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INSIGHTS INTO JATROPHA PROJECTS WORLDWIDE

Key Facts & Figures from a Global Survey

Centre for Sustainability Management

INOCAS
INNOVATIVE OIL AND CARBON SOLUTIONS

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Insights into Jatropha Projects Worldwide
Key Facts & Figures from a Global Survey

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ABBREVIATIONS

CO_2	Carbon dioxide
EU RED	Renewable Energy Directive of the European Union
FAO	Food and Agriculture Organisation of the United Nations
GEXSI	Global Exchange for Social Investment
GHG	Greenhouse gas
GIS	Geographic Information System
GPS	Global Positioning System
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH
ISCC	International Sustainability and Carbon Certification
LAC	Latin America and the Caribbean
LUC	Land-use change
NGO	Non-governmental organisation
PPO	Pure plant oil

GLOSSARY

Extension service
Farmer education and support to foster the application of scientific research and new knowledge to agricultural practices.

Outgrower
Outgrowers allocate land and/or other resources to the production and management of crops for a processing company with the company providing a guaranteed market.

Outgrower scheme
Project scheme in which cultivation sites are operated by outgrowers.

Plantation scheme
Project scheme in which cultivation sites are operated by the project owners themselves.

Press cake
Press cake is the solid remaining of the seeds or fruits after extracting the oil.

Smallholder
Smallholders are usually farmers supporting a single family with a mixture of cash crops and subsistence farming.

INTRODUCTION

1

Jatropha curcas L. (hereafter referred to as "Jatropha") has become an example for the tremendous hope placed in novel crops that "offer all the benefits of biofuels without the pitfalls" (Renner 2007, 20) to deliver oilseeds from marginal lands in (semi-) arid regions without compromising food production, diminishing natural resources or ecosystem services, such as carbon stocks and soil fertility.

As a result it has been praised as an economically and environmentally sustainable feedstock for biofuel production (Renner 2007). Governments in producing countries, for example in India and China, have launched supporting programs for the promising Jatropha cultivation industry (Weyerhäuser et al. 2007; Pandey et al. 2012). Expecta-tions of high yields with minimal inputs under marginal conditions have fuelled large investments in cultivation systems, especially in developing and emerging economies (Renner 2007; van Gelder et al. 2012). The potential for pro-poor development has motivated governmental and non-governmental development organisations to involve smallholder farmers in growing the energy crop (Achten et al. 2009; FAO 2010; German et al. 2011). Projects range from schemes involving smallholders planting windbreaks and hedgerows to large monoculture plantations spanning several thousand hectares. However, since the initial wave of excitement about Jatropha broke in around 2008, many projects have failed. Despite setbacks, Jatropha production is still being promoted and new projects are being undertaken. In order to shed light on the current situation and to understand approaches taken to oilseed production based on Jatropha and similar novel biofuel crops, we conducted a global survey between May and September 2011 we conducted a global survey of 154 oilseed producers.

Despite setbacks, Jatropha production is still being promoted and new projects are being undertaken

At the time when initial investments in large-scale commercialization of Jatropha were being made, little was known about Jatropha's basic agronomy (Achten et al. 2010). The failure of many Jatropha projects confirmed the concerns of those who recognized the economic risk of cultivating an undomesticated plant (Fairless 2007). It became apparent that cultivation outpaced both scientific understanding of the crop's potential as well as an understanding of how the crop fits into existing rural economies and the degree to which it can thrive on marginal lands (Fairless 2007; Trabucco et al. 2010). Broad-based evidence about whether and how environmental benefits and pro-poor development potential can be achieved through Jatropha cultivation is still lacking (Achten & Verchot 2011; German et al. 2011; Pandey et al. 2012). The variety of stakeholders involved in building up knowledge of this energy crop reflects the need for inter- and transdisciplinary perspectives on Jatropha in particular as well as on biofuel feedstock production in general. In 2008, "A Global Market Study on Jatropha" published by the social enterprise GEXSI drew on a sample of 242 identified and 160 surveyed Jatropha cultivation projects worldwide (GEXSI 2008). The "Jatropha Reality Check" by GTZ (2009) used quantitative data to analyse Jatropha's overall biofuel development potential in Kenya. Based on desk research, in 2011 the Hardman and Co. consultancy provided the investment community with data on Jatropha potential in global biofuel markets (Hawkins & Chen 2011). ››

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›› A number of researchers and development organisations have published state-of-the-art reviews on the Jatropha plant and its cultivation (Jongshaap et al. 2007; van Eijk et al. 2010; FAO 2010; Achten et al. 2010). Others have investigated different aspects of the environmental and socio-economic impacts of Jatropha cultivation (Borman et al. 2012). However, such publications mostly draw on a set of data that is limited and outdated or they employ case study designs yielding qualitative and not quantitative results.

The objective of this survey of oilseed production from Jatropha and other oilseed-bearing perennials is to contribute by establishing an up-to-date overview based on interviews with producers in 2011. This survey of 154 projects yielded a comprehensive database that covers critical aspects such as agronomic settings, agricultural practices, yields, business activities and financing as well as sustainability management. This summary of key facts and figures provides an overview of the 111 commercial Jatropha plantations found to be operational at the time of the survey in mid-2011. It presents key agronomic and economic data points from this sample. The report targets a wide range of stakeholders in governmental and non-governmental organisations, academia, as well as businesses and investors. In particular, we would like to express our thanks to the 180 interviewees – experts and oilseed producers – who kindly offered to share their time, knowledge and experience.

METHODOLOGY

2

2.1 Scope of the study and report

In this report we present selected findings from a global survey conducted in 2011 (154 responding projects in total) of a broad range of projects dealing with oil-bearing tree species. The sample includes projects cultivating most importantly Jatropha, Castor *(Ricinus communis* L.), Neem tree *(Antelaea azadirachta* (L.) *Adelb.),* Moringa *(Moringa oleifera* Lam.), Pongamia (*Milletia pinnata Panigrahi)*, and Croton (*Croton megalocarpus* Hutch.)

The focus of this summary of key findings, however, is on operational commercial Jatropha projects, as they represent the largest, most consistent and best validated sub-sample within the overall study. Our goal is to provide, based on 111 responding projects, the first set of international Jatropha benchmarks.

By definition a project in this study refers to an organisation's activities in one country and may include several owned and/or contracted plantation sites. An organisation may be active in a number of countries and thus manage several projects. Consequently, the number of projects does not equal the number of producers and interviewees in this survey.

Interviews were based on a standardized questionnaire including both structured and unstructured question types. Overall, it contained 67 questions divided into six sections (see the Appendix):

1. General company background (e.g. project location, size and yields)
2. Plantation site-specific information (e.g. annual rainfall, soil type)
3. Agronomic aspects (e.g. cultivation system and input management)
4. Biodiversity and ecosystem services (e.g. surrounding habitats, species diversity)
5. Financing and business model (e.g. markets, sources of financing)
6. Sustainability (e.g. social and environmental aspects, certification)

Box 1: Overview of survey sections

We have focused on tropical and subtropical regions as oilseed-bearing trees in general and Jatropha in particular thrive best in these climates. Based on the locations of responding projects, three regions are identified: Africa, Asia, and Latin America and the Caribbean (LAC) (see Chapter 3).

In this report we summarize and describe the main findings from sections one, three and five, as shown in Box 1, for 111 Jatropha projects to provide a general description in terms of main project characteristics and core activities. Further analyses of the sections two, four and six are currently being conducted and will be published in future reports and journal articles (see Chapter 6).

2.2 Survey approach and sample

The study is based on a triangulated mixed methods sampling design (Kemper et al. 2003; Teddlie & Yu 2007) and three pillars of data collection (Figure 1): desk research, expert interviews and a producer survey. All in all, the study draws on information gathered in more than 180 interviews with experts and project representatives.

In a first step, we identified projects by desk research drawing on a wide range of sources, including academic publications, reports from both civil society and international organisations, producer websites, professional online networks as well as industry websites and studies. Additionally, we conducted more than 80 semi-structured interviews with experts, amongst whom were representatives of non-governmental organisations (NGOs), development organisations, industry associations and research institutions. The aim of these expert interviews was to identify further projects and to validate the information we found in desk research. Furthermore, the experts provided important background knowledge about market developments and helped improve the questionnaire design.

Status (definition)	Total number of projects	Jatropha projects
In operation (fully established plantations)	119	111
In preparation (incomplete projects being actively developed)	15	8
Research and development (e.g. basic research on plant genetics or applied research on agricultural practices)	10	10
On hold (incomplete or abandoned projects that were not/no longer operational)	7	7
Unclear status (none of the above categories, clarification was not possible)	3	3
Overall	154	139

Table 1: Status of surveyed projects

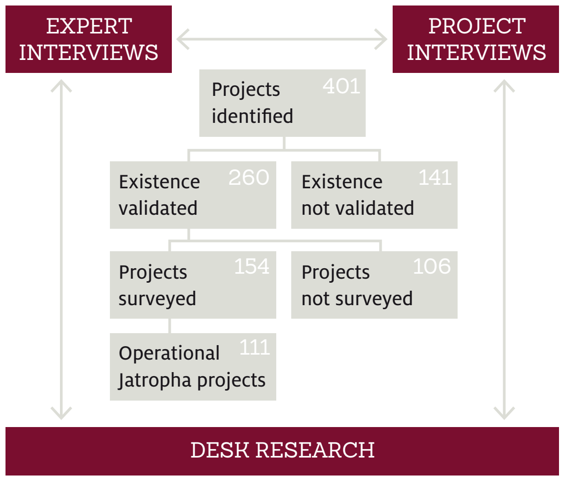


Figure 1: Mixed method sampling and data collection approach

Following desk research and expert interviews, we compiled a comprehensive list of 401 projects. Triangulation of results from desk research, expert and project interviews helped to validate the existence of 260 projects. The existence of 141 projects could not be validated (Figure 1).

In a second step we conducted interviews for 154 out of the 260 projects between May and September 2011 (59% response rate): 107 producers were interviewed in total, with a number giving information on multiple projects. The representatives of 106 projects decided not to take part or did not return the questionnaire. Of the responding 154 projects, 139 (90%) were dedicated to Jatropha. These were in different phases of development as categorized in Table 1.

The large majority of operational projects (93%) have Jatropha as the main crop. In the following sections we describe this sample of 111 operational Jatropha projects and their practices, some of which also cultivate other oil-bearing tree species in addition to Jatropha: 14 projects reported growing Castor, six projects Moringa and Pongamia, four projects Neem, and two projects Croton. ››

2

Survey purpose	General overview of commercial oil-bearing tree cultivation and a database on key parameters for agronomic and economic performance
Unit of analysis	Commercial oil-bearing tree plantations aiming at the production of plant oil feedstock
Interviewees	Project initiators, CEOs, project managers
Reporting units	Projects
Sampling	Mixed-methods sampling based on literature studies and expert interviews
Sample size	154 out of 260 validated projects, with 111 operational Jatropha projects
Response rate	59 per cent (154 of 260)
Interviewing mode	Computer-assisted telephone interviewing (CATI) and computer-assisted self-interviewing (CASI) based on an interactive PDF form and online survey tool
Time frame	May to September 2011

Box 2: Overview of survey approach

›› Note: The figures presented in the following relate to the number of projects for which a response to a question was received. Projects that responded „no information available" or did not answer at all are always excluded. As the sub-samples thus vary in terms of their questions, findings on certain categories may not be necessarily representative for the entire survey population. This limitation also exists for questions that were responded to by a relatively small number of projects. Several questions offer multiple-response choices. Consequently, results for those questions add up to more than 100 per cent and therefore the total number of responses can exceed the number of respondents or responding projects.

JATROPHA CURCAS L.

Botanical description

The species *Jatropha curcas* L., commonly known as physic nut, belongs to the family of spurges (Euphorbiaceae). It is a large shrub or a small tree and generally grows to a height of three to five meters (Carels 2009). Given the wide range of natural conditions it tolerates, Jatropha naturally occurs throughout the tropics and sub-tropics (Carels 2009).

The plant is well adapted to unfavorable growth conditions. In arid and semi-arid climates, it survives by shedding its leaves at the beginning of the dry season (Orwa et al. 2009). However, with adequate water, pollinators and overall favorable growth conditions, it can thrive and produce fruits throughout the entire year (Kumar & Sharma 2008).

Use of Jatropha oil

Jatropha seeds, oil and press cake can be used in different products and for different applications (ICRAF KEFRI 2009). Jatropha's primary product is its non-edible oil which is a suitable feedstock for biodiesel production (Salimon & Abdullah 2008) and even for biokerosene (Bailis & Baka 2010).

Agronomy

Mean annual temperature: Jatropha grows well in regions with an annual mean temperature between 20 to 28°C (Orwa et al. 2009). The plant is reportedly susceptible to frost and as a result a mean temperature in the coldest month below 10 degrees Celsius is likely to have a strongly negative impact on growth performance.

Precipitation: Jatropha should have at least 300 mm of precipitation per year to ensure survival (Orwa et al. 2009). Significantly higher water availability (minimum of 500 mm per year) is required for optimal seed production conditions because water availability is positively correlated with fruit production (Jongschaap et al. 2007).

Soil: Drained sandy or gravelly soils with good aeration are optimal for Jatropha as the shrub does not tolerate water logging conditions (Heller 1996). Although it is well adapted to marginal soils, commercially viable yields are only possible if sufficient amounts of nutrients are available to the plant.

Planting method: Jatropha can be propagated either by direct seeding, planting of seedlings from a nursery or by cuttings.

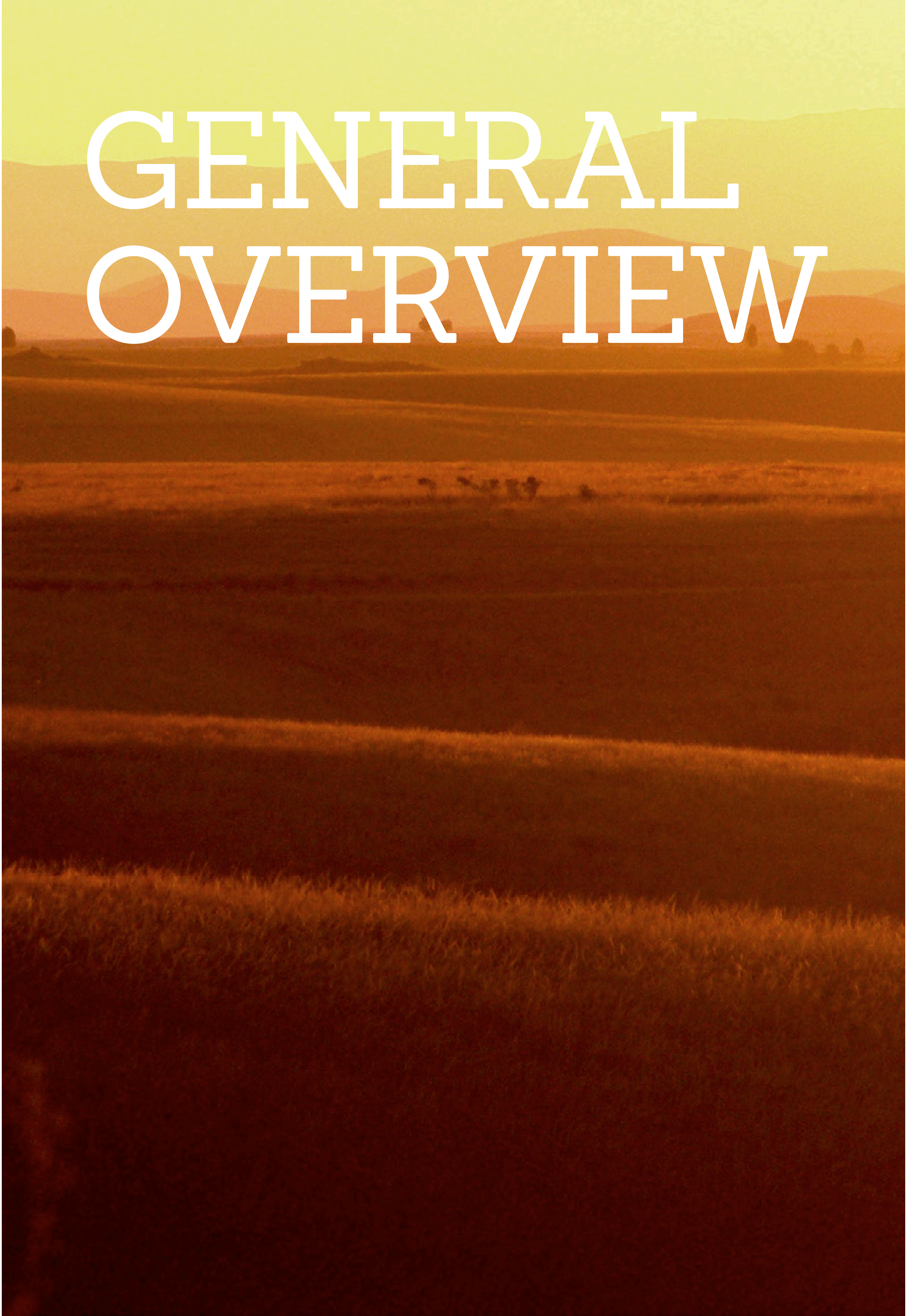
Oil content and seed yield: Oil yield is the most critical issue in Jatropha cultivation because oil is the primary product. Oil yield is a function of seed yield and oil content of seeds. The seed's oil content generally varies between 23 and 39 per cent (Jongschaap et al. 2007). Depending on "site characteristics (rainfall, soil type and soil fertility), genetics, plant age, and management ››

›› (propagation method, spacing, pruning, fertilisation, irrigation, etc.)" (Behera et al. 2010:39), seed yields per tree can vary significantly. Accordingly, annual seed production can range from about 0.2 to more than 2 kg per plant (Francis et al. 2005). A global literature search by GTZ (2009) finds seed yields of mature trees to range between 0.3 and 5.2 kg. However, the survey finds only three studies out of nine that reported yields above two kilograms per tree. Jongschaap et al. (2007) calculate a theoretical yield potential of 7.8 tons dry seeds per hectare and year.

By-products: Jatropha produces not only oil but also valuable by-products such as a nutrient-rich press cake, pruning material and seed husks that can either be used for composting and crop fertilisation or – in the case of the press cake – as feedstock for biogas plants.

Box 3: Jatropha profile

GENERAL OVERVIEW



3

When the first global Jatropha study was published in 2008, the business of producing oilseeds from Jatropha was in its early boom stages (Grass 2009). Soon afterwards, reports of failing Jatropha-based enterprises and unsustainable practices accumulated. Jatropha's downfall was declared by many researchers and practitioners (Friends of the Earth 2010; Openshaw 2000; Kant & Wu 2011) but obviously not by all. And despite being praised by some and heavily criticized by others, Jatropha is still being cultivated (Lane 2012). This section provides an overview of the scope of Jatropha cultivation in 2011 and its defining characteristics as represented in this sample of operational projects.

In 2008, 242 Jatropha plantations were found to cover an estimated total area of some 900 000 hectares according to a study by GEXSI (2008). At that time, most Jatropha plantations were located in Asia (84%) and covered land areas totalling almost 800 000 hectares – chiefly in Myanmar, India, China and Indonesia. Around twelve per cent of the total hectares planted were located in Africa (approximately 120 000 ha), mostly in Madagascar and Zambia, but also in Tanzania and Mozambique. Latin America accounted for approximately 20 000 hectares of Jatropha, mostly located in Brazil (GEXSI 2008). From today's perspective, projections on the development of Jatropha plantings were rather optimistic at that time: 4.7 million expected hectares worldwide by 2010 and 12.8 million hectares by 2015. It was assumed that Indonesia would be the largest Jatropha producer in Asia in 2015 with 5.2 million hectares. Ghana and Madagascar were expected to have the largest plantation areas in Africa (600 000 ha and 500 000 ha), and Brazil was projected to be the largest producer in Latin America with 1.3 million hectares (GEXSI 2008).

> From today`s perspective, projections on the development of Jatropha plantings were rather optimistic

Plantation schemes, in which cultivation sites are managed in public or private ownership, represented 31 per cent of all Jatropha cultivation projects surveyed in 2008. Slightly less, 25 per cent, of the Jatropha-based enterprises worked exclusively in so-called outgrower schemes, relying on farmers that are contractually linked to a central organisation to cultivate the energy crop. The 43-per cent majority of the cultivation projects involved both plantation and outgrower schemes (GEXSI 2008). Plantation schemes were predicted to see the greatest growth in the future. For Jatropha to fulfil its promise of contributing to sustainable bioenergy and pro-poor development, it is often argued however, that Jatropha cultivation should be inclusive, community-based and small in scale (FAO 2010; Achten et al. 2009). Plantation schemes, on the other hand, may be more efficient not only in production but also in building rural infrastructures and providing employment opportunities for communities (German et al. 2011). In this context, another consideration touches on access to land and costs. In order to establish plantations, land has to be leased or acquired, whereas outgrowing usually implies that farmers operate on their own farmland.

Compared to the 2008 data, it is interesting to learn if and how many projects endured the Jatropha crisis and are still in operation and also how many were initiated afterwards – despite the crisis. The shrub reaches maturity and full production only three to four years after planting (Jongshaap 2007), depending on its geographical location (other sources expect maturity between two or three years (BioZio 2011), or even longer periods of four or five years (FAO 2010). The age of Jatropha plantation projects thus also plays a crucial role in assessing key aspects, such as agronomic practices, yields and costs, which are presented throughout this summary.

The following section deals with overall distribution and country locations (3.1) of Jatropha cultivation in 2011, the area cultivated on an overall and regional base (3.2), as well as type of project schemes (3.3) and age of plantations (3.4).

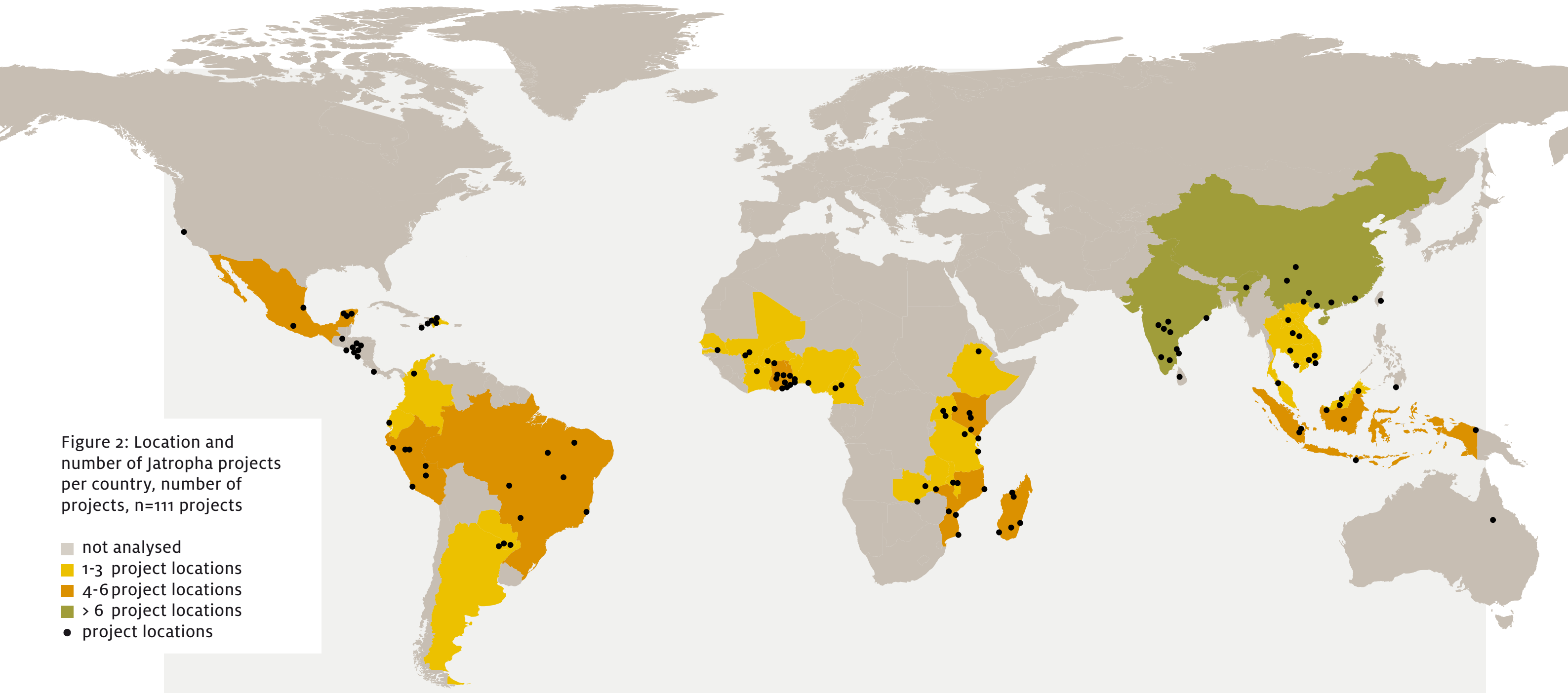


Figure 2: Location and number of Jatropha projects per country, number of projects, n=111 projects

3.1 Overall distribution of projects

Commercial cultivation of Jatropha is located in tropical and sub-tropical climate zones of emerging and developing economies in Africa, Latin America and the Caribbean (LAC), and Asia. The projects surveyed and considered for this summary are found to be fairly evenly distributed among these three regions (Table 2), with 42 projects located in Africa, 35 projects in Asia and 34 projects in LAC.

