – Central Sumba	maize, organisation meeting
18	Yakub Lowu	Staff at jatropha plantation PT Australian Biofuel	Desa Wendewa Barat – CentralSumba	jatropha
19	Keri Napu	Sub-district Head of Mamboro	Mamboro – Central Sumba	jatropha
20	?	Ex-Village Head Desa Weeluri and petty trader in candlenut shells	Desa Weeluri – West Sumba	candlenut
21	Deby Rambu Kasuatu	NGO Yayasan Satu Visi	Ruko Gelora Padaeweta– Waikabubak	candlenut and coconut
22	Obed Bani	Petty trader candlenut desa Bondo Tera	Desa Bondo Tera – Tana Righu	candlenut
23	Daniel Bani	Village Head Desa Bondo Tera/ candlenut trader (contact for womens group)	Desa Bondo Tera – Tana Righu	candlenut
24	John B. Pajaga	Kepala Desa Mamodu (contact person for coconut farmers,men and women)	Desa Mamodu – Wanokaka	coconut
25	Amos H. Wunu	NGO Yayasan Pakta Sumba ; contact person for farmers groups around the National Park Central Sumba	Jl. Cakrawala – Waikabubak	Advocy for National Park (against gold mining) and rice husks
26	Yohanis B. Djawarai	NGO Bird Life Indonesia, Sumba Program Coordinator	Jl. Ahmad Yani No. 16, Waikabubak	
27	Beny Ratu Lado	Owner of Toko Liberty/ trader in agricultural produce	Jl. Eltari No 22, Waikabubak	candlenut and copra
28	Umbu Wohangara	Secretary Agricultural and Plantation Service West Sumba	Waikabubak	maize
29	Klemens Dapa	Head of food crops section (rice and pulses) Agricultural and Plantation Service West Sumba	Waikabbak	maize
30	Yohannis Kette	Head of infrastructure and vehicles Agricultural and Plantation Service	Waikabubak	maize

		West Sumba		
31	Alex Wohangara	First Secretary Agricultural and Plantation Service West Sumba	Waikabubak	maize
32	I Made Respita	NGO Yayasan Sumba Sejahtera	Lewa – Sumba Timur	wild plants
	Pak Nadus	Field staff YSS appropriate technology – contact person for womens/farmers groups	Lewa Watu Otur	commoditization wild plants
33	Huki Manung	Farmer, chairman farmers group	Desa	traditional crops
34	Ir. Josis Djawa Gigi, Msi	Head of Agriculture Service Est Sumba	Waingapu	sorghum
35	Tunggul	Secretary Plantation Service East Sumba	Waingapu	cotton maize plantations
36	H. Mudjihartono	Operations Head PT Pertamina Waingapu	Jl. Nangamesi No.7, Waingapu	oil and ethanol
37	Ir. Johanis H.Wunu	Head of Plantation Service East Sumba Timur	Waingapu	oil harbour
38	Lazarus Tarapandjang, SE	Section head at Plantation Service East Sumba	Waingapu	plantation plans
39	Bambang	Manager PT Ade Agro	PT Ade Agro Laipori – Sumba Timur	cotton maize plantations
40	Ongko Matahari	Owner Toko Matahari/ trader in agricultural products	Prailiu – Waingapu	cash crops trade
41	Sulaiman	Assistant Manager PLN Head Office Sumba	Waingapu / Waibakul	jatropha and PLN
42	Ferry Lomy	General Secretary PLN Head Office Sumba	Waigapu	biomass feedstock for electricity generation
43	Pdt. Naftali Djoru	General Secretary Synode Protestant Chirstian Church of Sumba (GKS)	Jl. R. Suprapto – Waingapu	maize, PT Pramana
44	Herman J. Sudjarwo	Pusteklim – NGO Dian Desa	Yogyakarta	technology waste processing
45	Anton Soedjarwo	NGO Dian Desa	Yogyakarta	jatropha
46	Dina Bani	Candlenut farmer / women's group representative	Desa Bondo Tera, Wanokaka, West Sumba	candlenut
47	Petrus Pandanga	NGO Yayasan Sumba Sejahtera	Waingapu/ Lewa	maize and ethanol production
48	Agus S. Rua	Office secretary Agriculture, Plantations and Forestry Central Sumba	Waibakul	final meeting
49	Nela	Secretary Agriculture, Plantations and Forestry Central Sumba	Waibakul	final meeting
50	Mark Moriarty	Business Development Manager Sucrogen, www.sucrogen.com	Brisbane, Australia	sugar cane business
51	Tony Kleden	Executive Editor /journalist Pos Kupang (daily news paper)	Kupang	sugar cane developments
52	Achmad Chandra	Director PT Fathi Resources (gold mining company)	Jakarta	gold mining protests
52	Budiyanto Karwelo	Jatropha consultant, contractor, local director PT Australasia Biofuels, input supplier	Lewa – Sumba Timur	Jatropha, patchouli

