Chapter 10
Socio-Economic Experiences of Different Jatropha Business Models in Africa

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Abstract In Africa, a major motivation for embarking on biofuels, particularly from jatropha, is a desire to promote socio-economic, rural development and to reduce poverty. Despite their potential socio-economic benefits, biofuels investments can also lead to negative impacts such as human displacements. One option for suitable feedstock for biofuels is jatropha which can grow on marginal land. It can be used in different business models and for multiple purposes. Its oil produces biodiesel, soap, lotion, floor polish and as a by-product press cake that can be used as fertilizer. In many African rural areas, jatropha is used as a live fence by smallholder farmers and grows well under intercropping situations. This farming model has proven to be socio-economically the most successful, beneficial, and sustainable in Africa. Some of the challenges associated with jatropha are—despite claims of being a "miracle crop"—its commercial production which has yet to take off in Africa and commercial plantings which have not been widely implemented to date. In addition, its agronomic requirements, yield levels, and economics are highly unknown in the region. The crop takes 3–5 years to produce sizable quantities of seed. At the current low yields, the profitability of jatropha feedstock production for both community and large scale production is greatly compromised if the intended product is biodiesel alone. Furthermore, the amount of land required to produce a given quantity of biodiesel under plantation conditions largely depends on the productivity of feedstock. Consequently, substantial amounts of land are required to support jatropha based biodiesel production if seed yields remain low. The conversion of large tracts of land associated with this can adversely affect biodiversity, habitat and ecosystem integrity, climate change, mitigation capacity, household food security, and community land rights. It is therefore important to minimize such impacts by carefully considering among others the business model to be adopted in promoting jatropha for bioenergy production in Africa.

Keywords Jatropha · Africa · Tanzania · Small-scale farmers · Large-scale plantations

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10.1 Introduction

Africa is blessed with a huge potential of land for biofuel production, which could considerably contribute to export earnings, reduction of fossil oil imports, as well as generation of employment and rural economic growth. The African continent has a size of 30.22 million km² and a population of more than one billion people. About 15 % of the world population has thus available arable land of more than a billion hectares. Out of this land, about 630 million ha is suitable for cultivation; however, presently only less than 10 % of this land is in use. The continent has a forest cover of about 650 million ha or 21.8 % of the land area, which is about 17 % of the global forest cover (Sawe et al. 2012).

Currently (2012), the continent consumes about 5 million barrels (300 million l) of petroleum products per day (Viceroy Invest 2009). The production of liquid biofuels is insignificant, and electrification is available for less than 5 % of the population. According to Pimentel (2008), over 50 % of Africa's land has the right climate for growing jatropha (*Jatropha curcas)*. Since 2005, several local and multilateral companies have been acquiring large portions of land all over the African countries to invest in first-generation biofuel feedstock production. Jatropha has been one of the feedstock for biodiesel production. A large potential of jatropha production in Africa exists in many countries including Ghana, Madagascar, Mozambique, Tanzania, and Mali.

10.2 Liquid Biofuels Development in Africa

Africa has the potential of producing different forms of biofuels (solids, gases, and liquids) for its socio-economic development. Solid biofuels are the main source of energy for cooking using inefficient, traditional stoves in most African countries. Liquid biofuels (ethanol, biodiesel, and straight vegetable oils) still account for only a small share of total energy supplies in the continent. However, Africa has huge potential for biofuels production due to large, unused land and rural populations seeking for new income generation opportunities. A few countries produce small amounts of ethanol (e.g., Malawi, Zimbabwe, and Ethiopia) or vegetable oil (e.g., Tanzania, Mali) from jatropha, mostly for local markets. Different efforts for large-scale biofuels development are being initiated and several countries are developing national biofuels policies, strategies, and regulatory frameworks (Janssen and Rutz 2012).

A variety of feedstock can be grown to produce biofuels in Africa; those with greatest interest are sugarcane and cassava for ethanol, as well as jatropha for straight vegetable oil or biodiesel production. In this chapter, different models for liquid biofuels production in Africa are presented and discussed.

Fig. 10.1 Jatropha shrubs in Mali. (Source: D. Rutz, WIP)

Fig. 10.2 Jatropha fruits and seeds. (Source: D. Rutz, WIP)

10.3 Jatropha as Biofuel Crop in Africa

Jatropha curcas is a perennial and drought resistant plant (Fig. 10.1) with a life-cycle of 30–50 years. While it is not indigenous to Africa, it has been naturalized in many parts of the continent. Smallholder farmers have been growing this crop for many decades for reasons other than biofuels. Many trees older than 30 years, and in some cases older than 50 years, are grown as fences or in the wild. The plant grows in tropical, subtropical, and semiarid regions at altitudes of up to 500 m. It can grow in areas where annual rainfall is as low as 300 mm and on poor soils with reduced yield of seeds. In order to achieve sufficient high yields, appropriate rain-fall patterns of 1,200 mm and the use of fertilizers on poor soils are required. It takes 3–5 years before jatropha produces first fruits (Fig. 10.2) and considerable yields, but after that, harvesting is possible every 6–12 months. Jatropha seeds have a high oil percentage of 30, but the oil is poisonous to people and animals. Generally, pure plant oil yield varies between 400 and 2,200 l/ha. Selected feedstock characteristics are indicated in Table 10.1.