Although African countries slightly dominate the overall sample in terms of the number of surveyed projects, a comparison of projects per country shows a different picture. It is in two Asian countries where the most projects were surveyed, with nine projects in India and seven in China. Brazil is ranked third with six projects overall. Three African countries (Mozambique, Madagascar and Ghana) share fourth place with Indonesia and Mexico, with five projects in each country. Four projects were surveyed in two LAC countries, Peru and Honduras, and in one African country, Kenya. Figure 2 visualizes the number of projects surveyed (as also summarized in Table 3 on page 19) in each country on a world map. The darker the colour of a country, the greater is the number of projects surveyed in that country.

Continent	Number of operational projects
Africa	42
Asia	35
LAC	34
Total	111

Table 2: Total numbers of projects surveyed according to regions

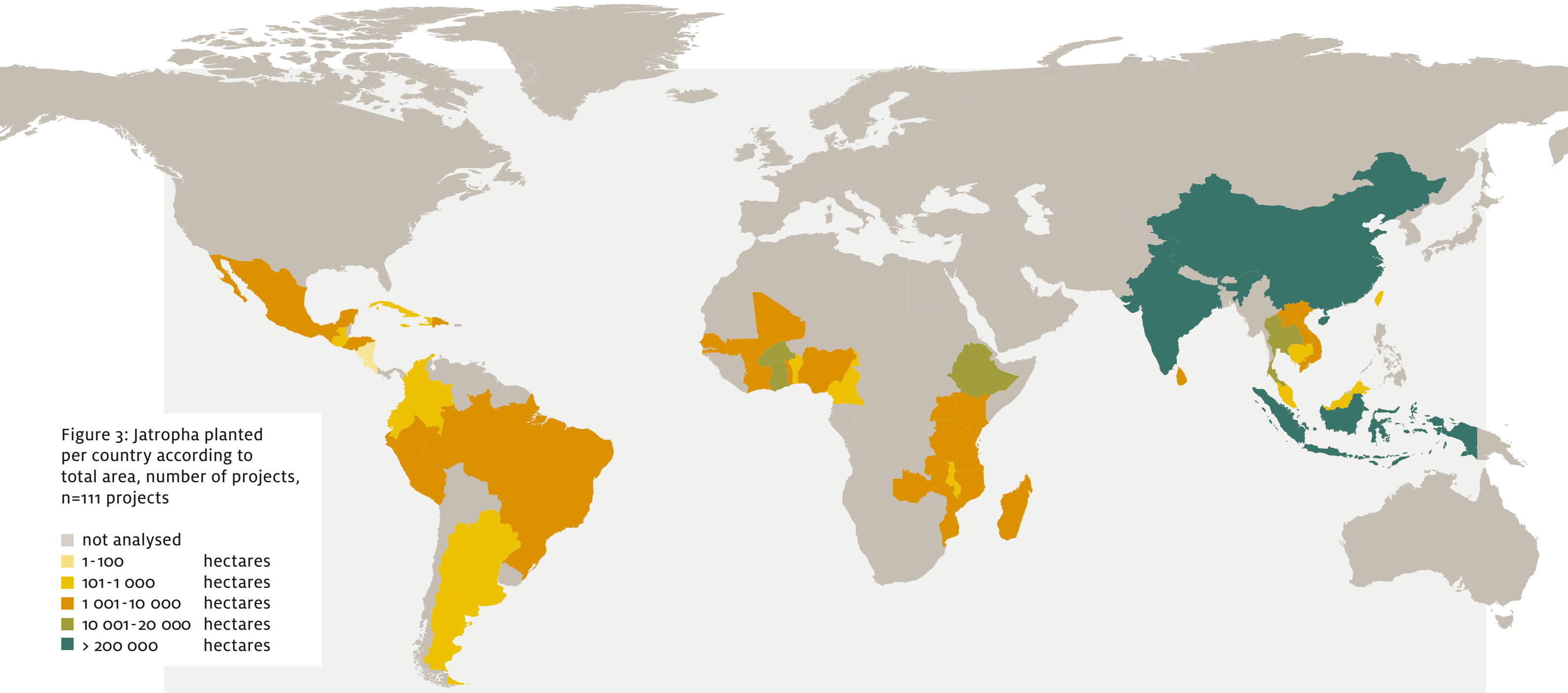


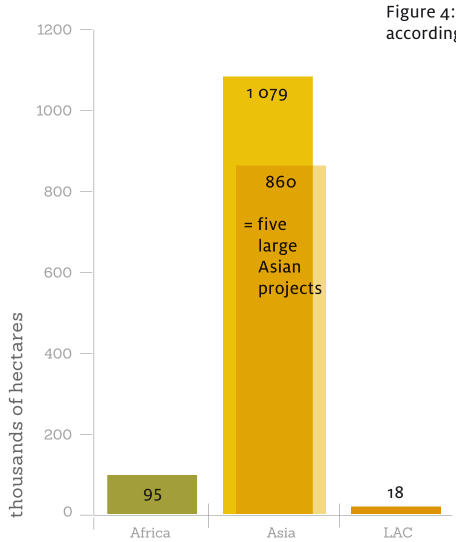
Figure 3: Jatropha planted per country according to total area, number of projects, n=111 projects

3.2 Area cultivated and project sizes

As of 2011, a total of 1 191 625 hectares were planted with Jatropha trees by the reporting projects in this survey. Figure 3 shows the amount of hectares planted in the three different regions.

The share of individual projects in the total hectares of Jatropha cultivation is highly uneven: 72 per cent, that is more than 860 000 hectares, are cultivated by five large projects in Asia ranging from 100 000 hectares to the largest project of 250 000 hectares in size. Without these five large outliers, the remaining 106 projects cultivated a total of around 331 000 hectares of Jatropha, of which two-thirds, or around 218 000 hectares, are located in Asia (30 additional projects) emphasizing the still dominant role this region plays in Jatropha cultivation

Figure 4: Total hectares planted according to regions, n=111



globally. 29 per cent of the remaining approximately 331 000 hectares are planted in Africa (around 95 300 hectares or 42 projects), and only five per cent in LAC (around 17 700 hectares or 34 projects).

The large variation of size for single projects, from four to around 250 000 hectares, prohibits taking a representative average. Therefore, we have classified projects into five different size groups to compare and discuss these findings in more detail. The first group is represented by projects with plantation areas from 1 to 100 hectares, the second group from 101 to 1 000 hectares, the third group from 1 001 to 10 000 hectares, the fourth group from 10 001 to 50 000 hectares, and the last group from 50 001 to 251 000 hectares (Figure 4). With 45 projects, the second group (101-1 000 ha) is the largest in this sample. Overall, African projects dominate in groups two and three (101-1 000 and 1 001-10 000 ha), and only two projects in the African sample belong to the fourth group. In the LAC region, most projects are smaller in size compared to other regions, as not one project operates cultivation sites of over 10 000 hectares in size. In contrast, projects in the Asian sample are relatively evenly distributed among all five groups.››

Country	Area planted (ha)	Number of projects
China	274 559	> 6
India	265 422	> 6
Malaysia	259 906	1-3
Indonesia	256 545	4-6
Ethiopia	20 000	1-3
Thailand	15 680	1-3
Ghana	13 000	4-6
Burkina Faso	10 000	1-3
Madagascar	8 300	4-6
Mexico	8 040	4-6
Mali	8 000	1-3
Nigeria	7 500	1-3
Tanzania	6 926	1-3
Togo	6 000	1-3
Mozambique	3 585	4-6
Brazil	3 135	4-6
Uganda	3 125	1-3
Sri Lanka	3 000	1-3
Zambia	2 789	1-3
Senegal	2 000	1-3
Honduras	1 678	4-6
Ivory Coast	1 500	1-3
Kenya	1 463	4-6
Vietnam	1 400	1-3
Argentina	1 300	1-3
Laos	1 204	1-3
Dominican Rep.	1 021	1-3
Benin	550	1-3
Taiwan	536	1-3
Colombia	500	1-3
Haiti	450	1-3
Peru	411	4-6
Cambodia	395	1-3
El Salvador	357	1-3
Malawi	350	1-3
Paraguay	205	1-3
Cameroon	205	1-3
Guatemala	150	1-3
Ecuador	150	1-3
Caribbean	100	1-3
Peru	100	1-3
Nicaragua	63	1-3
Costa Rica	24	1-3

Table 3: Country comparison of results on total hectares planted and number of projects, ranked according to total hectares planted per country, n= 111 projects

›› Figure 5 visualizes the total hectares planted in each country on a world map, differentiated in five different size groups (1-100 ha; 101-1 000 ha; 1 001-10 000 ha; 10 001-20 000 ha and larger than 200 000 ha). Table 3 shows hectares cultivated and ranges of number of projects surveyed per country (ranges are used for reasons of anonymity). The seven Chinese projects in this survey amount to the largest total planted hectares in a single country, followed by India's nine. Malaysia and Indonesia follow in third and fourth place. It is in these four Asian countries where the five outlier projects, amounting to a total of more than 860 000 hectares planted, were surveyed. Remarkably, Malaysia's three projects have almost the same cultivated area in total as the nine projects in India. Thailand is the only other Asian country, after the four giants, with considerably sized Jatropha cultivation sites.

Ethiopia, Ghana and Burkina Faso have the largest Jatropha projects in Africa. Together they amount to 43 000 hectares. Most hectares within the LAC region are planted in Mexico (8 000 ha) and Brazil (3 100 ha), but no country in the LAC region currently exceeds 10 000 hectares.

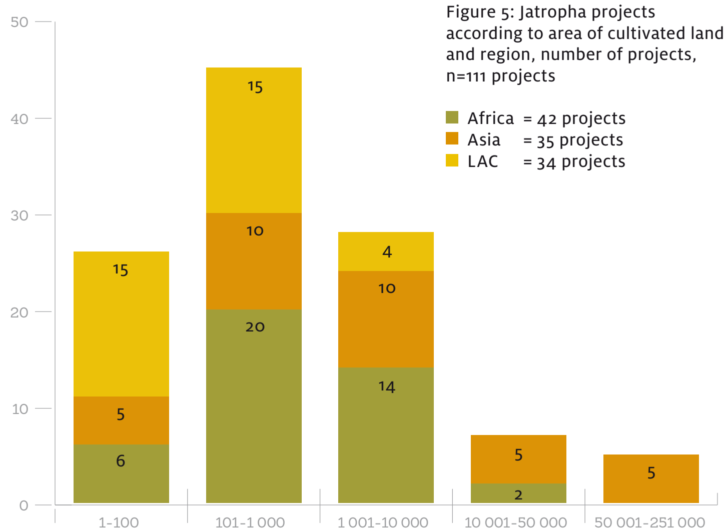


Figure 5: Jatropha projects according to area of cultivated land and region, number of projects, n=111 projects

3

3.3 Project schemes

Jatropha production is organized in three different types of project schemes, as described at the beginning of this chapter: plantations operated by the project owners themselves; cultivation areas operated by outgrowers; and a combination of these two schemes.

Figure 6: Project schemes overall, per cent of projects, n=111 projects

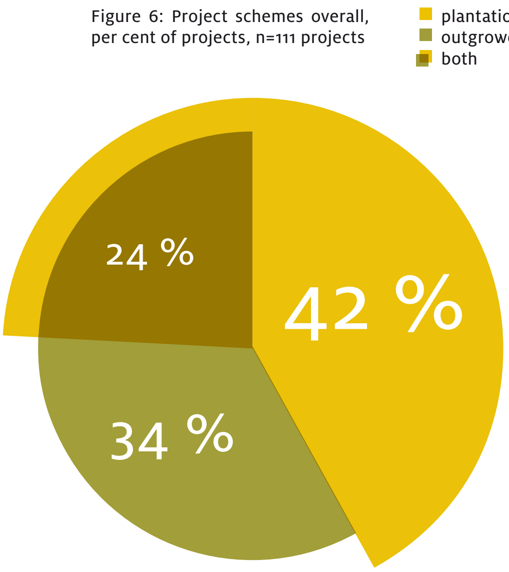
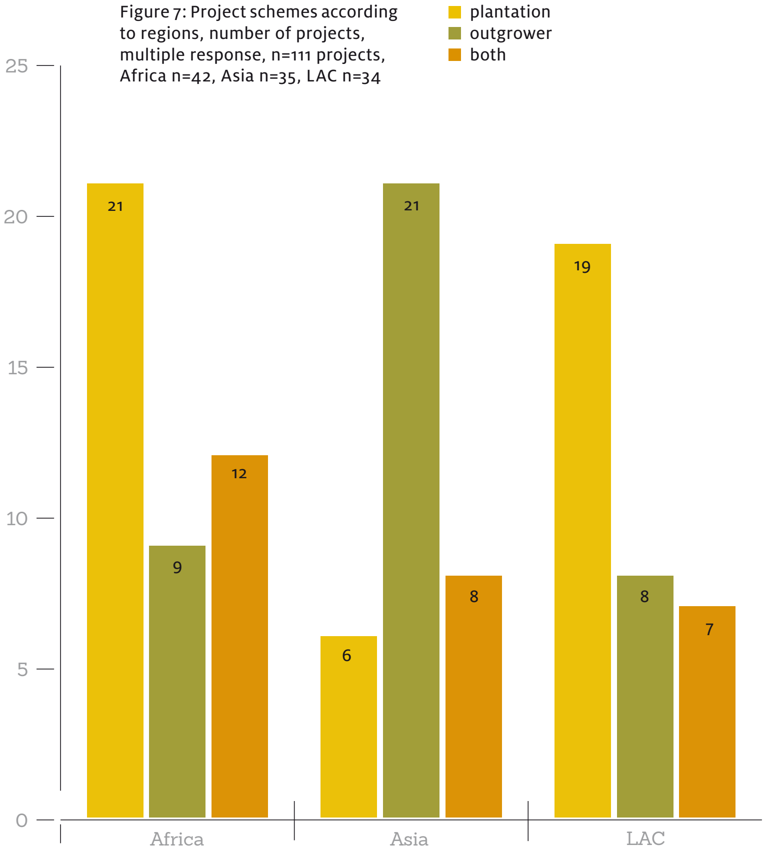


Figure 7: Project schemes according to regions, number of projects, multiple response, n=111 projects, Africa n=42, Asia n=35, LAC n=34



Among the Jatropha projects surveyed, the most common project scheme is companies operating their own plantations (46 of all projects; Figure 6) while outgrowing is less frequent (38 projects). Mixed models combining plantations and outgrowing schemes are least frequent (27 projects).

Plantations are prevalent in Africa and Latin America whereas outgrowing schemes are most common in Asia (Figure 7). The prevalence of outgrowing models in Asia might be partly due to the peculiarity of the Asian projects in this sample. Among the 20 Asian outgrowing projects included in the survey, twelve are managed by three companies or joint ventures, which replicate their business model in different countries. This model is not common in other regions. In this regard, the Asian sub-sample is distinct from the others. Four out of the five large projects of over 100 000 hectares in Asia (see 3.1) are organized as outgrowing systems; only one large project is operated as a company-owned plantation.

Modes of cooperation between the contracting projects and outgrower farmers are addressed in more detail in four case studies that have been prepared in the context of the survey in mid-2011 and can be found in this chapter (Box 4) as well as throughout Chapters Four and Five. Note that information provided in the case studies represents the status as of October 2011.

HOW TO MANAGE 17 000 OUTGROWERS – THE MODEL OF BIO ENERGY RESOURCES LTD. (BERL)

Outgrowing poses at least three major challenges: Identifying farmers and organizing them effectively, achieving continuous yields and constant seed quality at reasonable costs, and creating added-value for farmers. The Malawian biofuel producer Bio Energy Resources Ltd. (BERL) is a good practice example of managing these challenges – even with a large number of outgrowers. Since 2008, BERL has trained in excess of 30 000 farmers, of which nearly 17 000 were registered as outgrowers for BERL by the end of 2011. According to Abbie Chittock, Marketing and Sustainability Manager, BERL is the only Malawian company that buys Jatropha seeds from farmers and produces straight Jatropha oil in significant quantities.

BERL relies on a decentralised and incentivizing contract farming model based on two management strands: Extension services in support of planting, maintaining and harvesting Jatropha together with a multilevel purchasing system. This scheme organizes a large number of farmers in a multiple-tier system. Besides managed outgrowing, BERL also purchases Jatropha seeds collected from wild growing trees. Most of the 53 tons of seeds harvested in 2011 were used for planting further trees and for research and development; with an additional 5.5 million trees planned for this year. 2012 will be the first year of commercial operation, with a planned output of around 110 000 litres of Jatropha oil – by 2016 BERL plans to produce six million litres per year.

BERL does not secure its feedstock through agreements with individual farmers, but instead concludes contracts with farmer clubs. In order to become a member of a club, farmers need to grow a minimum of 200 trees and show good plantation management practice. Currently, the biofuel producer coordinates nearly 1 200 clubs, each consisting of up to 15 members. Establishment of additional clubs goes hand in hand with farmer training and is done on a yearly basis – following a set scheme and timeline including nursery setup, field preparations and transplanting of trees. After tree planting, farmers are registered, their fields are mapped and their trees are counted. BERL provides 21 000 seeds per season free of charge to the clubs, which set up nurseries and provide seedlings to the farmers. In return, clubs are expected to produce around 7 000 viable seedlings per annum.

In order to receive approval clubs are required to actively manage a number of agronomic and sustainability issues. For example: Is the soil water-logged or is there a risk of flooding? Have land rights been respected? Furthermore, to avoid food conflicts, BERL does not support cultivation on large fields and farmers are encouraged to plant hedges around their main plots instead of using residual land.

Extension services offered through BERL field technicians are crucial to the management scheme. Each technician is responsible for 30 to 40 clubs in a radius of approximately ten kilometres. The technicians themselves are supported by BERL field managers, who function as a quality management team by ensuring that standard operating procedures are adhered to. Through random sampling, field managers control plant quality and meet with farmers to learn about their experiences in the field. ››

›› BERL's contracts with farmer clubs include a guaranteed seed offtake at a fixed price, which creates not only trust and long-term relationships but also a secure market for outgrowers. The fixed price is USD 0.15 per kilogram A-grade seeds and USD 0.09 for B-grade (moist or dirty seeds, signs of mould). The purchasing of dry seed yields is subdivided into two tiers. So-called lead farmers – nominated by BERL field staff based on their proven good Jatropha plantation management – communicate to 60 to 70 outgrowers. They inform these farmers not only where to sell their seeds, but also how to harvest, dry and grade the seeds before sale to BERL. This purchasing system is backed up by a complex and optimised logistics system that provides buying points located between five to ten kilometres from each club. Finally, BERL buyers communicate the amounts to the head office, which then handles the payout. After processing the seeds, BERL sells the press cake back to farmers as an affordable alternative to chemical fertiliser.

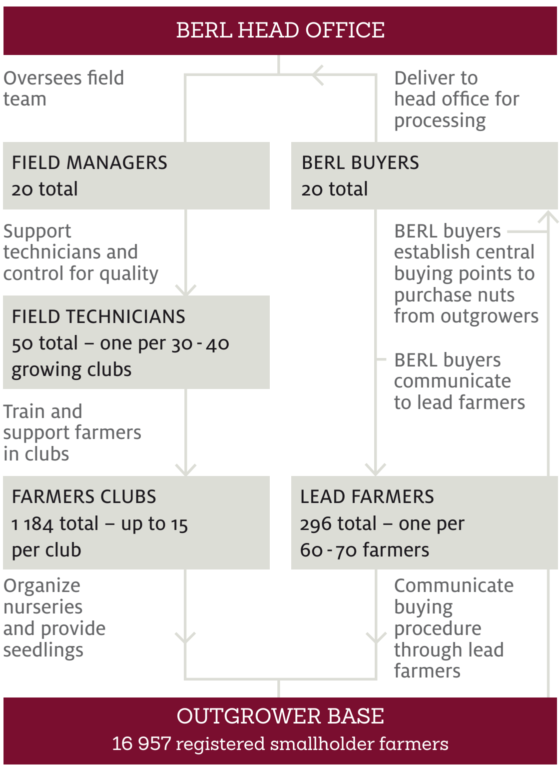


Figure 8: Basic organisational chart of BERL's outgrowing model

This case demonstrates how BERL has developed two different management strands to deal with organisational challenges. The first is the extension management system in which farmer clubs together with field technicians and field managers organize the growing of Jatropha and ensure quality produce. The second is the purchasing and seed delivery system of contract clubs, lead farmers and BERL buyers. Both strands, growing and purchasing management, are supported by optimised local logistics, showing that managing just short of 17 000 outgrowers in a single scheme is possible.

Added value is created for the supplying farmers as not only do they have new additional sources for income generation but also their knowledge and skills are built up on an individual basis through BERL's extension services. Furthermore, the multi-tier management system provides incentives for continuous improvement and promotion, which is manifested in the position of lead farmers. Also, clear rules and awareness for local needs through the decentralised club system minimizes risks for both BERL and the farmers.

As a next step, BERL is developing a carbon credit scheme as a future source of financing. Currently, around 230 hectares (in the form of linear plots) including 1 750 farmers in 250 clubs are prepared for inclusion in a voluntary carbon credit scheme under the Verified Carbon Standard.

Note: This short case study reflects BERL's outgrower model as of October 2011. It was written with the support of Abbie Chittock, Marketing and Sustainability Manager at BERL (www.berl.biz).

Box 4: Case study BERL, Malawi

3

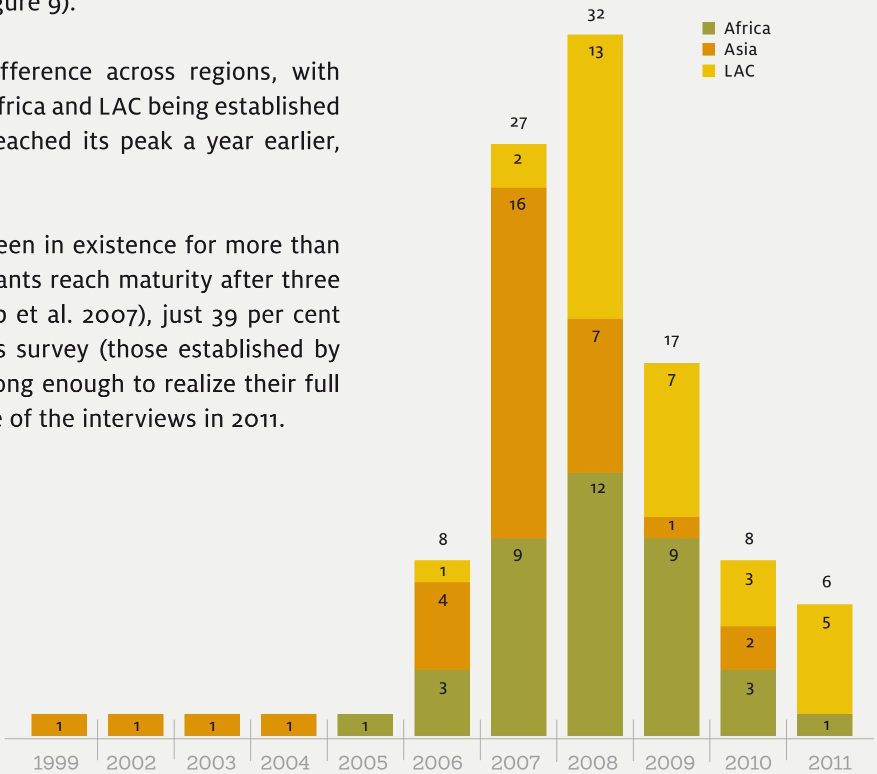
3.4 Year of cultivation site establishment

More than 70 per cent of the operational projects surveyed in this study project started planting Jatropha between 2007 and 2009. Cultivation site establishments peaked in 2008. Afterwards, the number of new projects dropped considerably (Figure 9).