Annex 4. Some key figures about Sumba's districts.
(Map of Sumba in kecamatan (sub districts))

Tabel A 4-1 Key figures about Sumba per district.

Description	unit	East Sumba	Central Sumba	West Sumba	Sumba Barat Daya	Total
Source of data		BPS: Sumba Timur in figures 2009	BPS: Sumba Tengah in figures 2009	BPS: Sumba Barat in figures 2009	Sumba Barat Daya in figures 2009	
Area (km2)	km2	7,000.5	1,878.77	737.42	1,445.32	11,062
Population	Persons	225,906	60,151	111,023	278,955	
Capital town	Name	Waingapu	Waibakul/ Katikutana	Waikabubak	Tambolaka /Waitabula	
Population in capital	Persons	32,375	9,733	28,832	32,968	103,908
Economic indicators						
GDRP (current market prices)	Rp 1,000 million in 2008	1,305	182	628	808	2,923
Districtbudget from national government	RP 1,000 million in 2008	442	130	292	295.5	1,159.5
Original regional revenues	RP 1,000 million in2008	27	2.6	22	9.5	61.1
District budget from national government [84]	RP 1,000 million in 2011	479	280	307	382	1,448
Labour data						
Total working population (% 15+ x total population)	Persons 15+	107,084	35,000	73,419	200,931	416,434
Government employees)	Persons (pegawai negeri)	14,495	917	2,865	2,909	
Men (15+) working in agriculture	% of total male working population in 2006	64.8	85[85]	85	85	
Women (15+) working in agriculture	% of total female working population in 2006	35.2	68	68	68	
Poverty indicators						
GDRP per capita (per year)	x1,000 Rp in 2008	5,727	3,020	6,275	3,031	
	In US$ (1 $ = Rp 9,000)	636	335	697	337	
House with bambu walls	% of all houses	40	80	60	69	
Source of lighting kerosene	% of households in 2008	65	84	63	75	

[84]http://timorexpress.com/index.php/index.php?act=news&nid=41809
[85] Figures on labour division are for the whole of West Sumba before split up in three districts.

Table A4-2. Some key figures per sub-district in Sumba.

A. Central Sumba

	Rainfall days	Rainfall	Popu-lation density	Maize area	Rice fields sawah	Coconut	Cashew	Uncultivated land**
District and subdistrict	**days per year**	**mm per year**	**head/ km2**	**ha in 2008**	**ha in 2008**	**ha in 2008**	**ha in 2008**	**Ha in 2008**
Central Sumba				3,364	4,563	6,603	**1,362**	**78,926**
Memboro	64	1,646	36	1,022	561	2,020	436	17,696
Katikutana selatan	143	2,902	29	723	1,844	1,028	117	18,696
Umbu Ratu Nggai	79	1,593	14	1,006	482	2,053	782	34,694
Umbu Ratu Nggai Barat	141	2,713	58	613	1,676	1,502	27	7,840
Katikutana *			123	*		*	*	

* The sub-district (kecamatan) Katikutana split up in two sub-districts in 2007, and therefore there are not many separate data for each district. The new Katikutana could be regarded as the 'capital town area'of Central Sumba.
** 'Uncultivated land' is the sum calculated from three categories of land: *padang rumput* (meadows), *lahan tidur* ('sleeping' or uncultivated land), and *lahan kering lainnya* (other dry land).

B. West Sumba

	Rainfall days	Rainfall	Popu-lation density	Maize area	Rice sawah	Coconut	Cashew	Uncultivated land**
District and subdistrict	**day per year**	**mm per year**	**head/ km2 (in 2009)**	**hectares in 2008**	**ha in 2008**	**ha in 2008**	**ha in 2008**	**Ha in 2008**
West Sumba			147	6,348	7,510	9,324	4,690	24,101
Lamboya	32*	708*	139	1,004*	1,048*	3,063*	1,569*	10,843
Wanokaka	63	644	111	598	1,443	2,522	1,051	5,589
Laboya Barat	-	-	43		-	-	-	0
L o l i	112	1,447	199	1,399	3,184	1.01	198	5,607
Kota Waikabubak	119	2,342	587	904	1,793	541	1	590
Tana Righu	105	1,646	121	2,443	42	2,188	1,871	1,473

* Including Lamboya Barat
** 'Uncultivated land' is the sum calculated from three categories of land: *padang rumput* (meadows), *lahan tidur* ('sleeping' or uncultivated land), and *lahan kering lainnya* (other dry land).