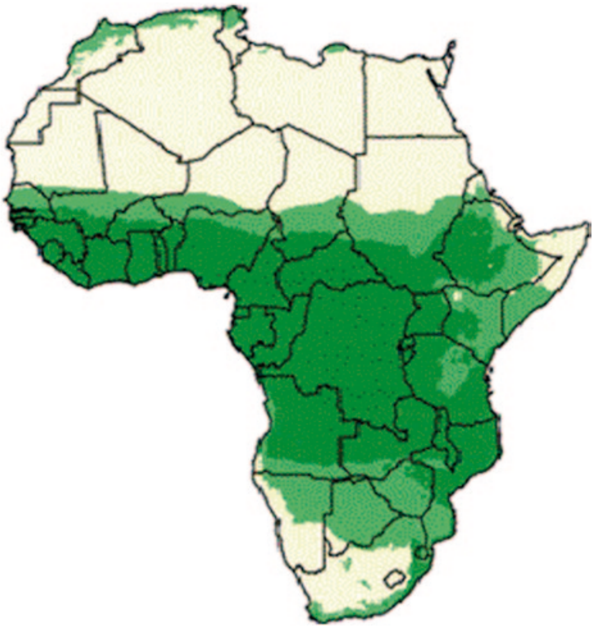

Fig. 10.3 Jatropha potential in Africa (*green*). (WordPress 2007)

10.4 Jatropha Development Models in Africa

The following different jatropha production, processing, and marketing models, currently emerging in Africa, are presented and discussed in this paragraph:

- *Stand-alone large-scale plantations* owned by large-scale farmers who are the main producers and suppliers of jatropha products
- *Large-scale plantations contracting smallholders as outgrowers* producing seeds for the plantation owners
- *Contracted small-scale farmers* producing for private organizations or companies who have no own farms
- *Independent small-scale farmers* (some organized in associations or cooperatives) locally producing, processing, and using oil for soap and energy production and selling extra oil or seeds to local biodiesel producing companies operating at district or regional towns

10.4.1 Jatropha Value Chains

There are three major functions taking place in jatropha production in Tanzania. These functions include *cultivation* which pertains to jatropha growing and seed harvesting, *processing* which includes activities of pressing the seeds to separate the oil and the seedcake, and *product use* of oil and seedcake. Present jatropha value

Table 10.1 Jatropha feedstock characteristics. (Source: Sielhorst 2008)

Characteristic	Quantity
Preferential rainfall (mm/year)	600–1,200
Required economical scale for competitive biofuel production (ha)	400–1,000
Fertilizer use	Low
Pesticide use	Low
Sensitivity to water supply	Medium
Mechanization potential	Low
Smallholder potential/outgrower scheme potential	High
Maximum time between harvesting and processing	Several months
Seed oil content	30 %
Oil yields (l/ha)	400–2,200

Fig. 10.4 Large-scale jatropha plantation. (J. Shuma, TATEDO)

chains are not fully driven by market forces, and many production incentives exist for developing jatropha farming.

Due to the emergence of various products of commercial value from jatropha trees, there have been a growing number of jatropha seed collectors and traders. Some women groups who extract oil and make soap have been potential buyers of jatropha seeds. Some women groups have decided to specialize in soap making and marketing and thus buy jatropha oil from their colleagues who extract the oil from the seeds. Interestingly, there is varying value addition per hour for every function along the chain.

10.4.2 Large-Scale Plantation Models

Large-scale plantation business models (1,000 ha or more; Fig. 10.4) normally are capital intensive, often using tractors, large amounts of fertilizers and pesticides, and expensive irrigation with contracted labor. In Africa most of the large-scale plantations are established by foreign companies with the objective of producing jatropha oil for export markets.

Large-scale jatropha plantations in Africa were visualized to be a new source of high revenues, employment, and production of substitute for petrol diesel. The main product from this model is jatropha oil, which has high potential for export. The economic viability of growing jatropha as a cash crop depends, to a large extent, on the yield obtained when it is grown in plantations. Some companies initially anticipated financial returns of 93 % per year of their investment, but these figures have now been scaled down (Viceroy Invest 2009).

This model has been observed to have the least potential to enhance rural development, although it could contribute to rural employment. In recent years, some companies which have practiced this model in Africa have experienced financial problems due to several reasons (i.e., financial crisis, lack of adequate capital, and overestimated yields). Until today, large plantation projects in Africa concerning jatropha cultivation have not proven to be successful due to their inability to generate sufficient revenues, as well as the destruction of natural resources (e.g., forest, biodiversity). Among the companies known that have invested in jatropha in Tanzania are Sun Biofuels, D1 Oils (UK), and Flora Eco Power (Germany). They have faced poor production performance, low yields, and low revenues leading to a withdrawal of BP from its joint venture with D1 Oils. Another example was the Swedish company Bio-Massive, which leased land in Tanzania to set up jatropha plantations. They have announced losses until 2009. The Dutch company BioShape who had also acquired land in Tanzania has officially declared bankruptcy in 2010 the jatropha plantations (Sawe et al. 2012).