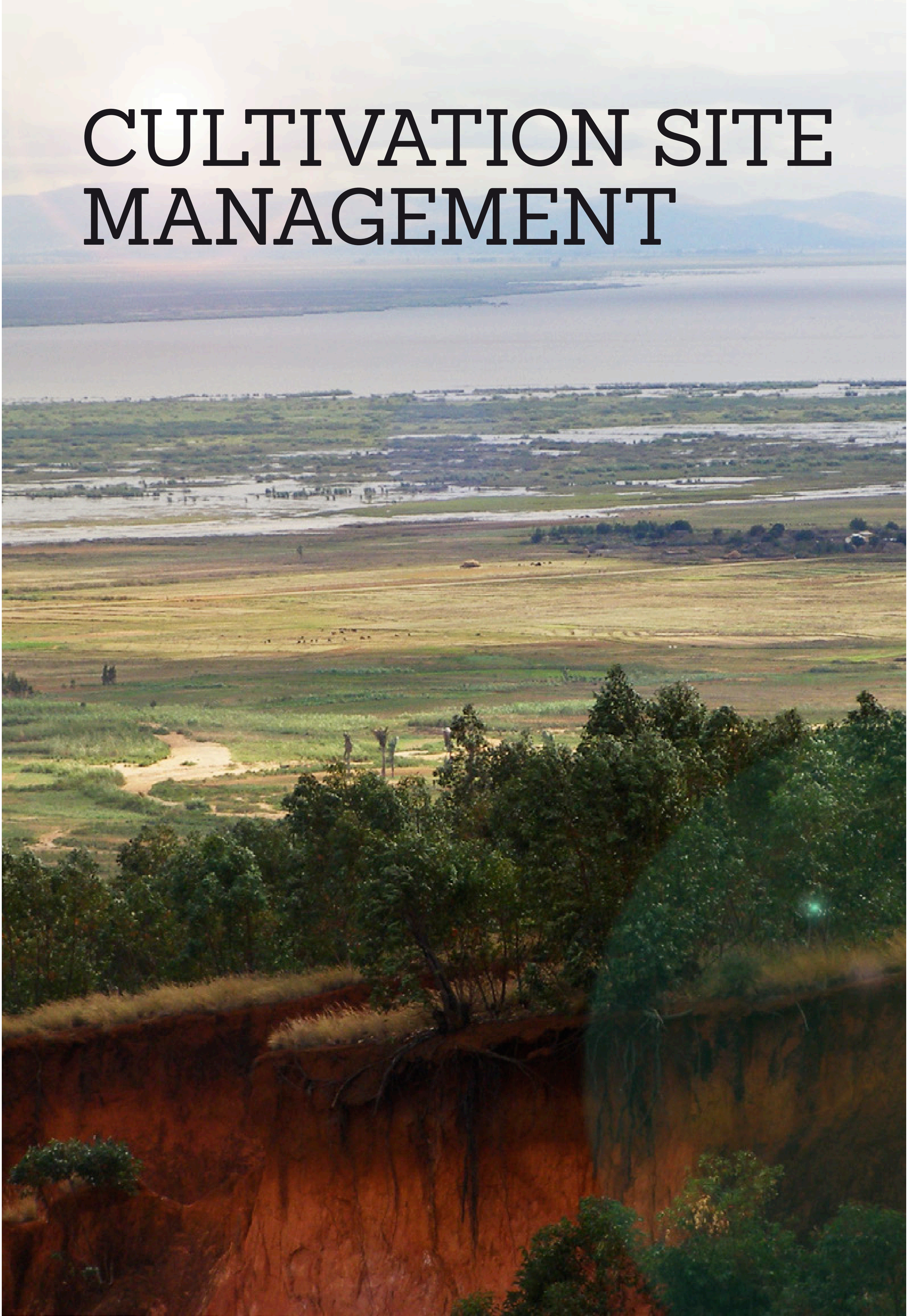
There is a noticeable difference across regions, with most cultivation sites in Africa and LAC being established in 2008, whereas Asia reached its peak a year earlier, in 2007.

Very few projects have been in existence for more than five years. As Jatropha plants reach maturity after three to four years (Jongschaap et al. 2007), just 39 per cent of cultivation sites in this survey (those established by 2007) were operational long enough to realize their full yield potential at the time of the interviews in 2011.

Figure 9: Years of cultivation site establishment according to region, number of projects, n=103 projects, Africa n=38, Asia n=34, LAC n=31



CULTIVATION SITE MANAGEMENT



Biofuel sustainability critically depends on sustainable feedstock production (Koh 2007; German et al. 2011; Lüdeke-Freund et al. 2012). For Jatropha in particular, a lack of agronomical knowledge is considered to be a major reason for failure (Wahl et al. 2009). That is why different aspects of agronomy and agricultural management practices form a central part of this survey. Findings in this section are arranged in a chronological order – starting with aspects of land conversion (4.1), through measures and decisions taken in establishing cultivation sites (4.2; 4.3; 4.4), to management practices applied on a regular basis as part of plantation maintenance (4.5).

The conversion of natural vegetation (e.g. forests) into agricultural areas may result in a change of natural habitat or loss of biodiversity (Hennenberg et al. 2009) as well as in an up-front release of carbon stored in above-ground and below-ground organic matter (Achten & Verchot 2011). The so-called "carbon debt" (Fargione et al. 2008) caused by such land-use change (LUC) is one of the most critical issues of biofuel production with regard to greenhouse gas emission reduction. Taken over a biofuel life-cycle, such negative impacts on the carbon stock have the potential to outbalance the positive effects biofuel production may have on the global climate through the replacement of fossil fuel and a net decrease in GHG emissions (Searchinger et al. 2008). Assessments for Jatropha show that the conversion of forests and woodlands in particular may result in significant overall increases in emissions and carbon debt from biofuels compared to conventional fuels (Bailis & McCarthy 2011; Achten & Verchot 2011; Romijn 2011).

> The so-called carbon debt caused by such land-use change is one of the most critical issues of biofuel production

In contrast, emission decreases have been found where biofuel crop production was introduced on former farmland and so-called marginal or degraded land (Bailis & Baka 2010; Romijn 2011). Not least, change of land use also directly affects feedstock producers and local communities. Jatropha is often touted for its pro-poor potential, particularly for smallholder farmer communities in the developing world (FAO 2010; Achten 2009). At the same time, land (use) rights and the direct or indirect displacement of food production and its impacts on food-insecure regions are among the most prominent issues (German et al. 2011).

In the process of establishing Jatropha projects, one-time measures as well as strategic decisions on key aspects such as planting material and cultivation systems may not only affect the viability of the enterprise but also its socio-ecological impacts. In preparing a site for cultivation, for example, the removal of trees not only destroys carbon sinks and stocks but may also result in high costs for machinery and/or workers. While less labour and capital intense, the ploughing of fields may disturb soil aggregates and thus increase soil organic matter decomposition (Bailis & Baka 2010). The genetic properties of the planting material determine to a large extent aspects such as growth performance, yield, and resistance to biotic and abiotic stress. Especially for Jatropha, practitioners and researchers agree that domestication of the "(semi-) wild" (Achten et al. 2010) plant is critical for its productivity (Achten et al. 2010; van Eijk et al. 2010; FAO 2010). Risks associated with the cultivation of wild seeds include variability in growth performance, uneven ripening of fruits and unknown yield potential (Friends of the Earth 2010). ››

4

›› Cultivation systems are the frameworks for managing agricultural production. Their different components are critical levers in order to achieve economic, environmental and socio-economic benefits on a specific site. Oilseed production on a dedicated plantation site, for example, is more efficient from a management and logistics perspective than harvesting dispersed hedges or wild trees. From a land use perspective, however, harvesting from hedges may be more efficient, particularly for small farmers, because it allows them to continue to cultivate other crops. However, yields from hedgerows or boundary crops are usually lower than from plantations. For plantations, monocultures are considered economically efficient, but they are controversial for the environmental risks they bear (FAO 2010) which may become economic risks in the long run as well. Integrating further crops allows growers to generate income in the first years when Jatropha cultivation does not generate any revenue. Both, mono- and intercropping strategies may contribute to local food and energy supply (Sachs & Silk 1991; Bogdanski et al. 2010). Planting density is a related and similarly ambiguous aspect. Whilst the carbon sequestration potential of a plantation benefits from a high density of trees, intercropping requires lower densities. Wide spacing of trees is likely to result in higher yield per tree because competition between individual trees is reduced, but productivity per hectare might decline (FAO 2010).

In contrast to measures taken only once during establishment, sustained management practices have on-going impacts. One of the myths spread in the early days of Jatropha cultivation was that the plant basically ‘grows by itself’ and does not require any input or management (Jongshaap 2007; Achten et al. 2010). Although this energy crop has often been portrayed as a hardy, resistant plant which is immune to pests and diseases, control measures are crucial for plant health and obtaining sufficient oil yields (FAO 2010).

Nutrient management is essential to obtaining consistently high yields at levels suitable for environmentally sustainable and commercially viable production. This may be especially important for projects operating on degraded lands (van Eijk et al. 2010). Of course, while agrochemical inputs increase yields and reduce the risk of crop failure, they can lead to detrimental effects on soil and water quality, increase GHG emissions and result in a less favourable energy balance.

For a comprehensive and conclusive evaluation of agronomical practices, additional data (for example on irrigation) and detailed case-by-case site assessments are needed. Although the data presented here do not allow for such a detailed analysis, general findings regarding plantation management are presented in this section.

4.1 Land conversion

In this survey, two questions address land conversion and land-use for the establishment of Jatropha projects. One question refers to the vegetation found on land before being used for producing Jatropha oilseeds; the other asks how the land was previously used.

Note that Jatropha production does not necessarily involve the complete replacement of pre-existing vegetation or displacement of land-use. As shown below, many projects cultivate Jatropha in hedges or intercropped with either annual or perennial crops. Also, projects may operate on multiple sites in one country (see project definition in Chapter 2) and employ different schemes (plantation and outgrowing) at the same time. Accordingly, questions on prior vegetation and land uses offer multiple-response choices. The presentation of findings on these responses therefore does not refer to the total land area planted but to the number of responses or per cent of projects per category.

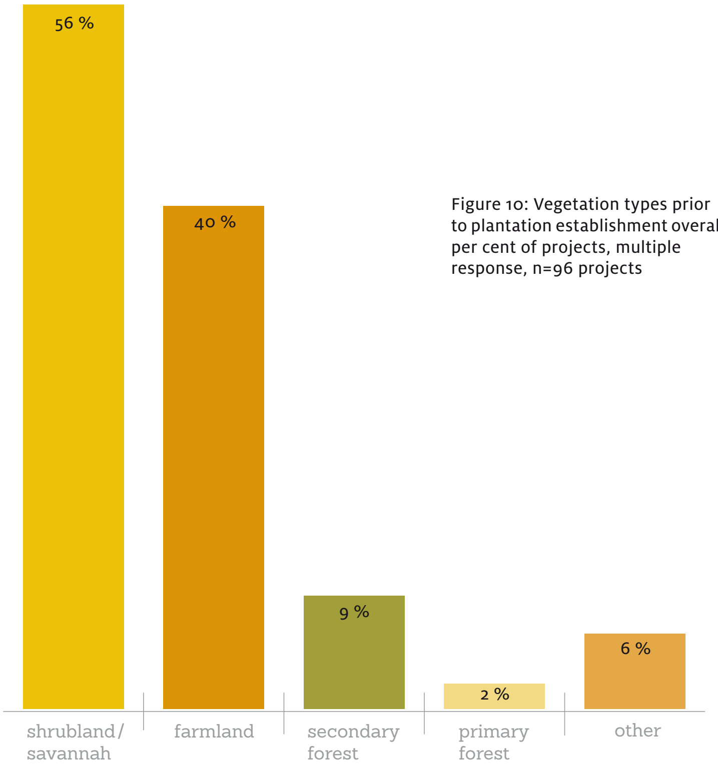
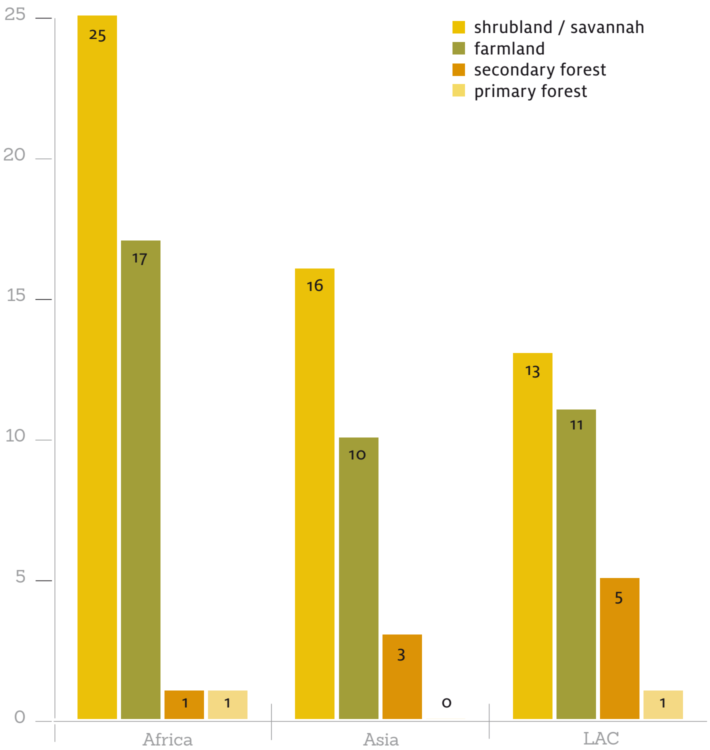


Figure 10: Vegetation types prior to plantation establishment overall, per cent of projects, multiple response, n=96 projects

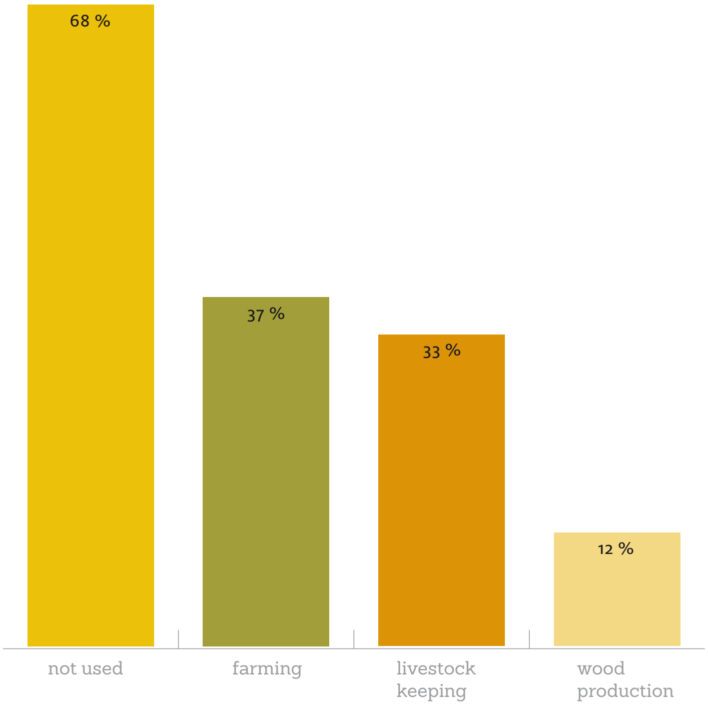
Figure 11: Vegetation types prior to plantation establishment according to region, number of responses, multiple response, n=96 projects, Africa n=38, Asia n=28, LAC n=30



›› Overall, 63 out of 96 responding projects (65%) were established (at least partially) on land characterized as degraded or marginal by interviewees. Throughout the regions, the use of degraded land to establish cultivation sites is found to be evenly distributed: 23 out of 38 projects in Africa, 19 out of 28 projects in Asia, and 20 out of 30 projects in LAC (around 70% respectively). Concerning prior vegetation type (Figure 10), more than half of the cultivation sites were established on savannah (56%). Agricultural land was used by 40 per cent of the projects. Eleven per cent replaced forests - defined as lands of more than 0.5 hectares, with a tree canopy cover of more than ten per cent, which are not primarily under agricultural or urban land use (plantations and agroforestry systems are also excluded) (FAO 2004). More specifically, for two per cent of the projects primary forests were given as prior vegetation, while secondary forests were mentioned for nine per cent of the projects. The latter differ from primary forests in that they are regenerated vegetation after the original natural forest has been removed or significantly disturbed by human or natural causes (Odera 2002).

Looking at regional features shows that patterns are largely the same in all three global regions (Figure 11). With one out of 38, the share of projects established (at least partly) on land with prior secondary forest coverage is proportionally smallest in Africa compared to LAC and Asia. In Africa proportionally more shrubland is converted to plantations. ››

Figure 12: Prior land use overall, per cent of projects, multiple response, n=94 projects

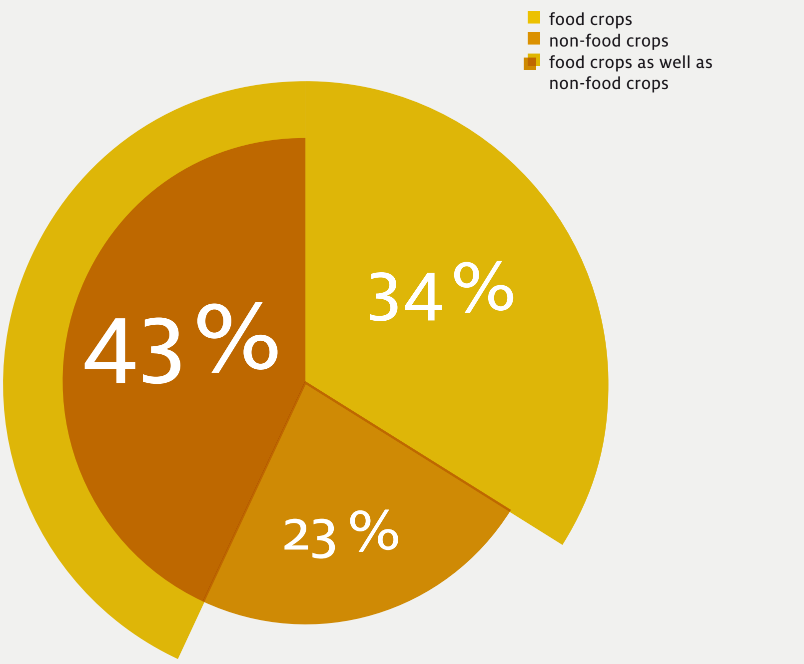


›› Regarding the ways the plantation areas were used prior to their establishment (Figure 12), more than two-thirds of all projects (64) responded that at least some part of their plantation is situated on land which was not in use before. About one-third (35) of the projects operate (partly) on land previously used for farming, and another third (31 projects) grow on land that was used for keeping livestock. For twelve percent of the projects wood production was the least common prior land-use type (11 projects).

Of those 64 projects that responded that their current plantation land was (partially) not in use before, 46 also classified at least part of their land as degraded or marginal. Regarding prior vegetation types, 35 out of those 64 projects had used shrubland and savannah, 21 had used farmland. Eight projects that described prior vegetation types of (at least some of) their plantation sites as forests also responded that land was not used before they began cultivating Jatropha.

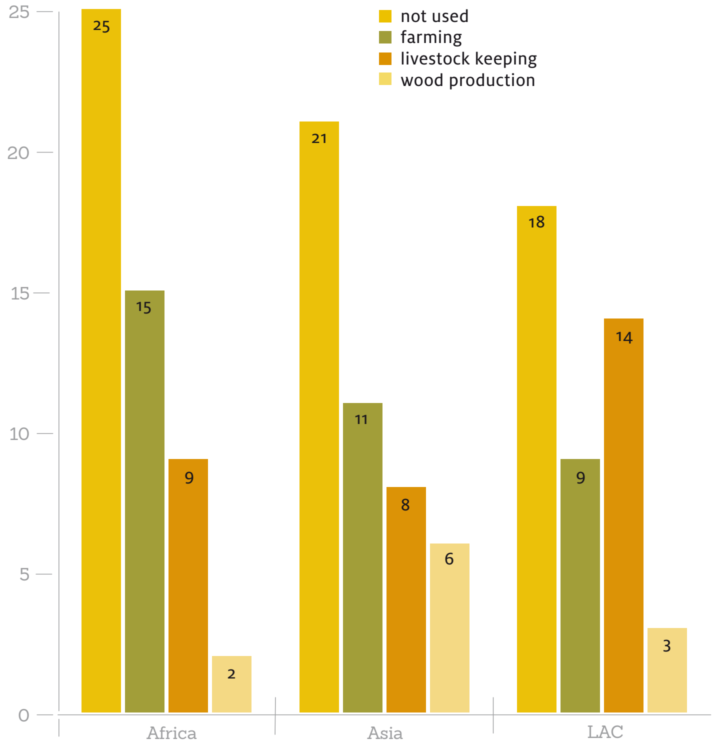
When asked to specify former farming activities, 27 of the 35 projects (77%) responded that parts of their current plantations are located on land that had been used for farming food crops (Figure 13). Non-food crop cultivation was reported as former land-use type for 23 oilseed producing projects (65%). For 15 projects respondents claim that a mixture of food and non-food crops preceded use as Jatropha cultivation sites. ››

Figure 13: Crop farming on land prior to plantation establishment, per cent of projects, multiple response, n=35 projects



›› Comparing findings on a regional basis (Figure 14), it is noteworthy that almost half of the projects in LAC countries at least partially replaced livestock keeping with Jatropha cultivation, compared to about one-quarter of the projects in Africa and Asia. In Asia, a proportionally larger share of one-fifth of the projects also displaced wood production, whereas this is the case for only two out of 38 projects in Africa and three out of 30 in LAC.

Figure 14: Prior land use according to region, number of responses, multiple response, n=94 projects, Africa n=36, Asia n=28, LAC n=30



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4.2 Cultivation site establishment

Concerning the types of measures taken for the initial establishment of cultivation sites, the focus is on one-time practices preparing a site before planting Jatropha. The four measures preparing plantation sites addressed in this survey – removing trees, removing shrubs, cutting grass, and discing or ploughing – may differ in labour and capital intensity as well as in their environmental implications as described above.