C. East Sumba

	Population density	Maize area	Rice sawah	Coconut	Cashew	Unculti-vated land
District and sub-district	**Head/km2**	**Hectares in 2009**	**Ha in 2009**	**Ha in 2009**	**Ha in 2009**	**Ha in 2008**
East Sumba	**32**	4,716	7,656	4,283	7,817	418,224
Lewa	57	210	1,306	164	942	8,844
Nggaha Ori Angu	32	231	411	73	181	14,988
Lewa Tidahu	21	109	943	289	1,064*	15,721
Katala Hamu Lingu	8	274	325	201	191*	24,901
Tabundung	17	358	413	102	316	4,623
Pinu Pahar	27	196	235	114	1,302	2,431
Paberiwai	27	67	117	270	84	12,421
Karera	22	89	175	405	827	1,651
Matawai La Pawu	15	130	324	50	58	29,657
Kahaungu Eti	17	115	54	67	174	31,947
Mahu	20	599	114	241	24*	13,170
Ngadu Ngala	24	73	259	356	897*	1,667
Pahunga Lodu	34	300	1007	254	658	18,517
Wula Waijelu	31	167	128	242	53	11,367
Rindi	25	267	161	213	577	18,677
Umalulu	50	311	688	350	69	6,047
Pandawai	36	267	324	380	109	30,023
Kambata Mapambuhang	9	284	50	297	139*	31,243
Kota Waingapu	439	187	38	26	7	2,107
Kambera	579	129	536	20	34*	2,713
Haharu	9	205	25	85	91	144
Kanatang	31	148	23	85	20*	21,260

* combined data before splitting up new districts; There were no rainfall data available for East Sumba.

D. Sumba Barat Daya

	Rainfall days	Rainfall	Population density	Maize area	Rice sawah	Coconut	Cashew
District and subdistrict	**day per year**	**mm per year**	**head/km2**	**hectares in 2009**	**ha in 2008**	**ha in 2009**	**ha in 2009**
Sumba Barat Daya			**177**	19,829	5,323	7,217	**8,646**
Kodi			251	1,449		646	1,356
Kodi Utara			165	1,738		1,012	2,256
Kodi Bangedo			153	541	137	2,015	2,828
Wewewa Barat			252	9,777	278	1,281	780
Wewewa Selatan			120	1,206	2,721	1,029	235
Wewewa Timur	157	3761	205	2,215	1,967	839	78
Wewewa Utara	104	1,605	168	957	23	187	122
Loura	63	1,388	133	1,946	197	205	988

Rainfall data for 5 districts were not available.

Annex 5. Jatropha Land Suitability Classification and Mapping

Source: NATIONAL JATROPHA TASK FORCE 2007, as quoted in GFA (2007)[86]

Table 1: Criteria of Land and Climate Suitability Class for Jatropha Curcas (1:1,000,000)

Land Suitability		Elevation (m asl)	Annual rainfall (mm)	Dry month, ≤ 100 mm	Wet month ≥ 200 mm	Limiting factor	Land unit of agriculture Planning**)	Climate unit (Rainfall pattern)*)
Sym-bol	Suit-ability							
$S1_1$	Very suitable	< 400	1.000 – 2.000	4 ≤DM ≤5	≤ 4; ≤ 5		1B2, 1B3, 1K2, 1K3, 1 K-4	II-B; II-C
$S1_2$			2.000 – 3.000	5 ≤DM ≤6	≤ 6			III-A
$S2_1$	Suitable	<400	1000 <CH < 2.000	6 ≤DM ≤8	≤ 4	Water availability	1B2, 1B3, 1K2, 1K3, 1 K-4	II-A
$S2_2$			2.000 <AR< 3.000		5 – 6	Slightly low radiation		III-B,
$S3_1$	Conditionally suitable	<700	< 1000	DM>8	≤ 2; 0; ≤ 2	Water availability	1B2, 1B3, 1K2, 1K3, 1K4	I-A, I-B, I-C
$S3_2$			2.000 < AR < 3.000	3 ≤ DM ≤ 4	6 – 8	Low radiation		III-C ,
$S3_3$			3.000 < AR < 4.000	DM = 3	7 – 9	Very low radiation		IV-C
N	Not suitable	> 700	3.000 ≤ AR ≤ 4.000	≤ 2	7 – 11	Very low radiation	-	IV-A, B, D
			> 4000	≤ 2	7 – 12	Very low radiation	-	VA-D; VIA-D