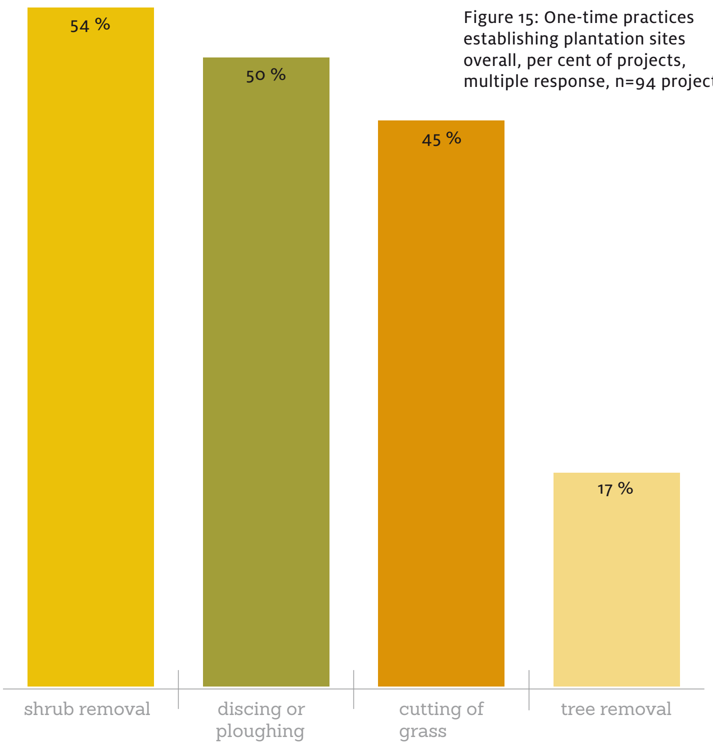
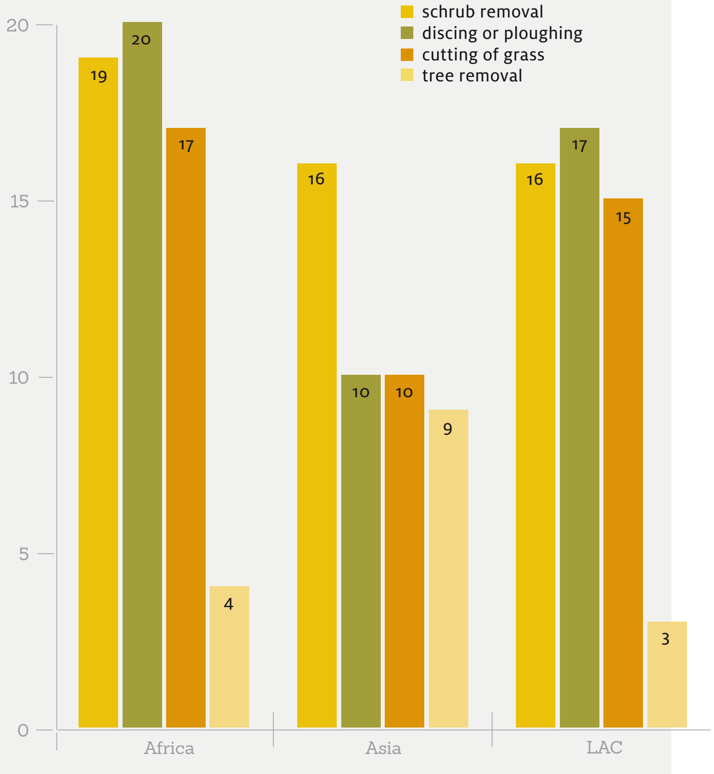


Figure 15: One-time practices establishing plantation sites overall, per cent of projects, multiple response, n=94 projects

Information on the initial site preparation practices is available for 94 operational Jatropha projects. Overall, removal of shrubs, ploughing or discing, and cutting of grass are almost equally common measures to prepare sites for plantation (Figure 15). Significantly fewer projects involved tree removal.

This overall pattern is reflected in the strikingly similar profiles of the African and LAC sample (Figure 16). Asian projects, however, show slightly different features. It is noticeable that removing trees to establish the plantation is a more common measure for projects based in Asia, where it is almost as common as cutting grass or ploughing fields.

Figure 16: One-time practices establishing plantation sites according to regions, number of responses, multiple response, n=94 projects, Africa n=36, Asia n=28, LAC n= 30



4.3 Planting material

Jatropha is an undomesticated species, which is why there has been significant investment in its domestication in recent years (Achten et al. 2010). However, systematic breeding has only started recently and seed development of perennials is a lengthy and costly process, so the question remains as to what extent Jatropha farmers already benefit from genetically improved planting material. This section highlights findings on the status of planting material used and its provenance in operational Jatropha projects today. To this end, no differentiation is made between project schemes (plantation versus outgrowing schemes) as the large majority of outgrowing schemes are found to provide planting material to their farmers either free of cost or at reduced price. In many cases, this is accompanied with extension service and training. See for example the case studies on BERL (Box 4 on page 21) and Mali Biocarburant (Box 5 on page 36).

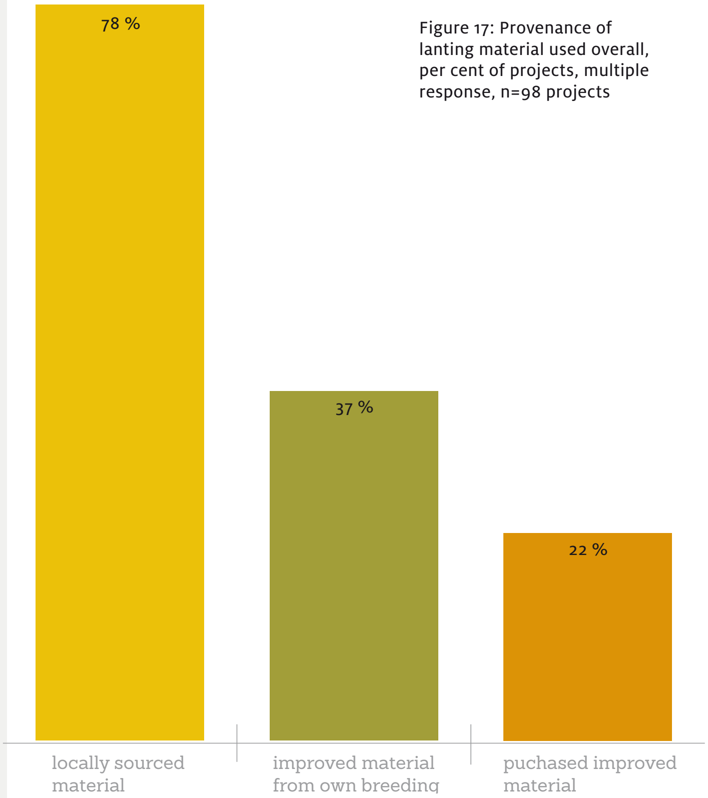


Figure 17: Provenance of lanting material used overall, per cent of projects, multiple response, n=98 projects

Most commonly, planting material for 98 reporting projects was sourced locally (78%) – for example by collecting seeds or cuttings from wild trees (Figure 17). The original question distinguished between locally sourced and wild material. However this distinction was not supported by the respondents and so the responses referring to these two categories are summarized under the one category of locally-sourced material.

Over one-third of the projects (37%) also obtained planting material through their own breeding efforts. Only 22 per cent of the projects purchased improved material developed in professional breeding schemes. However, the quality of varieties obtained from professional breeders could not be assessed. ››

›› In terms of planting, Jatropha can be propagated either by cuttings (i.e. branch cuttings from existing trees that are put into the soil), by direct seeding, or by transplanting seedlings from a nursery to the field. The majority of the 98 operational projects responding to this question employed multiple methods to establish their plantations (Figure 18). Seedlings were used in most of the projects (52%), closely followed by direct seeding (48%). Cuttings were used for comparatively few projects (29%).

›› As both aspects, planting material and its provenance, were addressed in the same question, responses can be presented in a cross table with nine combinations (Table 4). The combination of locally sourced material and seedlings was the most popular, closely followed by locally sourced seeds. A second group of frequent combinations is formed by seedlings from their own breeding efforts and locally sourced cuttings. They are followed by cuttings and seeds from their own breeding efforts. Improved materials (seeds, seedlings and cuttings) that were purchased from breeders are the least frequent combination.

Figure 18: Planting material overall, per cent of projects, multiple response, n=98 projects

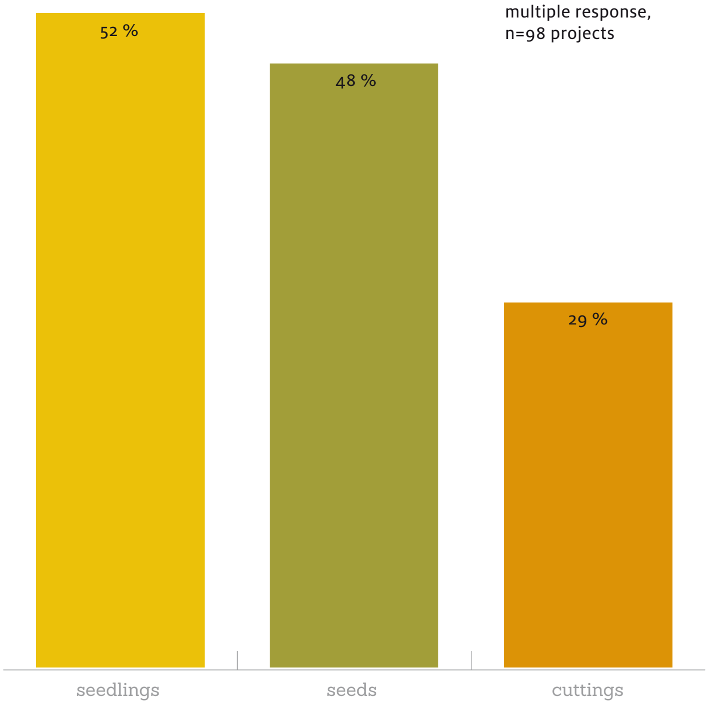


Table 4: Planting material and its provenance in detail
Number of responses, multiple response, n=76 projects

	Locally sourced material	Improved material from own breeding	Purchased improved material
Seeds	40	10	7
Seedlings	44	24	7
Cuttings	23	12	6

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4.4 Cultivation systems

With regard to cultivation systems, the presentation of survey findings focuses on three components: production models, cropping strategies, and planting densities.

4.4.1 Production models

Jatropha fruits are obtained from three distinct models of production: on agricultural land; as hedges – also called "living fences" – along roads, around properties or around agricultural plots; and from collection of fruits from wild trees.

The majority of the 99 projects surveyed on their production model established Jatropha as plantations, i.e. rows of trees planted on dedicated fields (82%). A much smaller number of projects relied solely or additionally on the collection of Jatropha fruits from hedges and/or wild trees (26% and 13% respectively).

Comparing results across the three main regions of production (Figure 19), the Asian sample is striking in comparison to the global trend and to the other regions. There is a proportionally lower share of plantation sites in the Asian sample but a higher share of outgrowing schemes relying on the collection of fruit from wild trees. On the other hand, plantation models are much more common in Africa and LAC than in Asia. The African sample reflects the global pattern, however, with a noticeably higher share of plantation and hedge models. In LAC, harvesting wild trees does not appear to be an established production system at all. Hedges are a comparatively less common approach in LAC as well.

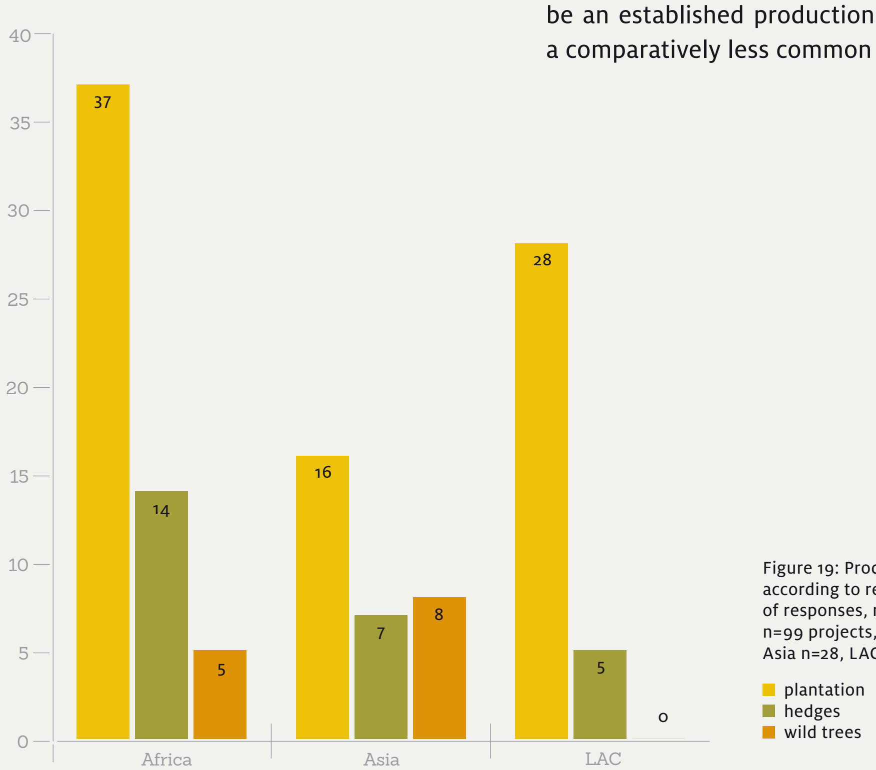

Figure 19: Production models according to regions, number of responses, multiple response, n=99 projects, Africa n=39, Asia n=28, LAC n=32

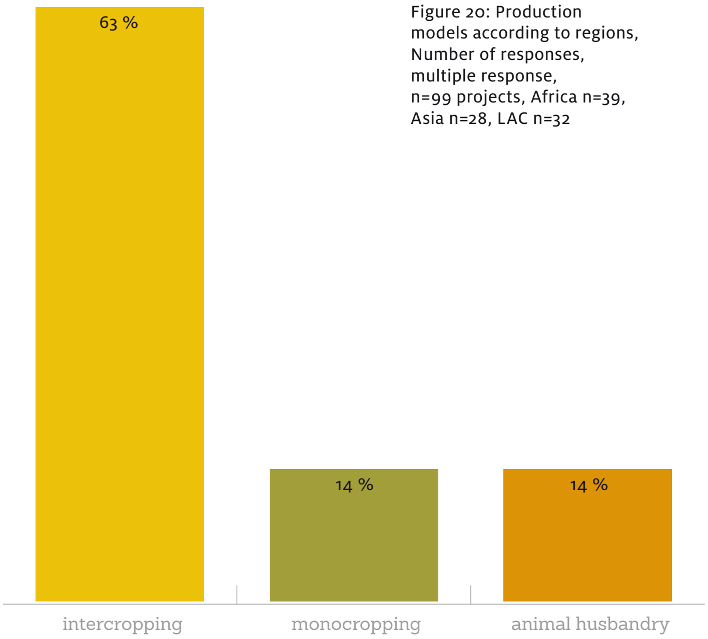

Figure 20: Production models according to regions, Number of responses, multiple response, n=99 projects, Africa n=39, Asia n=28, LAC n=32

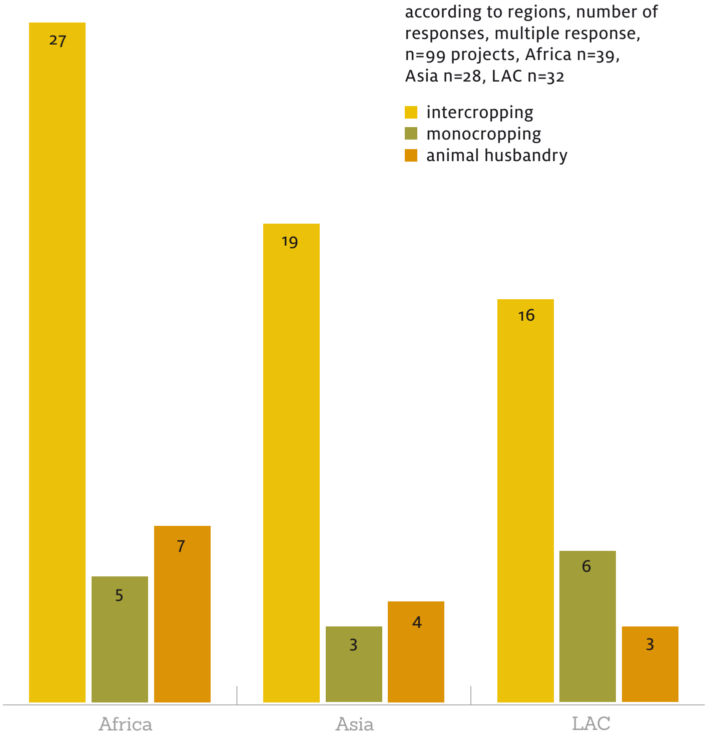

Figure 21: Cropping strategies according to regions, number of responses, multiple response, n=99 projects, Africa n=39, Asia n=28, LAC n=32

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4.4.2 Cropping strategies

On a plantation, Jatropha can either be cultivated as a single crop (monocropping) or in combination with other crops (intercropping), i.e. annual crops like maize and beans but also other perennial crops, such as coffee. Moreover, Jatropha cultivation can be combined with animal husbandry.

Intercropping is clearly the dominant strategy among the 99 projects responding to this question (Figure 20): In 63 per cent of projects intercrops are integrated with Jatropha trees. Only 14 per cent mentioned monocropping and animal husbandry respectively.

A closer look at intercropping reveals that, in 85 per cent (53 projects) of the 62 projects Jatropha is grown in combination with annual crops. Other perennials, for example other oil-bearing trees or fruit trees, are integrated in just nine projects (15%). In many projects more than one other crop type is integrated. Food crops are mentioned by a large majority of intercropping projects (37), with the most common being maize and beans. Other food crops mentioned include groundnuts, potatoes and millet. Also, cash crops such as cotton, soy or tobacco offer further sources of income among projects in this sample (for an example of intercropping outgrowers see case study on Kapiri Mposhi Jatropha Growers Association, Box 6 on page 51). ››

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›› Other oil-plant species – annual and perennial – that interviewees mentioned in the context of intercropping include Camelina (*Camelina sativa* (L.) *Crantz*); Candlenut tree *(Aleurites moluccana* (L.) Willd.); Castor (*Ricinus communis* L.); Croton *(Croton megalocarpus* Hutch.); Mahua *(Madhuca longifolia* (J.Konig) J.F. Macbr.); Neem tree *(Azadirachta indica* A. Juss.); Paradise Tree, Aceituno, or Bitterwood *(Simarouba glauca* D.C.); Shea tree *(Vitellaria paradoxa* G. Don); and Sunflower *(Helianthus annuus* L.). For an illustration of an outgrower project that includes several oilseed-bearing species refer to the case study on the Kapiri Mposhi Jatropha Growers Association in Zambia (Box 6 on page 51).

During the first years after the establishment of a plantation, crops can be grown on a large share of the plantation land because Jatropha trees are still small in size. As trees grow bigger and occupy more space, opportunities for intercropping decrease or vanish depending on the spacing of trees. Thus, the large share of intercropped plantations may arise from the fact that most of the projects have not fully reached maturity yet (see Chapter 3.4). Especially among projects that operate plantations with dense spacing the share of those that intercrop will likely decline after 2011.

4.4.3 Planting density

Planting densities of Jatropha trees depend on cultivation systems and cropping strategies. Another factor driving spacing is the development of mechanized harvesting. Projects that involve mechanization may need to plant with lower densities than projects relying on manual labour. The following findings refer to dedicated mono- or intercropped plantations.

Planting densities vary greatly. Some projects were found with less than 1 000 trees per hectare, while others had more than 3 000. Nevertheless, three common planting densities can be identified: 1 111, 1 666 and 2 500 trees per hectare equal to a squared spacing of 3.0 by 3.0, 2.4 by 2.4 and 2.0 by 2.0 meters per tree (Table 5). The case study on Mali Biocarburant SA (Box 5 on page 36) illustrates how planting densities and intercropping of outgrowers are managed in order to achieve carbon credit financing.

Trees per ha	m^2 per tree	Plant spacing (m)	Number of projects
1 111	9	3.0 x 3.0	15
1 667	6	2.4 x 2.4	18
2 500	4	2.0 x 2.0	21

Table 5: Common tree densities on Jatropha plantations in trees per hectare, square meters per tree, plant spacing, number of projects, n=54 projects

The average planting density for all projects is 2 090 trees per hectare. This density equals a spacing of approximately 2.2 by 2.2 meters. In general, there is little variation between projects established in different years. Interestingly, however, the six projects established in 2011 show a mean planting density of 1 435 trees per hectare (2.6 by 2.6 meters per tree), which is higher than the overall average.

MALI BIOCARBURANT SA – AN INTEGRATED BUSINESS MODEL FOR BIOFUELS AND PRO-POOR CARBON OFFSETTING

Founded in 2007, the biodiesel and biogas producer Mali Biocarburant SA (MBSA) cooperates with around 10 000 farmers in Mali and Burkina Faso in an integrated business model, cultivating Jatropha as well as food crops. It is the Jatropha tree which is crucial to MBSA's model. Biodiesel reduces CO_2 emissions when replacing conventional fuels, while the tree stores carbon as it grows. In order to reach a scale of carbon storage that generates carbon credits, farmers are pooled under carbon credit schemes – an often discussed but rarely realized model. MBSA is pioneering in pro-poor carbon offsetting in Africa. Both the Mali and Burkina Faso projects were approved for the voluntary carbon credit market (Trees for Travel campaign in Mali and the Fair Climate Fund in Burkina Faso), i.e. future emission reductions.

In order to make efficient use of available land, farmers grow Jatropha trees in spaces of two by two meters in double rows, between which eight meters space is left for annual crops such as sorghum, maize or other food crops. The advantage of this agronomic model is not only that it leaves existing tree covers intact but also allows a density of up to 1 000 trees per hectare. This density then determines the amount of carbon credits that can be acquired. At the same time, the system has to be balanced carefully – to ensure food production, to allow for effective intercropping, and to produce enough seeds for the refining facilities. To this end, MBSA assists its farmers in their agronomic practices by providing free seeds and by supporting weed, nutrient and plant health management, for Jatropha and food crops. Additionally, two foundations promote sustainable agroforestry systems to improve farmers' livelihoods.

MBSA decided to set up two refining companies to produce biodiesel from Jatropha oil: Koulikoro Biocarburant SA (KBSA) in Mali, established in 2007, and Faso Biocarburant SARL (FBSA) in Burkina Faso, established in 2009, constructed in 2012. MBSA has a relatively short supply chain since the company buys the nuts directly from the farmers, paying USD 0.10 per kilogram, and extracts the oil, which is then refined. MBSA's current target is to harvest 2 000 tons of nuts per year to produce 500 000 litres of biodiesel in the Koulikoro region alone. Today, the production volume has reached 2 000 litres per day, including rotten cotton oil. Biodiesel is sold to different companies for power generation. Moreover, biogas is made from press cake and other feedstock such as waste cotton oil.

In Mali, the revenues for expected future emission reductions through fuel switch and afforestation were paid in advance to the farmer union, providing important cash inflow to finance extension services and further tree planting. The unions also used income from the carbon credits to buy shares in MBSA's refining companies in order to participate in future dividends. While in Mali, unions hold 20 per cent of KBSA, in Burkina Faso they hold 30 per cent of FBSA. "The farmers are the ones who plant the trees – thus, they are the ones eligible for carbon credits. This is essential for financing the extension services offered to farmers as well as for investing in sustainable agricultural practices." says Ard Lengkeek, Dutch Jatropha expert and project developer at MBSA. ››

›› By integrating farmers in every step, from nurseries to the refineries where biodiesel and glycerine are produced, MBSA's approach is also a socially sustainable, inclusive business model. In short, MBSA offers a social value proposition to farmers, creating links to more professional value chains and markets. Another success story is that, as their financial standing improved through growing Jatropha, the union set up a soap factory on their own, with the glycerin of the refining facility as feedstock

Note: Ard Lengkeek, Dutch Jatropha expert and shareholder at MBSA, contributed to this short case study. It was written in October 2011 (www.malibiocarburant.com).

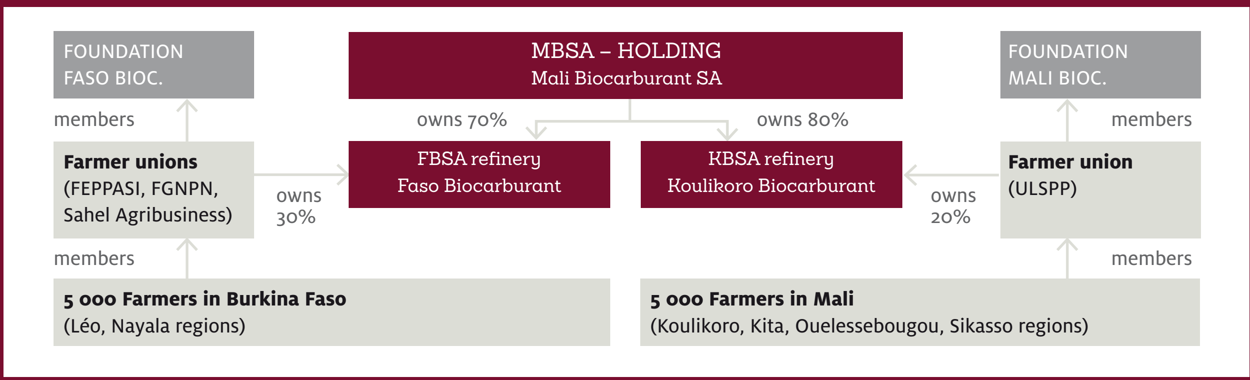

Figure 22: Stakeholder and shareholder relations in the Mali Biocarburant business model

Box 5: Case study Mali Biocarburant SA, Mali and Burkina Faso

4

4.5 Input management and cultivation site maintenance

Input management practices were systematically addressed in this survey. Project representatives were asked whether and how pest and disease control, weed management, and fertilisation were handled in their respective projects. However, these questions were only systematically addressed in projects that operated their own plantations as well as outgrowing. As a result, sample sizes in this section are significantly smaller. This is the case especially in Asia, where a large majority of Jatropha project operations rely on outgrowing (see Chapter 3.3). It should be noted that in some cases less than half as many Asian projects responded to this question as in Africa.

For projects that rely solely on outgrowers and do not operate their own plantation sites, the contracted farmers could not be surveyed. Nevertheless, interviewees representing such projects were asked for indications of how inputs are managed. Information provided for 53 outgrowing schemes are included as far as possible.

In 2011 the majority of plantation projects reporting on inputs applied measures in all three areas – weed, plant health and nutrient management (Figures 23, 24, 25). In comparison, weeding appears to be almost a necessity or a typical measure in Jatropha cultivation. Pest and disease control as well as fertilisation, on the other hand, are either not as necessary or pose a higher challenge for implementation.

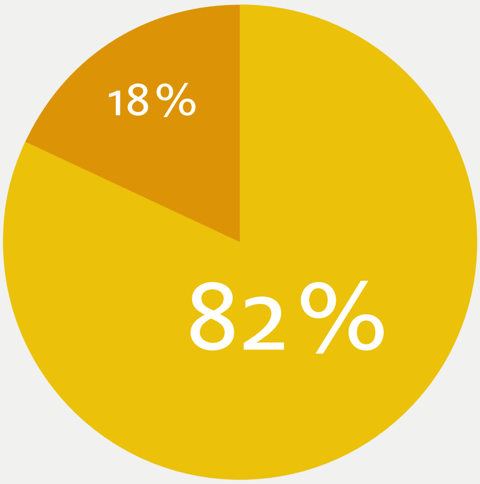

Figure 23: Overall pest and disease control, per cent of projects, n=56 projects

- pest and disease control
- no pest and disease control

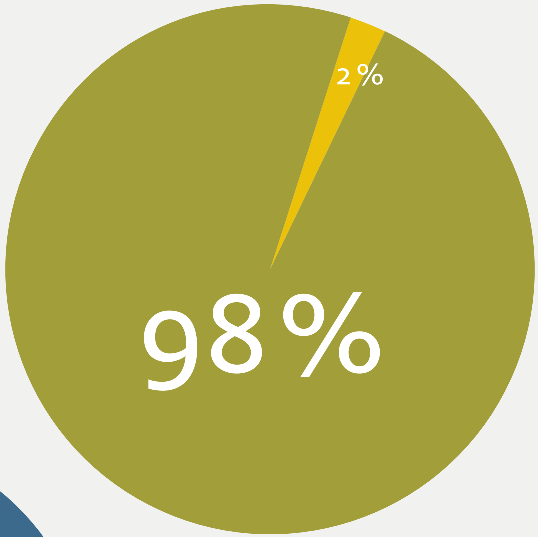

Figure 24: Overall weed management, per cent of projects, n=58 projects

- weed management
- no weed management

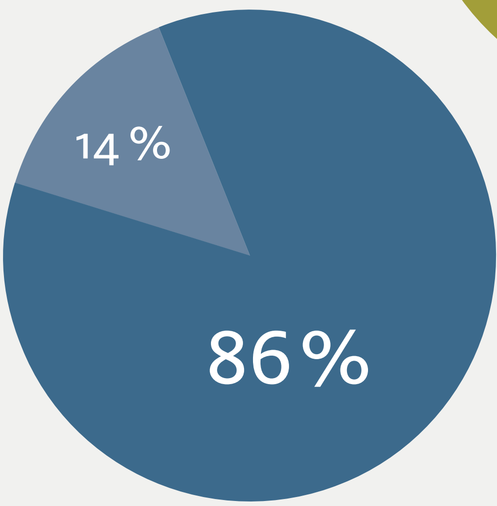

Figure 25: Overall nutrient management, per cent of projects, n=58 projects

- nutrient management
- no nurient management

4.5.1 Pest and disease management

Ten projects reported taking no measures at all to assure plant health on their Jatropha plantations. In 46 out of 56 projects (82%), some sort of pest and disease control is in place (Figure 23 on page 38). To this end, in 33 of these projects (72%) chemical pesticides are applied, whereas for 22 projects (48%) use of biological products or methods was reported. Regarding other measures, respondents reported using breeding techniques to develop immunity against pests and diseases.

Figure 26 shows that chemical treatment of Jatropha pests and diseases is dominant in Africa and LAC as well. As a result, biological treatments are less common in these regions. In 90 per cent of Asian projects biological control was mentioned, while in six projects chemical control was reported.

Less is known with certainty about pest control measures among outgrowers. Out of the 53 projects that provided information on their outgrowers' plant health management, 27 confirmed that their outgrowers actively control for pests and diseases. Some projects (12) try to stimulate pest control by providing subsidies, pesticides or other support. Nine respondents stated that pest management is clearly the farmers' responsibility.

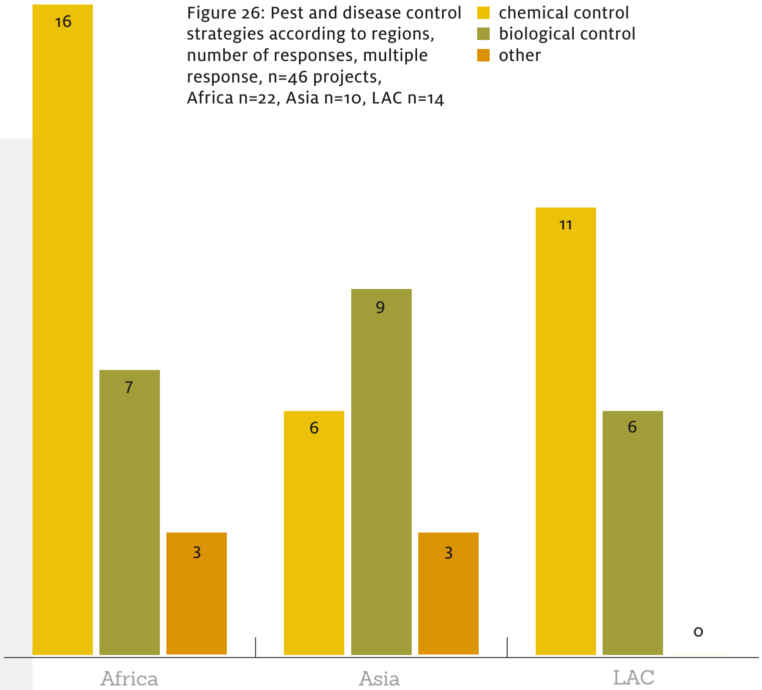

Figure 26: Pest and disease control strategies according to regions, number of responses, multiple response, n=46 projects, Africa n=22, Asia n=10, LAC n=14

4.5.2 Weed management

In all but one of 58 projects (98%), weeds are managed in some way. Manual weeding is by far the most common method (41 responses), followed by herbicide use and mechanical weeding (25 responses each). Grazing of livestock was reported for 13 projects. Intercropping with maize is another measure that one project representative said helps to prevent and manage weeds on his plantation in LAC.

One project in Asia reported dealing with weeds by burning them. While the Asian and African samples mirror the overall distribution of responses and especially the strong preference for manual weeding compared to other measures (Figure 27), projects in LAC have a preference for machinery use (mechanical) and grazing of livestock. In addition, the distribution of responses in LAC implies a greater flexibility towards different measures.

Forty-two out of 53 projects provided information on weeding activities of their outgrowers. In order to motivate farmers to control weeds, ten projects reported explicitly recommending weeding to their outgrowers. Furthermore, ten projects support outgrowers by facilitating weeding activities. With 17 responses, manual weeding is reported as the most common measure to control weeds. Only three projects mentioned that their outgrowers apply herbicides.

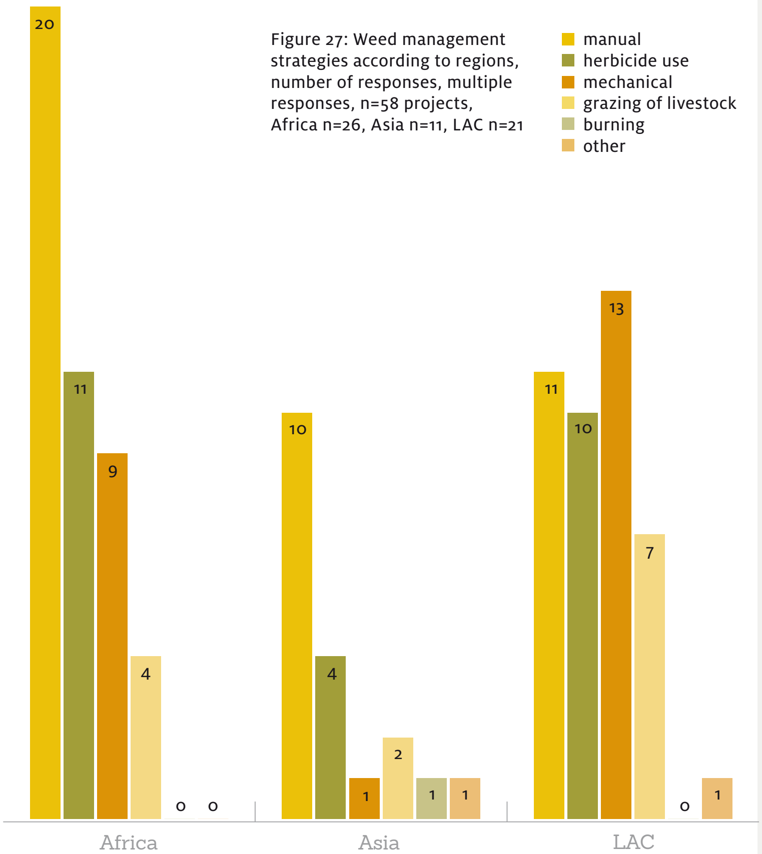

Figure 27: Weed management strategies according to regions, number of responses, multiple responses, n=58 projects, Africa n=26, Asia n=11, LAC n=21

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4.5.3 Nutrient management

With about 86 per cent (50 out of 58), the vast majority of respondents reported that plant growth is enhanced through fertiliser use (Figure 25 on page 38). In more than half of those (31 answers), organic fertilisers are applied, while 24 use chemical fertilisers. Press cake – the physical residue gained from processing seeds – contains nitrogen and can be used as an organic fertiliser as well (Jongschaap et al. 2007). Of the 49 plantation projects that apply fertiliser, 13 use press cake.

Again, responses for projects in Africa reflect the proportional preferences in nutrient management, while in the LAC sample agrochemical and organic nutrients are almost equally popular (Figure 28). In Asia, as many as nine out of the ten projects reported using organic and three reported chemical fertilisers while the application of press cake was reported for only one project.

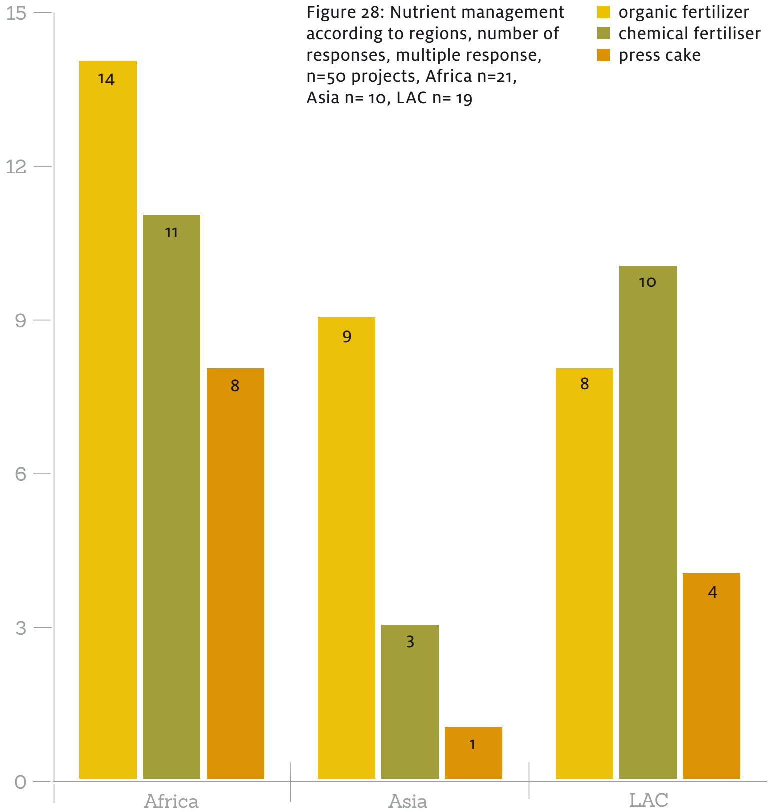
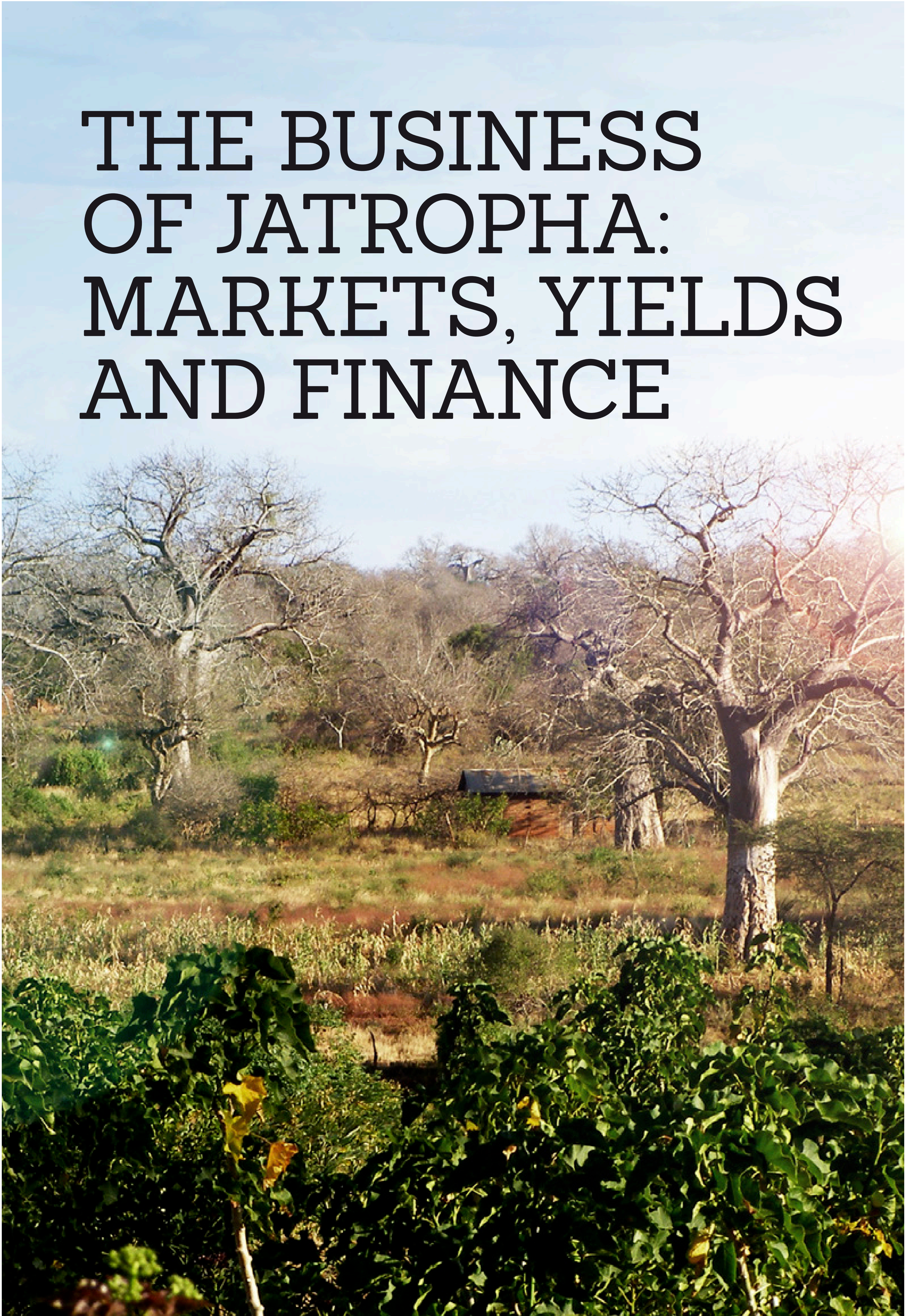


Figure 28: Nutrient management according to regions, number of responses, multiple response, n=50 projects, Africa n=21, Asia n= 10, LAC n= 19

It is less clear exactly what practices are used by outgrowers since the respondents did not necessarily have direct oversight over farm management. However, representatives of 42 projects stated that fertilising was as common as weeding among outgrowers. Respondents who provided more detailed information on types of fertiliser used by their outgrowers (23 projects) named organic fertilisers such as cattle manure or Jatropha press cake. Fewer projects (7) reported the application of chemical nutrients by outgrowers.

Some interviewees emphasized the limitations outgrowing project schemes faced concerning the agricultural practices of their farmers. Ten projects explicitly recommend fertiliser use to outgrowers, but verification and control of fertiliser use was often said to be difficult. To increase fertilisation efforts by outgrowers, 18 projects reported that they provide outgrowers with some kind of subsidy. Some projects provide fertilisers for free or at a reduced price, sometimes also with support from governmental or development organisations.

THE BUSINESS OF JATROPHA: MARKETS, YIELDS AND FINANCE



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The variety of small and large-scale approaches to cultivating Jatropha (e.g. plantation and outgrowing schemes) and agricultural practices (e.g. mono- and intercropping) described above results in different types of projects with different business models and financing needs, but also in different levels of performance potential in terms of yield per hectare. Furthermore, a project's business model depends on its domestic and international target markets, that is, its products and target customers as well as its value-chain configuration. Several case studies on the business and economic aspects of Jatropha providing country and context-specific results are already available (e.g. for India, Kenya, Mali or Tanzania; cf. Borman et al. 2012; FAO 2010; Romijn & Caniels 2011; more general in van Gelder et al. 2012). This report provides a broader view of Jatropha-based enterprises as well as preliminary international benchmark values. Findings in this section are arranged according to a project development perspective. They describe which markets are targeted and what kinds of value chains were set up by Jatropha projects (5.1), followed by an overview of investments, costs and Jatropha yields (5.2). Finally, the sources of financial capital are presented (5.3).

Biofuels are the most common target market of Jatropha enterprises. However, in many of the countries hosting Jatropha production, the biofuel industry is immature and carries numerous risks, such as unsustainable land use and increasing food insecurity (Borman et al. 2012; Eisentraut 2010; FAO 2008; The World Bank 2007). Whether these risks can be mitigated depends on the agronomical concepts and practices applied to produce biofuel feedstock (Lüdeke-Freund et al. 2012). The commercial cultivation of Jatropha however is still sparsely optimised and its opportunity-risk profile is not yet fully understood (cf. FAO 2010; GTZ 2009; Jongschaap et al. 2007). Domestication of the plant has only recently begun and therefore lacks a valid track record in terms of, for example, agricultural best practices, yields per hectare, and reliability of the plant's long-term performance (Batin 2011; Henning 2008; Silip et al. 2010).

> Creating a business case for Jatropha is a great challenge since literally all aspects of this business are still in a state of flux

Consequently, there is little information about the economics of this oil-producing plant (Borman et al. 2012; FAO 2010; GTZ 2009). Without doubt, creating a "business case for Jatropha" is a great challenge since literally all aspects of this business are still in a state of flux: optimal conditions and practices for plant growth, expected yields, oilseed and oil prices as well as the potential of different markets for Jatropha products. The most important cost categories for commercial Jatropha cultivation relate to land acquisition, labour, propagation and plant establishment, plant nutrition, irrigation, and pest and disease management (FAO 2010). On the output side, the absolute yield per hectare is decisive, both in terms of quantity and quality. Besides its most prominent uses, that is, biodiesel and pure plant oil as transportation and machinery fuel, Jatropha oilseeds and the plant as a whole provide further products and services: fuel for lighting and cooking; inputs for cosmetics; soap made from Jatropha oil or glycerine, a biodiesel by-product; erosion control; livestock barrier and land demarcation ("living fence"); green manure and fuelwood – just to mention a few (FAO 2010; Kumar & Sharma 2008). Some projects reported that they also try to generate carbon credits through Jatropha cultivation and fuel switch from fossil fuels to biodiesel (see case study on Mali Biocarburant SA in Box 5 on page 36). Of all projects, only three already receive ››

›› carbon credits and another eight are in the application process. However, interviewed experts and the literature clearly emphasize the importance of turning by-products, mainly press cake, into value-added products (Borman et al. 2012; Kumar & Sharma 2008). Otherwise, they say, a business case can hardly be achieved.

These characteristics are in particular challenging as both equity and debt investors in Jatropha projects have to base their financing decisions on reliable business plans and predictable cash flows, which is even more challenging since plantations and outgrower schemes are often financed by means of project finance. In general, the main purpose of project financing is the acquisition of large amounts of debt capital to lever the scope and profits of equity investments. Three features characterize this method (Nevitt & Fabozzi 2000; Vinter & Price 2006). First, financiers separate the Jatropha project from their own books by establishing a separate project company that operates the plantation or outgrower scheme (off-balance sheet financing). Second, debt capital is taken onto the books of the separate project company so that it does not affect the financial indicators of the parties involved (depending on the particular accounting standards). This financing method assumes that project cash flows from oilseed yields and the plantation itself have to cover debt service and returns on equity. In other words, there are no additional security-like assets of a holding company (cash-flow-related lending). Third, different degrees of recourse can be negotiated (full-, limited-, non-recourse lending), which can lead to higher credit costs. However, the survey and expert interviews show that most Jatropha projects aim for a project financing approach, but many still depend on their own financial resources, i.e. different sources of equity capital.

Note: When reading the following findings, especially aggregated total and average figures, it should be kept in mind that the viability of any Jatropha business ultimately depends on how well the enterprise adapts to local specifics.

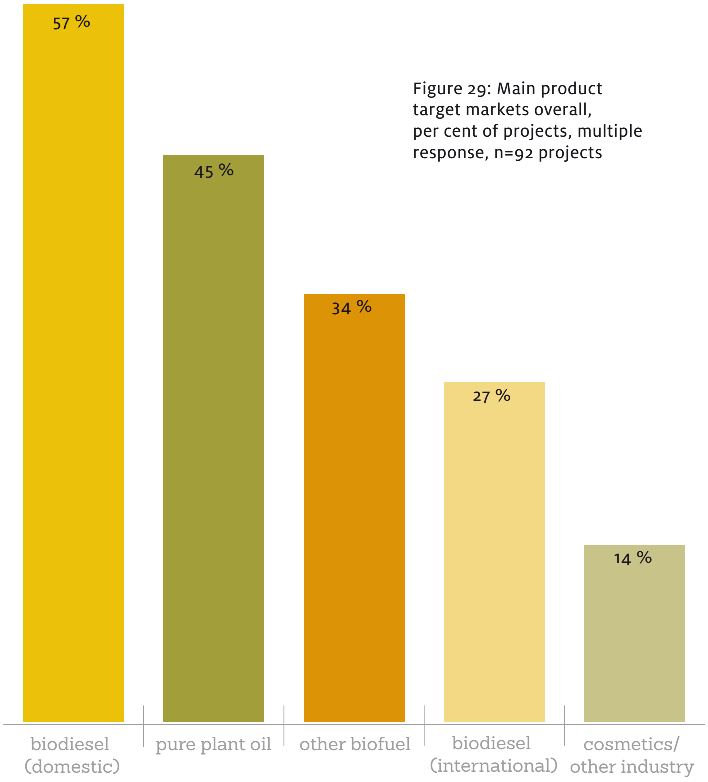

Figure 29: Main product target markets overall, per cent of projects, multiple response, n=92 projects

5.1 Target markets and value-creating activities

The main raw product gained from Jatropha cultivation is oilseeds with oil content between 30 and 35 per cent (FAO 2010). Processing of seeds yields a crude plant oil from which different derivatives can be extracted (e.g. biodiesel). Oilseed processing leaves different kinds of by-products, mainly press cake, but also glycerine from biodiesel production. In order to find out more about business models, we asked project representatives to describe what their final Jatropha products are used for, i.e. which target market needs they address and which value-creating activities they undertake.