*)Symbol of climate mapping unit:
- I = rainfall < 1,000 mm/year
- II = rainfall 1,000 – 2,000 mm/year
- III = rainfall 2,000 – 3,000 mm/year
- IV = rainfall 3.000 – 4.000 mm/year
- V = rainfall 4,000 – 5,000 mm/year
- VI = rainfall > 5,000 mm/year

Rainfall pattern:
A = Simple rainfall pattern, min. rainfall on July-August
B = Multiple annual rainfall pattern
C = Bi-annual rainfall pattern
D = Simple wave pattern, maximum rainfall on July-August

**) Symbol of Agriculture Planning mapping unit:
- 1B2 = suitable for annual crop on upland with wet climate, and lowland (elevation < 700 masl)
- 1B3 = suitable for perennial / estate crop on upland, wet climate, and lowland (elevation < 700 masl)
- 1K2 = suitable for crop on upland with, dry climate, and lowland (elevation < 700 masl)
- 1K3 = suitable for perennial / estate crop on upland, dry climate, and lowland (elevation < 700 masl)
- 1K4 = suitable for crop livestock, lowland (elevation < 700 masl)

[86] KfW banking group commissioned GFA Consulting group to conduct the feasibility study 'Development of Jatropha Curcas Oil for Bio-Energy in Rural Areas in Indonesia'atthe request of the Department for Processing and Marketing of Agricultural Products (DPMAP) within the Ministry of Agriculture.GFA, 2007. This table of criteria is copied from Annex 5.4 of that report.

Annex 6. Participants of the final meeting in Waibakul, 19 October 2011.

	Name	Institution, function	Address	m/f
1	Adi Lagur	Hivos- coordinator biogas project Sumba	Waitabula	m
2	Yohanis Yakob Sigakole (Yoga)	Quality Inspector NTT biogas program BIRU	Waitabula	m
3	Ir. Yakobus Bulu, MMA	Head Agricultural Service SBD	Tambolaka	m
4	Ir. John Oktavianus, MM	Head Plantation Service SBD	Tambolaka	m
5	Farida Padu Leba	Yayasan Wahana Komunikasi Wanita	Desa Umbu Mamijuk	f
6	Deby Rambu Kasuatu	Yayasan Satu Visi	Ruko Gelora Padaeweta-Waikabubak	f
7	Sulaiman	Assistent Manager Sumba head office PLN	Waingapu/Waibakul	m
8	Herman J. Sudjarwo	Appropriate technology expert Dian Desa	Yogyakarta	m
9	Anton Soedjarwo	Director NGO Dian Desa	Yogyakarta	m
10	Dina Bani	Candlenut farmer West Sumba	Desa Bondo Tera, Tana Righu	f
11	Petrus Pandanga	Secretary Yayasan Sumba Sejahtera	Waingapu/Lewa	m
12	Agus S. Rua	Office secretary Agriculture, Plantations and Forestry Central Sumba	Waibakul	m
13	Nela	Secretary Agriculture, Plantations and Forestry Central Sumba	Waibakul	f
14	Stepanus Makambombu	Director NGO Yayasan Stimulant / facilitator in this meeting	Waingapu	m
15	Mila Nuh	Hivos Jakarta project officer Iconic Island	Jakarta	f
16	Dorkas M. Riwa	retired Head of primary school Waibakul	Waibakul	f
17	A.L. Atarabu	retired Head of secondary school (SMA) Waikabubak	Waibakul	f
18	John B. Pajaga	coconut farmer	Desa Mamodu, Wanokaka	m
19	Agustinus Wakur Kaka	maize farmer, model farmer (*petani teladan*) SBD, biogas user	Desa Mangganipi, Kodi Utara	m
20	Respati Nugrohowardhani	member research team	Waingapu/Salatiga	f
21	Jacqueline Vel	Research team leader	Leiden	f

Contact

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