5.1.1 Target markets

Unsurprisingly, a majority of 77 out of the 92 operational Jatropha projects (84%) that provided information on the use of their final products target biofuel markets (Figure 29). The remaining 15 projects sell their produce not as a transportation fuel, but as pure plant oil (PPO) for other uses. Sale in domestic biodiesel markets and PPO for direct use are the most common targets. Overall, 57 per cent of the projects produce feedstock for domestic and 27 per cent for international biodiesel markets. One-third (34%) aim at other biofuel markets, including PPO as straight transportation fuel or as an additive for conventional diesel. This also includes aviation biofuels, which were mentioned by 15 projects (16%) as a current or future target market.››

›› Forty-five per cent of the reporting projects sell PPO locally for purposes of lighting and cooking. Nearly one-third of this group also responded “other biofuels”, i.e. their oil is used as transportation fuel as well. Cosmetics and other industries are targeted by 14 per cent, including three projects whose main product is soap for the local market. These projects cooperate with development agencies and NGOs and aim to promote local socio-economic progress through additional value-creating activities. As Jatropha is a non-edible oil feedstock, food markets are not targeted by the surveyed projects. From a regional perspective (Figure 30), the project sub-samples show unique profiles in terms of target markets. The group of operational projects in Africa is the most balanced one with regard to target markets and local versus international orientation, while Asian and LAC projects share a stronger focus on domestic markets for biodiesel (and PPO in LAC).

The African project sample combines local fuel uses and export orientation. Pure plant oil for purposes of lighting and cooking (18 responses) is most important, followed by domestic biodiesel and other biofuels (16 responses). One-third target international biodiesel markets. Three of the seven projects targeting other markets were found to be solely dedicated to producing Jatropha soap.

Biodiesel for domestic markets is the most common product in Asia (20 responses) and LAC (16 responses). While Asian projects have a clear focus on this market, LAC projects mention PPO for lighting and cooking (14 responses) nearly as often as domestic biodiesel markets. Another difference is that projects in LAC seem to be less interested in trading their feedstock or biodiesel beyond national borders (only 4 LAC projects mention biodiesel for international markets). ››

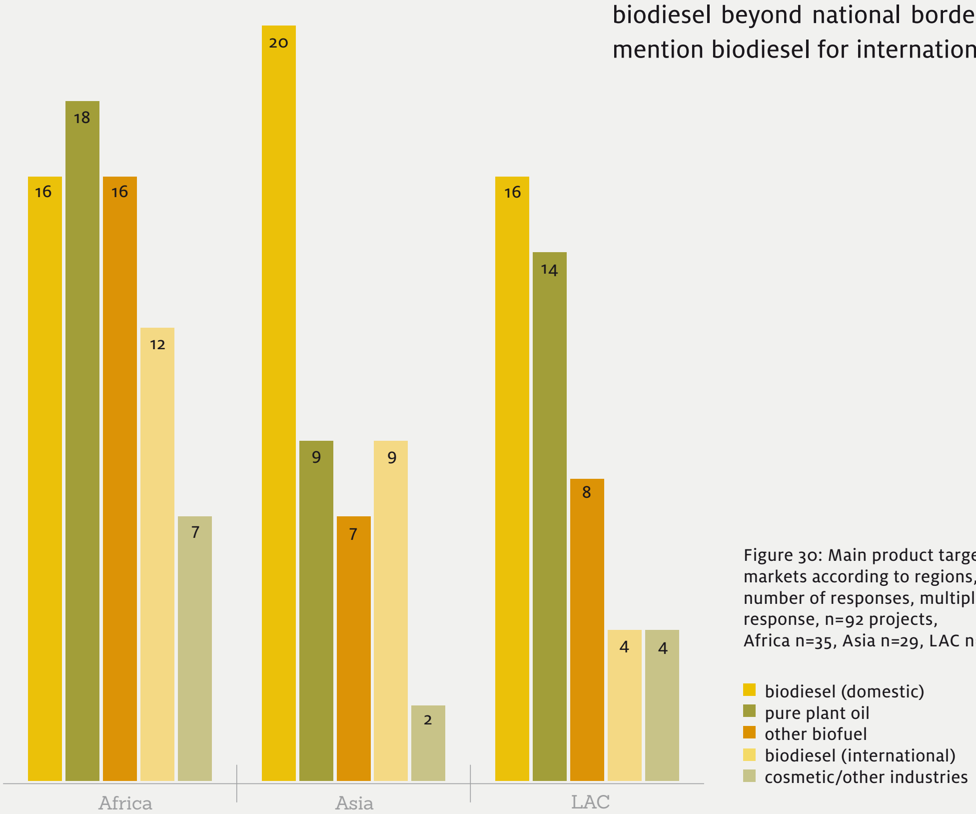

Figure 30: Main product target markets according to regions, number of responses, multiple response, n=92 projects, Africa n=35, Asia n=29, LAC n=28

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›› Project representatives and industry experts confirmed that adding value to by-products is essential to make a business case for Jatropha projects. Plant oil residues can serve different purposes, such as fertiliser, energy feedstock or, if non-toxic, as animal feed.

Press cake, the main by-product of Jatropha oil production, is commonly (71%) used as organic fertiliser (Figure 31), which is applied on the plantation, delivered to outgrowers, or sold on the local market. About one-quarter (28%) use press cake as energy feedstock, for example, to produce biogas and 13 per cent plan to use it as animal feed once Jatropha press cake can be detoxified.

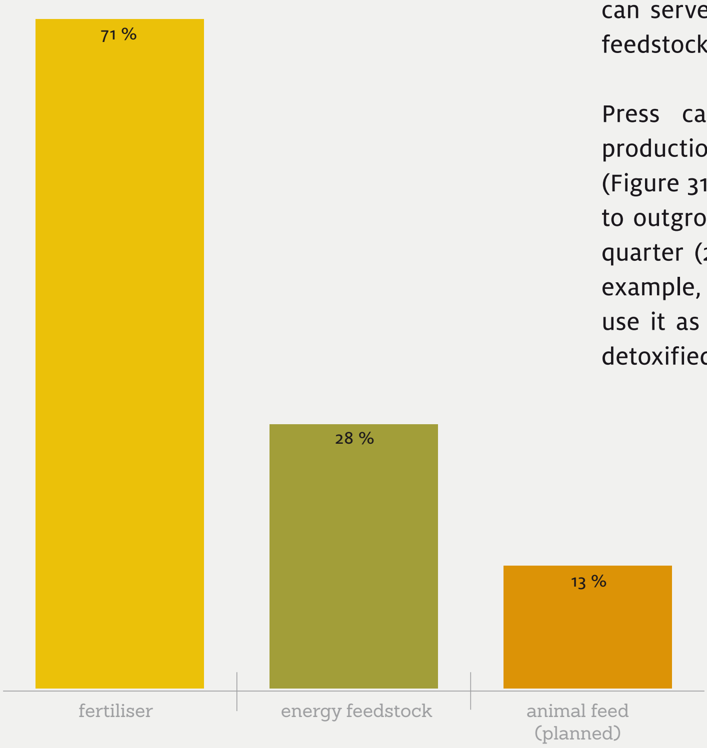
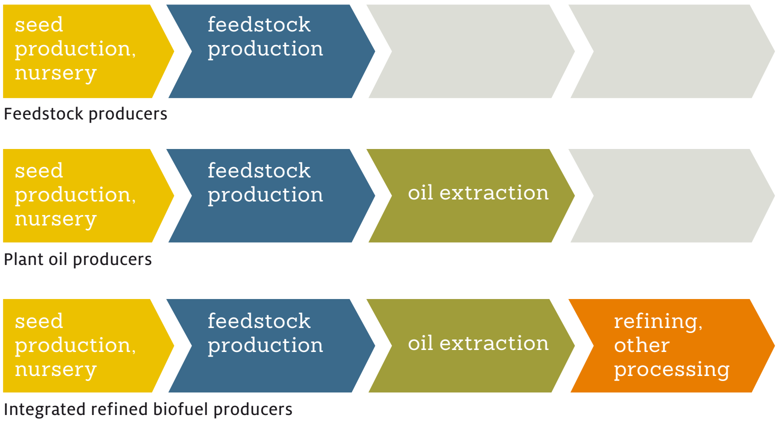


Figure 31: Press cake target markets overall, per cent of projects, multiple response, n=92 projects

Figure 32: Three groups of project value chains



5.1.2 Value-creating activities

To target these markets, the surveyed Jatropha projects developed both locally and internationally integrated value chains. Based on the value-creating activities undertaken within 96 projects, three types of value chains were identified (Figure 32). These activities reflect the common orientation towards biofuel markets. While some projects provide the final value-added product, for example, refined biodiesel, others deliver raw oilseeds or pre-treated oil as feedstock.

5

5.2 Project investments, costs and yields

The survey also addressed the financials of Jatropha projects and the different factors determining their economic viability. This section deals with three key aspects in particular and in the following presents findings on investments in plantations, maintenance and labour costs as well as dry seed yields and market prices for crude Jatropha oil and press cake.

5.2.1 Project investments and establishment costs

Upfront investments to set up plantations include, for example, costs of land acquisition and land preparation, labour costs, expenses for machinery and planting material, and – depending on the target country – costs caused by regulatory, administrative and other formal requirements as well.

Until 2011, a total of around USD 270 million was invested in the 97 reporting Jatropha projects worldwide (Table 6). Forty-one per cent of the overall total (USD 111.7 million) was invested in Asian projects, 37 per cent (USD 99.1 million) in African and 22 per cent (USD 58.5 million) in LAC projects.

Region	Total investments (USD until 2011)	Average investment per project (USD until 2011)
Africa	99 118 000	2 478 000
Asia	111 659 000	4 136 000
LAC	58 465 000	1 949 000
Global	269 242 000	2 776 000

Table 6: Total and average investments in operational Jatropha projects according to regions, n=97 projects, Africa n=40, Asia n=27, LAC n=30

On average USD 2.8 million was invested per project. In Asia, the average of around USD 4.1 million is twice as high as in the LAC region, where around USD 1.9 million was invested in an average project (Africa: USD 2.5 million). It should be noted, however, that the sample contains three outliers with project investments ranging from USD 25 million to 32 million, which together account for USD 82 million, that is, 30 per cent of the total overall investment.

Excluding these two Asian and one LAC outliers changes the overall figures significantly. The remaining 25 Asian projects invested an average of USD 2.2 million per project and the group of 29 LAC projects shows an average of around USD 1.2 million. Especially the investment figures of the Asian sub-sample are dominated by its two outliers as they represent 51% (USD 57 million) of the total investments in this region (Table 7).

Region	Total investments (USD until 2011)	Average investment per project (USD until 2011)
Africa	99 118 000	2 478 000
Asia	54 659 000	2 186 000
LAC	33 465 000	1 154 000
Global	187 242 000	1 992 000

Table 7: Total and average investments in operational Jatropha projects according to regions excluding three outlier projects, n=94 projects, Africa n=28, Asia n=25, LAC n=29

Once agricultural land has been identified and acquired, the plantation has to be established. The reported overall average of establishment costs for one hectare of cultivated land amounts to USD 909 (based on 82 projects providing per hectare data). These costs include labour, land clearing, purchase (or own production) of seedlings, planting and further inputs necessary to prepare the land for cultivating Jatropha. There are differences among the regions (Table 8). In Africa, the reported average establishment costs per hectare are 20 per cent lower than in Asia (USD 727 compared to USD 892). The upfront costs in LAC (USD 1 099) are 20 per cent higher than in Asia and 34 per cent above those in Africa.

Region	Average establishment costs (USD/ha)
Africa	727
Asia	892
LAC	1 099
Overall average	909

Table 8: Average establishment costs per hectare according to regions, n=82 projects, Africa n=28, Asia n=25, LAC n=29 (per hectare establishment costs include labour, clearing, seedlings, planting and other inputs)

5

5.2.2 Running costs

Apart from upfront investments and establishment costs, plantations also incur running costs. These maintenance costs include labour costs for field workers and plantation management, and inputs for nutrient and plant health management, irrigation and energy. Indications of maintenance costs were provided for 81 operational projects. In Africa, Jatropha projects spend least (USD 220) while projects in LAC spend most (USD 482) to maintain one hectare of cultivated land over a period of one year (Table 9).

Maintenance costs are mainly determined by labour costs. These were addressed in a separate question asking for local averages. From a regional perspective, LAC projects entail the highest costs. The average labour costs in LAC countries (USD 12.5 per day) are four times higher than in Africa (USD 3.0) and nearly twice as high as in Asia (USD 6.6).

While regional differences in maintenance follow the differences in labour costs across the three regions, Asian projects show relatively low maintenance costs. An explanation might be that outgrowing is more common in Asia. In such models, maintenance is usually outsourced to outgrowers and therefore less costly for project owners.

Region	Maintenance costs (USD/ha*year)	Labour costs (USD/day)
Africa	220	3.0
Asia	268	6.6
LAC	482	12.5
Overall average	328	7.3

Table 9: Maintenance and labour costs, according to regions for maintenance costs, n=81 projects, Africa n=29, Asia n=23, LAC n=29, for labour costs n=84 projects, Africa n=32, Asia n=22, LAC n=30 (maintenance includes costs of labour and other inputs)

5.2.3 Yields

In terms of output, dry seed yield per hectare is the crucial indicator determining the economic potential of a Jatropha plantation project. Of the 111 operational projects, 45 provided information on the actual development of their dry seed yields over time (11 African, 18 Asian, and 16 LAC projects).

Interviewees were asked to indicate actually measured yields per hectare from the second to the sixth year after the plantation was established (Figure 33 on page 48, 34 & 35 on page 49). The question explicitly asked for actually measured yields. However, it cannot be excluded that in some cases respondents provided expected yields. For example, in the case of a Nigerian project that was established in 2009, the respondent provided an annual yield of six tons per hectare for a five-year time span when the project had only reached its second year at the time of the interview. A(nother) project in Sri Lanka reported yields of nine tons per hectare in the third year. In the following analyses, we omit data in which respondents provided yields for years in excess of the stated plantation age (4 projects, out of 49, were excluded).

Therefore, in addition to regional values (shown in Figure 33 on page 48), yields are also clustered into age groups for the second to the fourth year after planting to allow for cautious interpretations (the 5th and 6th year are not depicted separately due to a lack of yield data) (Figure 34 on page 49). In the following analysis, box plots present the yields in an aggregate manner along with statistical variation without losing too much of the sample characteristics, as would be the case, for example, with average values.››

›› The first figure shows the range of reported yields on a regional level (Figure 33). For this chart, only the most recent harvest data for each project was included (regardless of plantation age).

In Asia 18 projects provided yield data, ranging from a minimum of 33 kilograms dry seed yield per hectare at the lower end of the “whisker” (a 3rd-year project from Laos), to a maximum of 9 000 kilograms at the upper end (a 3rd-year project from Sri Lanka). The box contains the middle 50 per cent of the Asian sub-sample. This interquartile range has a calculated lower value of 2 000 kilograms and an upper value of 6 000 kilograms. In other words, 25 per cent of the Asian sample report actually measured yields below 2 000 kilograms and 25 per cent indicated 6 000 kilograms or more per hectare. The median is 3 350 kilograms, i.e. half of the Asian sample yield up to this amount per hectare.

	Africa	Asia	LAC
Lowest	20	33	20
1st quartile	200	2 000	250
3rd quartile	2 500	6 000	2 000
Highest	6 000	9 000	4 000
Median	900	3 350	780
Mean	1 743	3 608	1 221

Table 10: Reported actual dry seed yields according to regions, n=45 projects, Africa n=11, Asia n=18, LAC n=16

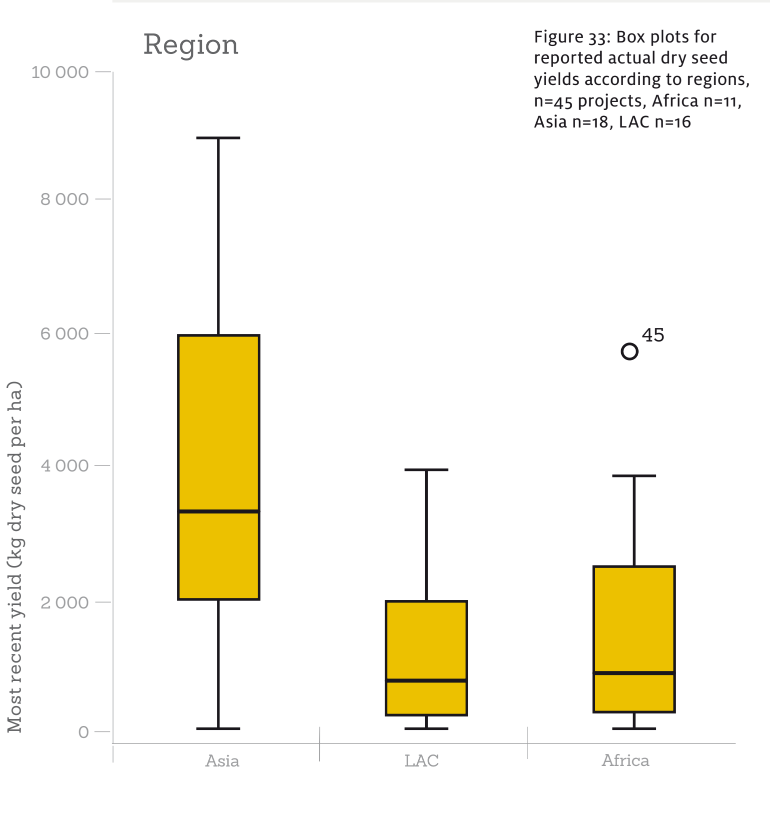


Figure 33: Box plots for reported actual dry seed yields according to regions, n=45 projects, Africa n=11, Asia n=18, LAC n=16

With 900 kilograms, the median of the eleven reporting African projects is significantly smaller than that of the Asian projects. The median yield among the 16 LAC projects was smaller still, at 780 kilograms. In both cases, Africa and LAC, the interquartile ranges show rather small values compared to Asia, with calculated lower values of 200 and 250 kilograms, and upper values of 2 500 and 2 000 kilograms, respectively. The extreme values and overall dispersion of yield data are less pronounced than in the Asian sub-sample. However, this might partly be due to the lower number of responding projects. One outlier was identified within the Africa group, a project from Madagascar that claimed a yield of 6 000 kilograms per hectare in the second, third and fourth year. The main characteristics of the regional sub-samples are also summarized in Table 10.››

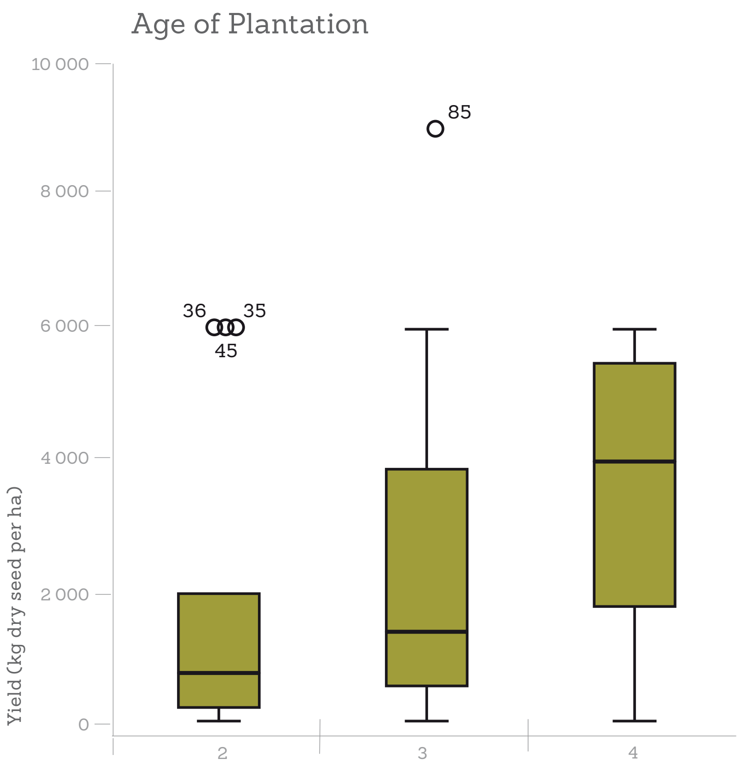


Figure 34: Box plots for reported actual dry seed yields according to years after planting, n=45 projects, Africa n=11, Asia n=18, LAC n=16

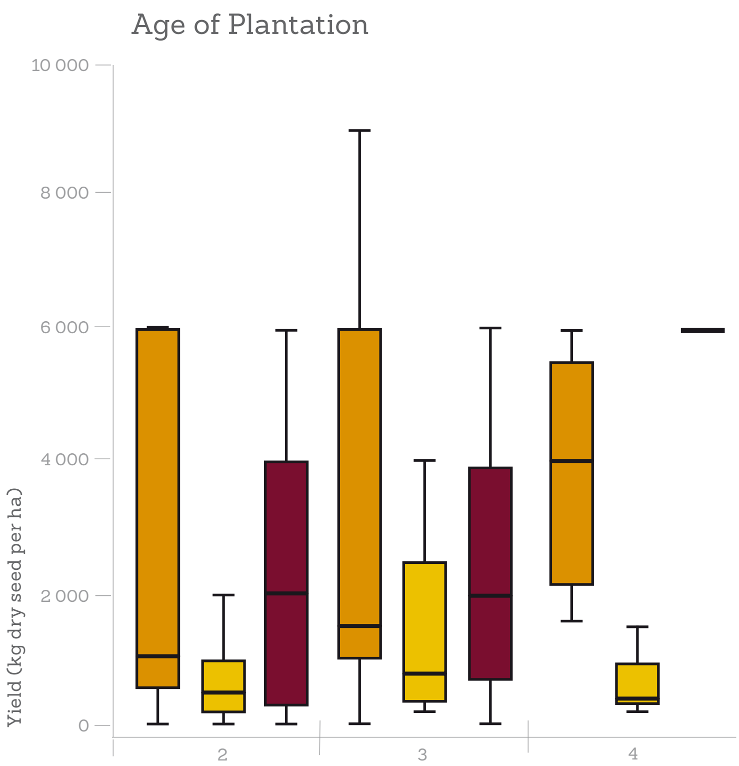


Figure 35: Box plots for reported actual dry seed yields according to years after planting and region, n=45 projects, Africa n=11, Asia n=18, LAC n=16

- Asia
- LAC
- Africa

›› Figure 34 shows box plots for the global sample clustered into age groups. These groups depict the reported values of all projects from the second to the fourth year after planting. Barring some African and Asian outliers reporting 6 000 kilograms per hectare, the second-year group has an interquartile range from 400 to 2 000 kilograms, a median of 750 kilograms and a distinctly higher mean of 1 835 kilograms. Projects reported yields of up to 6 000 kilograms for both the third and fourth year after planting (one outlier from Sri Lanka reported 9 000 kg). While the third-year median is far from the fourth-year value (1 400 kg versus 4 000 kg), the corresponding mean values show a much smaller spread (2 425 kg versus 3 395 kg).

In the third year the upper interquartile value is 3 950 kilograms, i.e. 25 per cent are above this value, while in the fourth year this value is even 6 000 kilograms. In other words, for the fourth year after planting 25 per cent of the responding projects report yields of six tons or more per hectare. However, the interquartile ranges (i.e. the dispersion of the middle 50%) for both years are rather large. As both location and plantation age together determine the possible per hectare yield, the overall sample has also been arranged into age groups per region (Figure 35).

Most of the Asian cultivation sites were started in 2007 and were therefore four years old at the time of the survey. Their median yield in the fourth year was around 4 000 kg per hectare (mean 3 893 kg). Some projects achieved significant yield increases over time so that the first quartile and median of the fourth year are distinctly higher compared to the third year. Due to the small sample size, this effect is to a certain degree caused by single cases. One Indian project, for example, increased its per hectare yield fourfold within three years, from 1.25 tons in year one to five tons in year four.

The African plantations were mainly established around 2008. Their third-year median was 1 950 kilograms per hectare (mean 2 420 kg). The distribution of yield hardly differed between the second and third year after planting. Only the first quartile value increased slightly. ››

›› For the LAC region most yield data were provided for the second and third years. Most of these projects started between 2007 and 2009. They show a median of 780 kilograms dry seed yield per hectare in the third year (mean 1 426 kg), compared to 500 kilograms in the second year (mean 705 kg). However, the third quartile and the maximum value increased significantly in the third year.

(Note: The one extreme value for Asia and year three is the above-mentioned Sri Lankan project that reported 9 000 kg per hectare. This was the highest reported value in the whole survey. The box diagram for African projects in the fourth year includes one project only. Therefore, a regular box could not be plotted.)

5.2.4 Regional prices

Finally, interviewees were also asked about prices obtained for one ton of crude Jatropha oil in their respective region. The responses indicate that Jatropha crude oil trades for a range of between USD 473 and USD 1 911 per metric ton and at a global average of around USD 1 068 – a value that is close to the average prices of rapeseed and soybean oils in 2010 (according to Index Mundi (2012) rapeseed oil trades for USD 1 012, soybean oil trades for USD 925).

The average price in Asia is close to the global average, while prices in Africa were on average almost ten per cent higher (Table 11). In LAC, on the other hand, Jatropha crude oil was reported as selling at average prices about ten per cent below the global benchmark.

Also, prices for press cake were provided for 28 projects. Based on their data, Jatropha press cake is sold for an average of USD 170 per ton. However, actual prices depend on the respective target markets. The value of press cake used as fertiliser is relatively low, while animal feed trades at higher prices. Many interviewees confirm that press cake is the product they actually expect will turn the Jatropha business to profit. However, Jatropha's toxicity continues to prevent press cake from being sold as feed.

Region	Median price (USD/t)	Average price (USD/t)	Minimum price (USD/t)	Maximum price (USD/t)
Africa	1 187	1 190	625	1 911
Asia	1 147	1 082	600	1 683
LAC	910	956	473	1 638
Overall	1 000	1 068	473	1 911

Table 11: Prices obtained for Jatropha crude oil according to regions, n=48 projects, Africa n=15, Asia n=15, LAC n=18

THE KAPIRI MPOSHI JATROPHA GROWERS ASSOCIATION – CONNECTING FARMERS TO LARGE FIRMS

More than 200 farmers cultivate Jatropha as biofuel feedstock in the Kapiri Mposhi District in the Central Province of Zambia. Is this 'business as usual' in the African Jatropha feedstock production sector, which often relies on so-called outgrowing schemes? Not quite. These 200 farmers are organized in a co-operative, the Kapiri Mposhi Jatropha Growers' Association. Its objective is to facilitate the development of producer capacities by organizing groups in associations or co-operatives and thus to enable them to participate effectively in biofuel and other value chains.

"This also includes raising awareness of the possibilities but also the different risks which are inherent in growing biofuel feedstock. Only if we set up a supply chain that is favourable to all the actors will the farmers – who are our entry point in the fight against poverty – benefit" Namakau Maswenyeho from the Dutch development organisation SNV underlines the objectives and challenges of the co-operative. In 2005, a number of companies (including Oval Biofuels, a subsidiary of Munali Nickel Mine; D1 Oils; or Northwestern Biopower Ltd.) tried to engage farmers to directly participate in Jatropha outgrowing schemes. Such approaches failed to recognize that Zambia has a strong culture of leadership focused on central institutions, such as the Ministry for Agriculture. Often projects have not involved or even consulted these institutions. SNV now acknowledges these cultural specifics in its work to facilitate the setting up of the self-administered association.

On average, a farmer cultivates half a hectare, with around 500 Jatropha trees intercropped with cotton, potatoes and corn. Each farmer takes care of only a few hundred Jatropha plants, thus minimizing individual risk. To grow these plants, they use local species and produce their own seed material. The association hopes to have more than 1 000 members cultivating more than 500 hectares by 2015. As of now Jatropha is the only biofuel feedstock. However, the association also plans to establish the cultivation of Moringa and Castor, as for example Castor can be grown in one season together with Jatropha to increase both yields and revenues. In order to complete the Kapiri Mposhi Jatropha Association's oil supply chain, the acquisition of new mills is currently being arranged.

The most important condition for a successful inclusive Jatropha business model, however, is to stabilize the volume of feedstock production so as to be able to reliably supply customers with oil and to make Jatropha, Castor and further plants a stable and additional source of income for local farmers. In developing the smallholder farmers' supply chain in such a direction, one important determinant has already been achieved. Copperbelt Energy Corporation (CEC), a major Zambian electric utility, has entered a partnership to establish long-term supplier relations with the cooperative, which will also process the Jatropha crude oil. CEC plans to use the plant oil for power services in Zambia's mining industry and for its own car fleet. Emmanuel Katepa, head of CEC Renewables, confirms that "for CEC the use of locally produced Jatropha crude oil is an interesting alternative to imported conventional fuels."

Previously farmers had sporadically sold roughly half of their crops to so-called briefcase on the black market buyers at reduced rates for ready cash. Selling seeds collectively through the association – e.g., to central crude oil buyers – has proven to be more profitable for the farmers. Management of the farmers' network and its production capacity is one of the crucial objectives of the Kapiri Mposhi Jatropha Growers Association.

Note: This short case study was written in October 2011 with the support of Namakau Maswenyeho from the Dutch development organisation SNV and Emmanuel Sampa Katepa from Copperbelt Energy Corporation (www.snvworld.org; www.cecinvestor.com).

Box 6: Case study Kapiri Mposhi Jatropha Growers Association, Zambia

5.3 Sources of project financing

Based on a dedicated set of questions, the survey sheds some light on how operational Jatropha projects are financed. To provide an overview of sources of project financing, three aspects are addressed here: sources of equity financing, sources of debt financing, as well as donations and non-refundable financial contributions.

5.3.1 Equity financing

Two-thirds of the operational projects that reported on their equity investors received direct equity contributions from project owners who usually also initiated and developed the project (Figure 36). These owner-investors are either private persons or companies directly involved in project execution and day-to-day business.

Public-private partnerships finance 14 per cent of reporting projects. These projects are jointly funded by governments (often through ministries or other agencies) and private equity providers such as companies, individual or institutional investors.

Institutional investors are financiers like investment funds that are not necessarily interested in the plantation business and Jatropha itself, but have a solely financial interest. Four per cent of the projects are exclusively equity-financed by institutional investors. Projects with owner and institutional investors as shareholders represent nine per cent. Obviously, these projects have been successful in attracting additional funding apart from seed and venture financiers.

Another seven per cent are financed by governmental institutions or NGOs. These projects were often established with the objective to foster rural development either through demonstration plots or through outgrower projects focusing on smallholder development. In China, for example, provincial governments implemented programs supporting Jatropha cultivation in order to secure energy supply and promote biofuels.

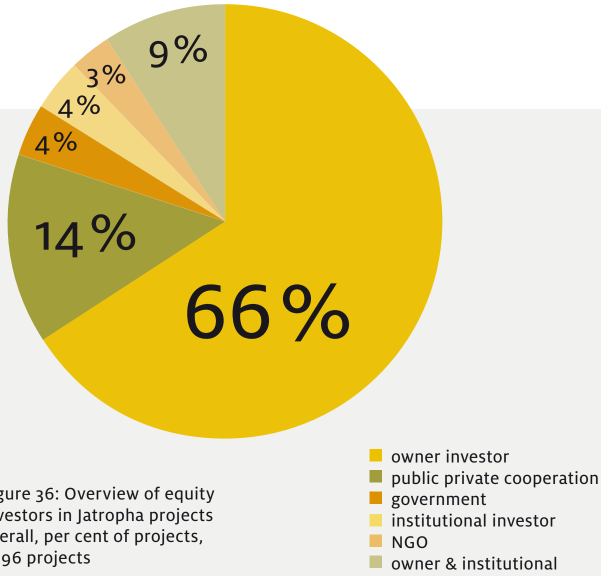


Figure 36: Overview of equity investors in Jatropha projects overall, per cent of projects, n=96 projects

5.3.2 Debt financing

Where equity financing is not sufficient, debt financing provides additional financial and operational scope. Of 89 projects that responded to the questions related to debt financing, 42 projects (47%) managed to obtain loans (Figure 37). Four of these projects received debt capital from more than one type of financier. Underlining the risk perception of debt investors, the findings show that shareholder loans – essentially equity provisions – were the most common form and were granted in 25 cases, that is, in 60 per cent of those projects that received some form of debt capital.

Commercial and development banks granted loans to 17 operational Jatropha projects (40%). Interestingly, the number of projects supported by development banks is smaller than the number supported by commercial banks. In four cases, other loans came from companies or governmental institutions.

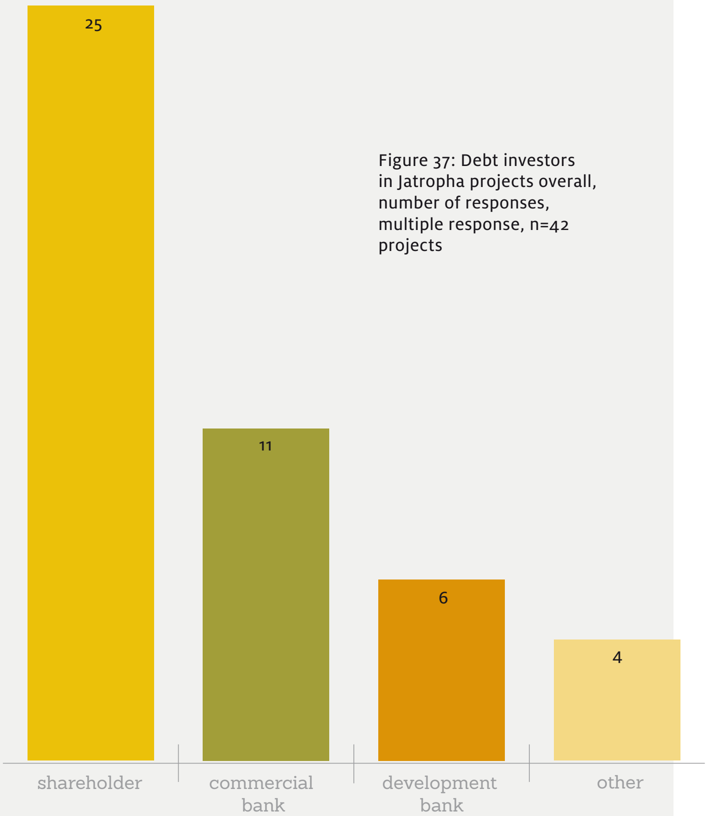


Figure 37: Debt investors in Jatropha projects overall, number of responses, multiple response, n=42 projects

5.3.3 Non-refundable financial contributions

A third source of project funds are donations and other non-refundable financing brought in by governmental institutions, NGOs, companies or private persons. Of 93 reporting projects, 39 received this kind of monetary support (Figure 38).

The figures also show regional differences. While 20 projects (69%) in LAC do not have to reimburse parts of their external funding, this share was relatively smaller in Africa (12 projects or 33%) and Asia (7 projects or 25%).

Concerning the sources of donations and non-refundable financing, it is noteworthy that 27 (69%) of the above-mentioned 39 projects were supported by governmental agencies, while only three (8%) received solely private support (including private persons, foundations, NGOs and companies). Nine projects (23%) were supported by both governmental and private sponsors (Figure 39).

Governmental support for projects is very common in all three regions. In the LAC region, all of the 20 projects that received donations or non-refundable financing were supported by governmental agencies, and six were additionally sponsored by the private sector. In Asia six out of seven and in Africa ten out of twelve projects were supported by governmental agencies. Three African projects received additional funds from private sponsors.

The case studies on Mali Biocarburant SA (Box 5 on page 36), BERL (Box 4 on page 21) and Mission NewEnergy Ltd (Box 7 on page 54) address carbon credit financing as another, often discussed but rarely implemented source of project financing with the potential to positively impact the environment.

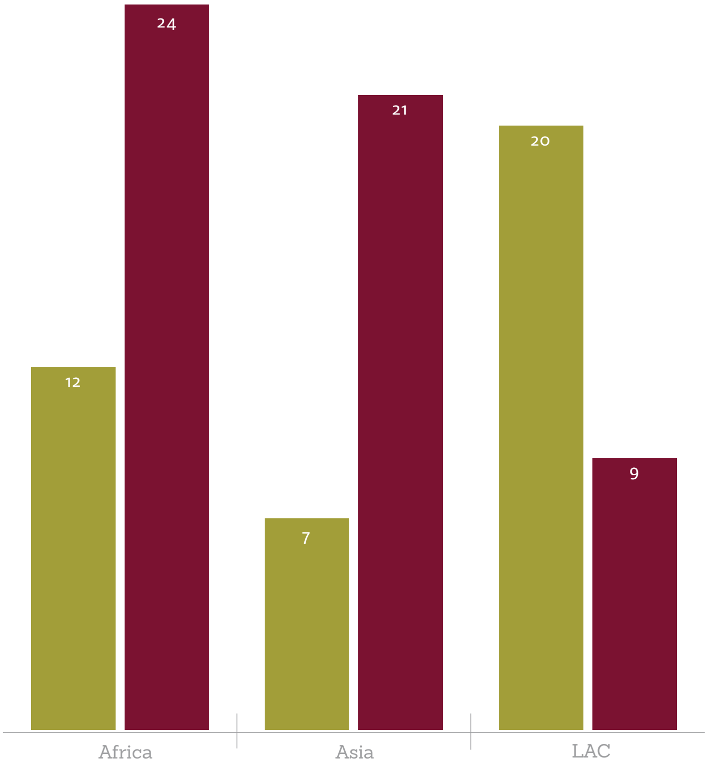


Figure 38: Number of projects receiving donations or non-refundable funding according to regions, number of projects, n=93 projects, Africa n=36, Asia n=28, LAC n=29

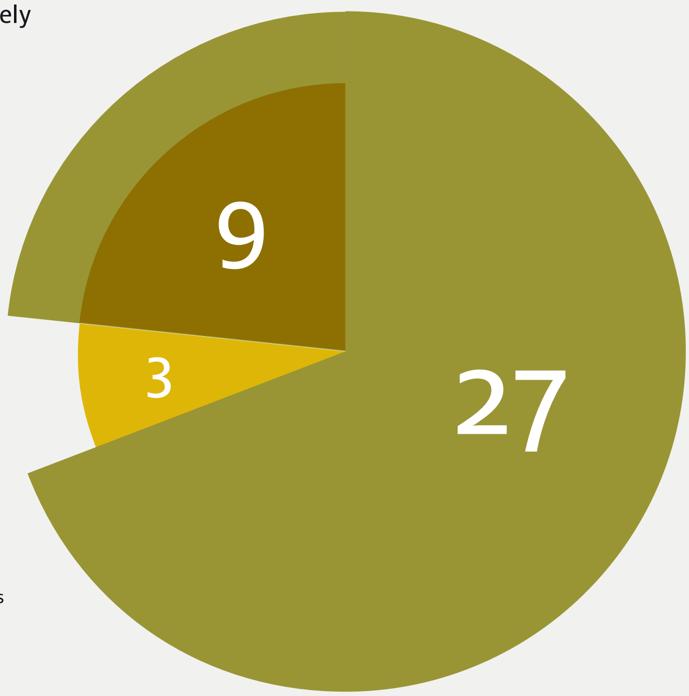


Figure 39: Sources of donations and non-refundable financing, number of projects, n= 39 projects

MISSION NEWENERGY – THE FIRST JATROPHA PROJECT TO ACHIEVE SUSTAINABILITY CERTIFICATION

Creating the "world's largest sustainable renewable energy business" is the vision that drives the biodiesel producer Mission NewEnergy. Operating across Asia, India, Australia, Europe, and North America, this energy company is on its way to becoming a global player. Besides refining, feedstock production is the other pillar of Mission's business. As set out in its vision statement, sustainability is at the core of the operations. With the objective of contributing to climate change mitigation as well as to resolving the food and the energy crisis, Mission commits itself to utilizing sustainably produced and harvested feedstock such as Jatropha. What is more, and unique in the context of this study: Mission NewEnergy is among the very few companies in this industry that can also demonstrate the sustainability of its production by means of an acquired sustainability certification – for both palm and Jatropha oil supply chains.

While it still buys palm oil to bridge the supply gap, in order to live up to its mission this bioenergy company aims to increase its reliance on Jatropha as a non-food crop that grows on marginal land. In this regard, with more than 75 000 hectares Mission NewEnergy is among the largest cultivators of Jatropha worldwide. The plantations across six states and more than 15 000 villages in India involve more than 140 000 contract farmers and provide them with a purchasing guarantee. An extension network provides on-going support services to the small farmers involved – e.g., in planting on marginal and unutilized parts of their land properties and agricultural input management. Since early 2010, GPS-mapping of the large number of small farms of up to two hectares in size allows Mission to monitor agricultural practices with precision and optimise yields.

It is Mission's efforts to enter global markets that made verification of its sustainable production practices necessary, as EU countries in particular promote biofuels but attach sustainability conditions to their buying. "In the future we will increasingly focus on the European market for marketing our produce", explains Chief Operating Officer Mr Sinnasami, and adds the possibility of charging a price premium for certified Jatropha oil as another decisive factor. Not least, guidance to implementing a comprehensive approach to sustainable feedstock production motivated Mission to apply for sustainability certification.

International Sustainability and Carbon Certification (ISCC) has been one of the first certification schemes to be recognized under the EU Renewable Energy Directive (RED) sustainability standard. Established in a three-year, multi-stakeholder consultation process, the ISCC has among the biomass sustainability certification systems the most extensive list of criteria – exceeding those of the EU RED. The "reputed kind of recognition" was why the sustainability department at Mission NewEnergy chose to apply for certification by this demanding scheme in late 2009. ››

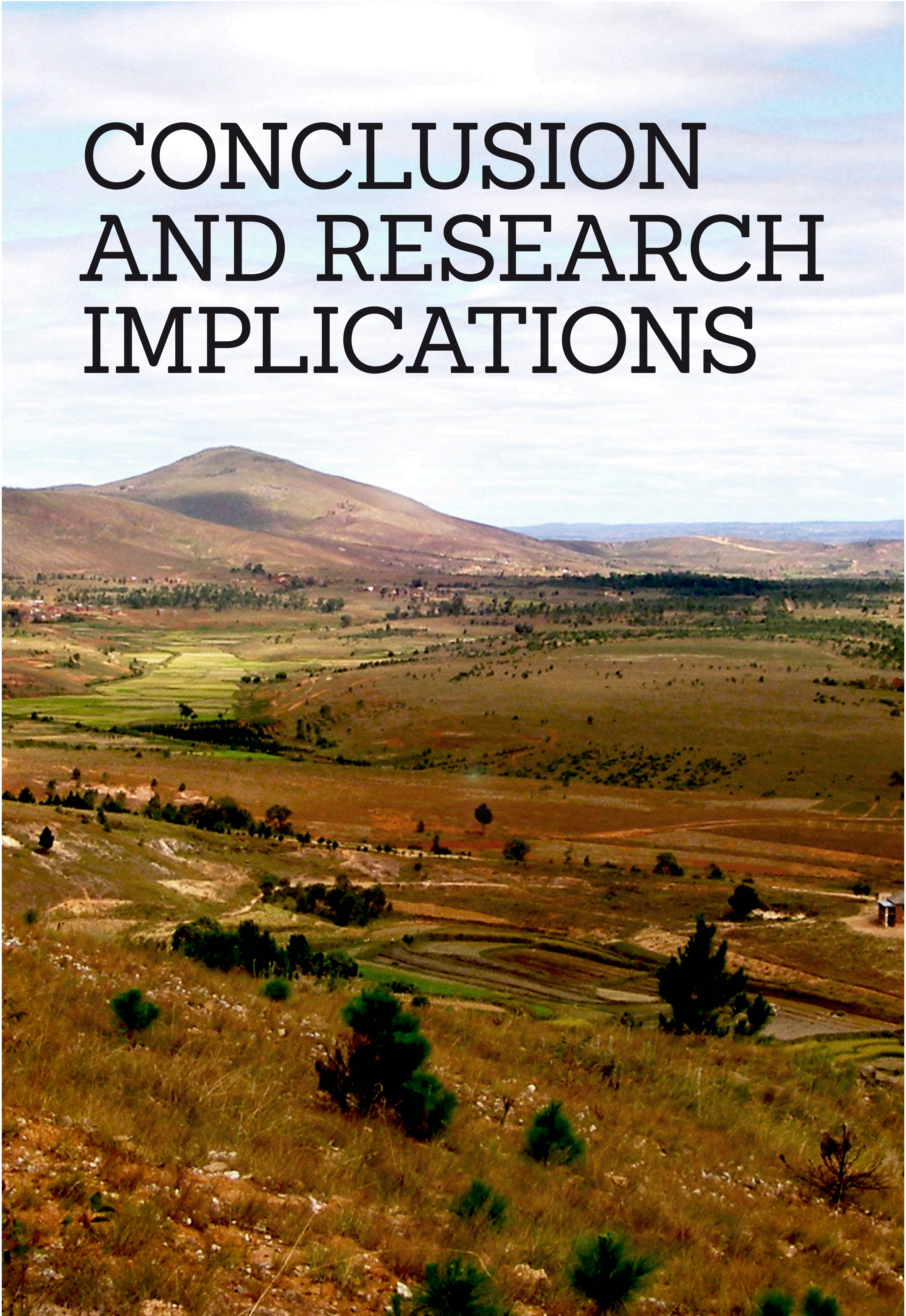
›› In India, Jatropha is planted on marginal or waste land. To meet the requirements set out by the EU and ISCC, this bioenergy producer had to take a number of further sustainability precautions. Documentation of prior land use has been gathered from state departments. Anti-erosion measures have been taken and soil samples collected to test all soil types with a view to input applications. Farmers and staff have undergone extensive field training on different agronomical practices, contract farming agreements have been updated and self-declarations of compliance with ISCC principles obtained from all farmers. Manuals have been prepared and internal audits conducted in order to ensure the 'certifiability' of Mission's operations.

In late 2011, Mission was the first Jatropha feedstock producer to receive ISCC certification. Strict adherence to the ISCC criteria was one of the main challenges of the certification implementation process – in particular as compliance has to be assured for the large number of small farms that belong to outgrowers. Besides the price premiums and improved market access, Mission NewEnergy takes pride in the certificate – thereby further motivating its staff and farmers. Above all, being certified also brought about previously unknown opportunities. "We were unaware about the carbon credit potential of Jatropha as it does not fall under the definition of forest. Now, we can even more differentiate ourselves from other Jatropha cultivators in India", says Mr Sinnasami.

Note: This short case study was written in October 2011 with the support of Mr Sinnasami, Chief Operating Officer at Mission NewEnergy Ltd. (www.missionnewenergy.com).

Box 7: Case study Mission NewEnergy Ltd., India

CONCLUSION AND RESEARCH IMPLICATIONS



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This report sheds light on the data collected in a global survey of 154 projects cultivating Jatropha and other oil-bearing trees. The focus is on the 111 Jatropha projects that were in the business of oilseed production at the time of the interviews. In this concluding section, we provide a brief overview of the defining characteristics of those projects, their agronomic strategies and management practices as well as the economic and financial factors shaping their business and affecting their viability. This final section closes with an outlook on forthcoming research that we are currently conducting based on our survey data.

6.1 Main findings

From the fact that most plantations in this sample were established in 2007 and 2008 (in Asia mostly in 2007, in Africa and LAC mostly in 2008), we find that the projects surviving the recent 'downfall' of Jatropha (and the broader economic downturn) outnumber the projects that have been established in the aftermath of the crisis. Nevertheless, growth expectations formulated in 2008 clearly were not met, as a total of 1.2 million hectares were found to be cultivated in mid-2011. On a regional basis, Asia still plays a dominant global role in Jatropha cultivation – almost 91 per cent of the total hectares are planted in this region. China, India, Malaysia and Indonesia host projects that, with a collective planted area of around 1 million hectares, practically lead the global Jatropha market. However, this sub-sample is dominated by just five very large projects, accounting for around 860 000 hectares. Ethiopia, Burkina Faso and Ghana are the countries in Africa where the most Jatropha is grown, with 43 000 hectares in total. Projects in Mexico and Brazil together cultivate a total of 11 000 hectares and take a lead in Latin America and the Caribbean.

The area of most cultivation sites lies between 100 and 1 000 hectares in size. Overall, most Jatropha-based enterprises operate plantations. However, regional differences are pronounced, with project-operated plantation schemes prevalent in Africa and Latin America, whereas outgrowing schemes are most common in Asia. Indeed, the majority of Jatropha oilseed production today is conducted by outgrowing farmers in Asia. In clear contrast to findings in 2008 (GEXSI 2008), a hybrid approach combining both plantations and outgrowers is least prevalent in this sample, perhaps indicating that experience has led projects to streamline their approaches. ››

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›› The sustainability of the Jatropha business depends critically on the agricultural management practices applied. Our overall findings concerning the type of vegetation and prior land use on current plantations reflect the hopes placed in Jatropha as a crop that grows on marginal lands. Although we have found some projects establishing cultivation sites in forests and many on shrubland as well as some removing trees and many removing shrubs, the large majority of projects reported that they are situated on marginal lands. However, as especially the term marginal and degraded land is not clearly defined, one cannot assume that this land does not hold significant stocks of carbon (Bailis & Baka 2011). For marginal land in particular, the potential land-use change impact on GHG emissions needs to be assessed on a site-by-site basis (Bailis & McCarthy 2011).

Given that most of the projects surveyed are survivors from the first days of Jatropha and that breeding efforts for improved varieties have begun fairly recently, it comes as no surprise that most plantation projects until 2011 relied on locally sourced seeds. The early myth of Jatropha as a plant with no needs appears to have given way to a more realistic agronomic understanding. Weed, pest, and nutrient management are practiced by the majority of projects. In light of the preference for plantation systems – instead of planting hedges and harvesting wild trees – it can be concluded that the producers surveyed have great hopes in Jatropha as an important source of income. The dominance of intercropping strategies is not a contradiction to this preference, but may reflect sustainability strategies contributing to local food security as well as a necessity of generating additional income in the first years of maturing Jatropha plantations.

Concerning the main findings on Jatropha economics, the survey shows that while respondents are clear about their target markets and value-creating activities, their financial bottom line is still in need of further improvements. On the output side, yield levels are not yet sufficient to assure the necessary cash flows and financial profitability and, on the input side, project financing besides project-owner funds is scarce. Overall, creating a Jatropha business case is a real challenge in terms of setting up viable business and financing models.

Nevertheless, until 2011 a total of around USD 270 million was invested in 97 reporting Jatropha projects worldwide (similar to the range of investments found by van Gelder et al. 2012). Average investments per project vary greatly across regions – from USD 2 million in LAC to USD 4.1 million in Asia. But for Asia and LAC these figures seem to be biased by three outliers which account for 30 per cent of all investments. In terms of financial capital, Jatropha projects clearly depend on owner-investors' funds. They are the most important source of equity capital, while loans are in most cases granted as shareholder loans.

Banks, institutional investors, governmental agencies and NGOs tend to be reluctant to finance such projects, while governmental agencies are the most common donors of non-refundable financing. Interestingly, despite the Jatropha boom and bust of the last years and the disappointing experiences made by high profile firms like D1 Oils and GEM Biofuels, some companies are still successful in raising amounts of new financial capital, e.g. a Californian holding, which raised an additional USD 7.9 million in 2011 (GCE Holding 2012).

On average, most of the plantations were established between 2007 and 2008 and yield an average of 2.1 tons of dry seeds per hectare and year (as of 2011). A majority of 84 per cent of reporting projects dedicate their oilseed yields to different biofuel markets. Domestic biodiesel and PPO for direct use are most common. Overall, 57 per cent target domestic and 27 per cent target international biodiesel markets. Aviation biofuels were mentioned by 16 per cent as a current or future market. The reported global average market price for crude Jatropha oil is USD 1 068 per metric ton, but price indications vary significantly from USD 473 to (USD) 1 911.

Seventy-one per cent of all projects use Jatropha press cake as fertiliser, but it is also used as energy feedstock (e.g. for biogas). The global average price for one ton of press cake was reported to be around USD 170. According to experts and project representatives, finding lucrative markets for by-products will be decisive for making a successful business case for Jatropha.

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6.2 Research implications

This summary of results has touched on many aspects of commercial Jatropha cultivation, but it still leaves many issues unaddressed. Given the limitations of this off-site interview-based study, some issues such as the local impacts of feedstock production and practices require further, case-by-case and on-site empirical analysis.

Much of the survey targeted different dimensions of project sustainability. In order to achieve sustainability, commercial biofuel feedstock provision must satisfy a range of social and environmental criteria while also constructing a viable and profitable business model. Each of these dimensions of sustainability is a subject of further analysis by members of this project team.

In the area of economic parameters, two research teams are further investigating the business of growing Jatropha. Based on this empirical study of Jatropha projects worldwide, a basic typology of Jatropha business models is currently being developed. The purpose of this research is to identify and classify state-of-the-art business models in this field. In a related strand, another team of researchers is looking at determinants of success in biofuel feedstock projects based on the example of Jatropha plantations included in the survey.

The social dimensions of sustainability are perhaps best understood in the context of social inclusion. Indeed, by collaborating with outgrowers, many projects included in this survey explicitly aim at pro-poor development. The idea behind such inclusive business models in agricultural commodity procurement is to contribute to the socio-economic development of smallholder farmers while at the same time promoting an agribusiness company's core business activities. Little is in fact known about the effects of smallholder inclusion on businesses and smallholder farmers. Based on this survey data another research project is analysing the effects of smallholder inclusion on the different factors relevant to project performance.

The impact of existing Jatropha projects on environmental sustainability is linked strongly to land-use and land management decisions. Evaluating biofuel policies and their implications, another researcher team is exploring the relationship between producers' cultivation practices and land management decisions with biofuel policies and programs effective in the countries of production. Focusing on India, a similar research strand investigates whether Indian policy targets for promoting Jatropha as a potential biodiesel feedstock were achieved, whether the provision of cultivating on marginal lands was followed, and whether Jatropha projects on marginal lands are economically viable.

Additionally, while sustainability issues play out at the farm-level, macro-scale policies and decisions may be critical determinants of practices on the ground. A final line of questioning focuses on projects' experiences with overarching governance mechanisms. Governance for sustainability of biofuel markets has emerged as a key issue affecting projects worldwide. A forthcoming study matches perceptions of sustainability by producer projects in this survey with the criteria put forward through international biofuel sustainability standards applied by biofuel buyers and the European Union. To this end, respondents' understandings of sustainability issues in their field of operation as asked for in the survey are analysed and contrasted with respondents' ratings of sustainability criteria and their positions on sustainability certification.

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APPENDIX

Questionnaire for the "Growing Oil on Trees" Study

Interview information (for interviewer only)

Interviewer

Function of interview partner:

Date

Phone

Type of interview conducting

Contact person

Address from project list

SECTION A
company and project background

FOR THE FOLLOWING QUESTIONS, PLEASE REFER TO YOUR COMPANY AND/OR THE PROJECT YOU ARE INVOLVED IN.

1. General company background

1.1 What is the name of your company/project?

1.2 In which countries is your company/project engaged?

1.3 How many different sites does your company use for feedstock production per country?

1.4 What is your main project, to which you will refer to in the following?

1.5 Which species are you cultivating in your project? Multiple answers possible.

- ☐ Jatropha
- ☐ Croton
- ☐ Moringa
- ☐ Neem
- ☐ Pongamia
- ☐ Castor (Ricinus)
- ☐ Other, please specify: __________________

1.6 How much land do you have generally available for your project in the following categories (not necessarily planted yet)?

- ☐ Own land: ____________________ha
- ☐ Leased land: ___________________ha
- ☐ Outgrowers' land: _______________ha
- ☐ No information available

1.7 How much land has been and will be planted with oil bearing trees? [ha]

	Mid 2008	Mid 2011	Mid 2012	Mid 2013	Mid 2014	Mid 2015
Own plantation						
Outgrowing scheme						
Other, please specify:						

SECTION B
project specifics

In the following, please refer to the largest plantation site or a representative outgrower project.

2. Plantation site specific information

2.1 In case you work on several sites, which plantation site are you referring to?

2.2 Which species do you cultivate at the plantation?

2.3 In which year did you start sowing/planting?

- ☐ Sowing: _____________________
- ☐ Planting: ____________________
- ☐ No information available

2.4 Geography and climate of the plantation site

2.4.1 Which is the closest town, postal code or geographic location?

2.4.2 What is the average annual rainfall at the plantation site? (in mm)

- ☐ No information available

2.4.3 What is the soil type at the plantation site (relative percentage of sand, silt and clay)?
- ☐ Dominantly Sand
- ☐ Dominantly Silt
- ☐ Dominantly Clay
- ☐ Loam (roughly equal distribution of sand, silt, clay)
- ☐ Other, please specify: ___________________

3. Agronomic aspects

3.1 What steps were necessary to establish the plantation? Multiple answers possible.
- ☐ Manual clearing
- ☐ Clearing with machines
- ☐ Removal of trees
- ☐ Removal of shrubs/bushes
- ☐ Cutting of grass
- ☐ Burning of removed biomass
- ☐ Other use of removed biomass, please specify: ________________________
- ☐ Discing or ploughing of field
- ☐ No information available

3.2 What type of genetic material do you use? Multiple answers possible.
- ☐ Wild material
- ☐ Locally selected material
- ☐ Improved material from own breeding
- ☐ Purchased improved material, please indicate cultivar:_________________
- ☐ Seeds
- ☐ Cuttings
- ☐ Seedlings
- ☐ Other, please specify: ___________________
- ☐ No information available

3.3 Which cultivation systems do you mainly practice? Multiple answers possible.
- ☐ Planted as hedges/living fences
- ☐ Planted in rows
- ☐ One species only
- ☐ Several species in combination
- ☐ Oil bearing trees and annual crops (indicate type of crops: _________________)
- ☐ Combination with animal husbandry (cattle, sheep, etc.)
- ☐ Collection of wildlings/wild seeds
- ☐ Other, please specify: __________________
- ☐ No information available

3.4 How are your oil bearing trees pollinated?
- ☐ Self pollination
- ☐ Wind pollination
- ☐ Insect pollination
- ☐ Hand pollination
- ☐ No pollination required
- ☐ No information available

3.5 Have you introduced measures to improve pollination?
- ☐ Yes, please specify: ___________________
- ☐ No
- ☐ No information available

3.6 How is your plantation set up?
- ☐ One large plot (no other fields or types of vegetation in between plots)
- ☐ Separated smaller plots (separated by other fields or types of vegetation)
- ☐ No information available

3.7 What is the spacing of the plants?

Distance between rows: _________________m

Distance between trees in rows: ___________m
- ☐ No information available

3.8 What is the average height of the trees in your plantation today? For other trees than Jatropha, indicate average diameter at breast height
- ☐ Average height:____________________m
- ☐ Diameter at breast height:____________m
- ☐ No information available

3.9 What is the measured OR expected average dry seed yield of your plantation?

Year	Yield measured (t/ha* year)	Yield expected (t/ha* year)
2		
3		
4		
5		
6		
7		
8		

- ☐ No information available

3.10 If you are already producing oil, how much have you produced in the last harvesting season: (in t)

3.11 What is your average extracted oil yield? (in %)

3.12 If you operate your own plantation site, how do you control pests and diseases? Multiple answers possible.

- ☐ Not at all
- ☐ Chemical pesticides, please specify times/year: __________________________
- ☐ Biological pesticides, please specify times/year: __________________________
- ☐ Other, please specify: __________________
- ☐ No information available

3.13 If you operate your own plantation site, how do you control weeds? Multiple answers possible.

- ☐ Not at all
- ☐ Hand weeding, please specify times/year: __________________________
- ☐ Mechanical cutting, please specify times/year: __________________________
- ☐ Grazing animals, please specify times/year: __________________________
- ☐ Burning, please specify times/year: __________________________
- ☐ Herbicide use, please specify type and times/year: __________________________
- ☐ Other, please specify: __________________
- ☐ No information available

3.14 If you operate your own plantation site, how do you fertilize your plantation? Multiple answers possible.

- ☐ Not at all
- ☐ Chemical fertilizer, please specify types and amount: ________________kg/ha* year
- ☐ Organic fertilizer, please specify types and amount: ________________kg/ha*year
- ☐ Press cake
- ☐ Other, please specify: __________________
- ☐ No information available

3.15 If you operate with an outgrower model, please describe the plantation and maintenance model:

- ☐ Average size of outgrower plot [ha]: ____________________________________
- ☐ Provision of seedlings: _________________
- ☐ Fertilization: _________________________
- ☐ Weeding: ____________________________
- ☐ Pest control: _________________________

4. Biodiversity and Ecosystem Services

4.1 If you operate your own plantation site, how far away is the nearest forest from your plantation? (Forest Definition FAO: Forests are lands of more than 0.5 hectares, with a tree canopy cover of more than 10 %, which are not primarily under agricultural or urban land use. Plantations and agroforests are excluded.)

- ☐ Up to 100m
- ☐ 101 – 500m
- ☐ 501 – 1 000m
- ☐ 1 001 – 5 000m
- ☐ More than 5,000m
- ☐ No information available

4.2 What habitat type is mainly surrounding your site? Multiple answers possible.

- ☐ Natural habitat (natural forest, savannah, etc.)
- ☐ Agricultural land (incl. pasture land)
- ☐ Wet land
- ☐ Urban areas
- ☐ Protected areas (wildlife sanctuary, national park, biosphere reserve)
- ☐ Other, please specify: __________________
- ☐ No information available

4.3 If you operate your own plantation site, are beneficial insects present in your plantation?

- ☐ Yes, please specify benefit: _______________
- ☐ No
- ☐ No information available

4.4 What was the vegetation type prior to the establishment of your plantation?
Multiple answers possible.
- ☐ Primary forest (forest of native species with no clearly visible indications of human activity)
- ☐ Secondary forest, canopy cover >30%
- ☐ Secondary forest, canopy cover <30%
- ☐ Shrubland (shrubs without a definite crown are the dominant vegetation)
- ☐ Savannah/grassland
- ☐ Farmland
- ☐ Degraded land or wasteland
- ☐ Other, please specify: _________________
- ☐ No information available

4.5 How was the land in your project used before?
Multiple answers possible.
- ☐ Farming food crops
- ☐ Farming non-food crops
- ☐ Animal husbandry/pasture (cattle, sheep, etc.)
- ☐ Wood production
- ☐ Not used at all
- ☐ No information available

4.6 What kinds of wild animals are living in and/ or around your plantation?

____

- ☐ No information available

4.7 Do you observe nesting of birds in your plantation site?
- ☐ Yes
- ☐ No
- ☐ No information available

4.8 Are there any rare or protected species (i.e. animals, birds or plants) that are seen in and around the plantation?
- ☐ Yes, please specify if possible: ___________
- ☐ No
- ☐ No information available

4.9 Are there any wildlife conservation programs or activities in the plantation area?
- ☐ Yes, please specify what type of conservation activity: _________________
- ☐ No
- ☐ No information available

4.10 Is the plantation site or any of the outgrower farms located close to a cultural site, e.g. a sacred forest or community forest?
- ☐ Yes, please specify: ___________________
- ☐ No
- ☐ No information available

SECTION C
business model, financing, sustainability

For the following questions, please refer to the project level.

5. Financing and business model

5.1 Investments and costs

5.1.1 How much money was invested in your project until today?
- ☐ ≤100,000 US$
- ☐ >100,000 - 500,000 US$
- ☐ >500,000 - 1 m US$
- ☐ >1 m - 3 m US$
- ☐ >3 m - 10 m US$
- ☐ >10 m - 20 m US$
- ☐ > 20 m US$
- ☐ No information available

5.1.2 How much additional money do you plan to invest in your project until 2015?
- ☐ ≤500,000 US$
- ☐ > 500,000 - 1 m US$
- ☐ > 1m - 5 m US$
- ☐ > 5 m - 10 m US$
- ☐ >10 m - 20 m US$
- ☐ > 20 m - 50 m US$
- ☐ 50 m US$
- ☐ No information available

5.1.3 What is your average investment to establish one hectare? (Including labor costs, clearing, seedlings, inputs, planting)
- ☐ ≤100 US$
- ☐ 101 - 200 US$
- ☐ 201 - 300 US$
- ☐ 301 - 500 US$
- ☐ 501 -700 US$
- ☐ 701 - 1,000 US$
- ☐ > 1,000 US$
- ☐ No information available

5.1.4 What are your average expenses for the maintenance of one hectare? (Including labor costs and inputs)
- ☐ ≤ 50 US$
- ☐ 51 - 100 US$
- ☐ 101 - 200 US$
- ☐ 201 - 400 US$
- ☐ 401 - 600 US$
- ☐ >600 US$
- ☐ No information available

5.1.5 What are the average daily labor costs in your region?

____

Currency: ______________________________

5.1.6 Which farm gate prices are currently achieved for oil and press cake in your region?
- ☐ Jatropha oil: ________________________
- ☐ Jatropha press cake: __________________
- ☐ Other oil: ___________________________
- ☐ Other press cake: ____________________
- ☐ No information available

Currency: ______________________________

5.1.7 What do you think were the main reasons for failure of projects in your country? Multiple answers possible.
- ☐ Lack of funding because of financial crisis
- ☐ Lack of funding because of project risks
- ☐ Lack of agronomic knowledge
- ☐ Bad choice of project location
- ☐ Bad quality of genetic material (seeds)
- ☐ Problems with outgrowers
- ☐ Other, please specify: _________________
- ☐ No information available

FOR THE FOLLOWING QUESTIONS, PLEASE REFER TO THE COMPANY LEVEL.

5.2 Sources of corporate financing

5.2.1 Do you have a parent company which is active in multiple industries?
- ☐ Yes
- ☐ No

5.2.2 What are your major equity shareholders? Multiple answers possible.
- ☐ Owner-investors
- ☐ Institutional investors
- ☐ Government
- ☐ Other, please specify: _________________
- ☐ No information available

5.2.3 Is a well known shareholder investing in your company?
- ☐ Yes, please specify the name: __________________________________
- ☐ No
- ☐ No information available

5.2.4 Who is providing debt to the company? Multiple answers possible.
- ☐ Commercial banks, currency: __________________________________
- ☐ Development banks, currency: __________________________________
- ☐ Shareholder loan, currency: __________________________________
- ☐ Other, please specify: _________________
- ☐ None
- ☐ No information available

5.2.5 From which of the following did you receive donations or non-refundable financing? Multiple answers possible.
- ☐ NGOs
- ☐ Governmental agencies
- ☐ Private persons/foundations
- ☐ Companies
- ☐ Other, please specify: _________________
- ☐ None

5.2.6 Which stakeholders significantly contribute to your company in non-financial terms? Multiple answers possible.
- ☐ Governmental institution
- ☐ NGO
- ☐ Research institution
- ☐ International company
- ☐ External advisor, please specify: __________________________________
- ☐ Other, please specify: _________________
- ☐ None
- ☐ No information available

5.2.7 If you have stakeholder contributions, how do these stakeholders contribute? Multiple answers possible.

- ☐ Know-how
- ☐ Reputation (e.g. in terms of environmental or social sustainability)
- ☐ Network
- ☐ Policy support
- ☐ Other, please specify:______________
- ☐ No information available

5.3 Which of the following value-creating steps doesyour company perform?
Multiple answers possible.

- ☐ Plant breeding/research&development
- ☐ Seed production/nursery
- ☐ Feedstock production
- ☐ Oil extraction
- ☐ Refining or other processing, please specify: ______________________
- ☐ Other, please specify: _________________
- ☐ No information available

5.4 What are your final products used for? Multiple answers possible.

- ☐ Biodiesel (domestic)
- ☐ Biodiesel (international)
- ☐ Pure plant oil (light, cooking)
- ☐ Other biofuel, please specify: ____________
- ☐ Cosmetics/other industry
- ☐ Food
- ☐ Press cake as fertilizer
- ☐ Press cake as animal feed
- ☐ Press cake as feedstock for energy production
- ☐ Other, please specify: _________________
- ☐ No information available

5.5 Do you receive or aim to receive carbon credits?

- ☐ Yes
- ☐ No (please continue with 6.1)
- ☐ No information available

5.5.1 If yes, how do you generate carbon credits? Multiple answers possible.

- ☐ Fuel switch
- ☐ Reforestation
- ☐ By-products
- ☐ No information available

5.5.2 What is the status of the application process for carbon credits?

- ☐ Application planned but not started
- ☐ Applied but acceptance pending
- ☐ Accepted
- ☐ No information available

5.5.3 Which standard do you (plan to) work with?

- ☐ Don't know yet
- ☐ Voluntary standard, please specify: _________________________________
- ☐ tCER under CDM
- ☐ Other, please specify: _________________
- ☐ No information available

5.5.4 At which market price do you sell or intend to sell your carbon credits? Please estimate [US$/credit]: _________________________________

- ☐ No information available

6. Sustainability Certification

6.1 In your opinion, what are important sustainability issues to be considered in your field of business?

____

6.1.1 Should sustainability regulation be introduced in your sector?

- ☐ Yes
- ☐ No
- ☐ No information available

Follow-up question: If yes, how should they be regulated? Multiple answers possible.

- ☐ Voluntary for social aspects
- ☐ Voluntary for environmental aspects
- ☐ Mandatory for social aspects
- ☐ Mandatory for environmental aspects

6.2 How do you promote sustainability within your project/company? Please refer to main activities you pursue for environmental, social and economic sustainability.

Follow-up question: Do you engage in reporting on your sustainability activities?

6.3 In your opinion, how important are the following sustainability measures for decision making in your own business? Please specify level of importance of each option on a scale from 1 to 5:

	1 not important	2 somewhat important	3 neutral	4 quite important	5 very important
Complying with relevant laws and regulations	☐	☐	☐	☐	☐
Assessing environmental impacts	☐	☐	☐	☐	☐
Assessing social impacts	☐	☐	☐	☐	☐
Consulting stakeholders	☐	☐	☐	☐	☐
Assessing long-term economic viability	☐	☐	☐	☐	☐
Reducing greenhouse gas emissions	☐	☐	☐	☐	☐
Safeguarding human and labor rights	☐	☐	☐	☐	☐
Contributing to social and economic development	☐	☐	☐	☐	☐
Ensuring local food security	☐	☐	☐	☐	☐
Avoiding negative impacts on biodiversity, ecosystems, and conservation values	☐	☐	☐	☐	☐
Mitigate soil degradation/ maintaining soil health	☐	☐	☐	☐	☐
Safeguarding quality and quantity of surface and ground water resources	☐	☐	☐	☐	☐
Respecting water rights	☐	☐	☐	☐	☐
Minimising air pollution along the supply chain	☐	☐	☐	☐	☐
Minimising risks of damage through technology use	☐	☐	☐	☐	☐
Respecting land rights and land-use rights	☐	☐	☐	☐	☐

6.4 What is the status of sustainability certification of your plantation(s)?

- ☐ No certification in place and none planned (please continue with 6.4.3)
- ☐ Certification planned but not yet achieved
- ☐ Certification achieved
- ☐ No information available (please continue with 6.4.3)
- ☐ Other, please specify: ________________

6.4.1 According to which standard(s) do you (plan to) certify your projects? Multiple answers possible.

- ☐ ISCC (International Sustainability and Carbon Certification)
- ☐ FSC (Forest Stewardship Council)
- ☐ NTA 8080 (Netherlands Technical Agreement 8080)
- ☐ REDcert (REDcert certification system)
- ☐ RSB (Roundtable on Sustainable Biofuels)
- ☐ Other, please specify: ________________
- ☐ No standard chosen yet
- ☐ No information available

6.4.2 If you are certified or aim for certification, what is your main motivation for doing so?

___

___

Follow-up questions:
- What is your motivation to choose this particular certification program?
- Under which conditions, if any, would you consider switching to another certification program?
- Under which conditions, if any, would you consider quitting certification?

6.4.3 If you do not plan any certification, what are your motives?

___

___

Follow-up question:
- Have you ever worked with a certification scheme? If yes, what were your motives for quitting?
- Under which conditions, if any, would you consider certification?

Further comments?

___

___

END OF INTERVIEW
THANK YOU FOR YOUR PARTICIPATION

Administration

Do you agree that we indicate your project and location in the report?
- ☐ Yes
- ☐ No

Do you want to receive a note when we finalised the report?
- ☐ Yes
- ☐ No

Would you be available for further questions?
- ☐ Yes
- ☐ No

CONTACT

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