Based on such negative experiences and other social and environmental concerns, South Africa banned jatropha planting in 2010, the government in Zimbabwe has banned export of jatropha products and in Tanzania, the government has reportedly suspended approvals for new biofuel projects until clear policy and regulations are put in place.

Several multinational companies invested in advertising for jatropha, promising a guaranteed return on investment with cultivation on marginal lands, but these promises have proven to be absolutely unrealistic. These companies have already abandoned their projects in Africa, because yields were far below expectations on good land. Investing in large plantations of jatropha is thus neither economically viable nor environmentally sustainable. According to the report of Friends of the Earth International on "Jatropha—money doesn't grow on trees" (Pohl 2010), there are ten reasons on why jatropha is neither a profitable nor sustainable investment. In summary, jatropha as cash crop does not guarantee high returns, cannot thrive on marginal land, requires significant amounts of water, and is not pest resistant. Large jatropha plantations also compete with food production, have negative impacts on biodiversity, and are likely to increase carbon emissions. The displacement of people from their original land areas was minimal since most of the land was used for annual crop production and other lands were reserved for natural forests and woodlands.

However, the failure of large plantation models does not necessarily lead to a total failure of jatropha cultivation in Africa, as it is possible to achieve success with other production models. Successful production models for jatropha involve smallholder farmers as outgrowers or independent farmers. The feedstock for these models is cumulatively gathered from extensive networks of smallholder farmers. Avoiding the large investments needed for plantations, seed collection by outgrowers, and processing to produce oil and press cake for biogas production and as bio fertilizer application, seems to be a suitable business model.

10.4.3 Large-Scale Plantations Contracting

This business model involves a central company facilitating seed collection from jatropha farmers. For biodiesel and Straight Vegetable Oil (SVO) production, a company is required to promote jatropha cultivation to small-scale farmers using outgrower and collection schemes.

Some large-scale jatropha plantations have agreements with smallholder farmers to provide inputs and technical support for jatropha production and in turn buy all seeds from small-scale farmers. However, the potential positive socio-economic impact of this scheme depends on a number of issues including the quality of provided support services and the fairness of the terms of contract.

Jatropha seeds are collected from smallholders' farm hedges and public areas. The production of seeds is performed by smallholder groups or individuals as outgrowers supported by companies. Some smallholder farmers can locally produce, process, and use jatropha oil as well as its by-products for meeting their own needs. Jatropha production may also be done through group farming on dedicated communal land areas. Family labor is used during seed collection and processing (by farmer groups) using manual oil presses. Farmers may thereby intercrop jatropha with other food crops. The seeds are collected from farmers and supplied to collection centers. The company hires trucks for transporting seeds to the conversion facility located in urban areas, where they are processed to Straight Jatropha Oil (SJO). There are no agrochemical inputs used by smallholder farmers during production of jatropha seeds, however, some chemicals are used during conversion of jatropha oil into biodiesel.

This jatropha production model generates income for smallholders, employees, transporters, and jatropha companies. Typical examples of such outgrower models in Africa are found in Mpanda, Tanzania (Prokon), and Koulikoro, Mali (Mali Biocaburant). Economic assessments have shown that collection and sales of seeds give the lowest added value. Oil extraction is more profitable than seed collection, but not as good as soap making. Even though all assessed activities contribute to the rural economy it may still take some time, until such jatropha models can significantly contribute to rural development.

The price for seeds is established by agreements between the company and the farmers. Different collection areas have different prices: the longer the transport, or the higher the expenses for transport, the lower the price for the seeds. Collectors are always given the option to bring seeds to the factory gate (for a "factory-gate price"); otherwise, the company organizes and pays for the transport of the seeds.

Jatropha seed collection (especially for smallholders) is labor intensive which is considered as strength in the context of pro-poor development. The outgrower

Fig. 10.5 Intercropping: jatropha and corn. (Mali Biocaburant 2011)

model involves several actors (small farmers, field coordinators, extension staff, local actors, collectors, etc.). Smallholder farmers are self-employed, whereas other farmers and collectors are employed on contractual basis. Extension staff and field coordinators are formally employed by the company. Labor is required for clearing the site, ploughing, pitting, planting, weeding, irrigating, spraying of crop protection chemicals, fertilizers, and pruning. As labor costs account for a high percentage of total costs, scale effects are unlikely when establishing a jatropha plantation on a larger scale. Labor requirements will increase almost linear with area size. Transportation costs could be reduced when transporting inputs or seeds, but this is a rather small portion of the total costs.

Jatropha production by outgrower models is undertaken by smallholder farmers working in the informal sector. Although the management of companies may be aware of health and safety regulations, compliance with regulations concerning appropriate use of agrochemicals, provision and use of protective gear, availability and accessibility to first aid services, working hours, wages and provisions for establishing a workers union may vary from one company to another. Since these companies do not have control over the outgrowers, their influence on working conditions is limited. The health and working conditions are applied to permanent workers in processing plants and seed collection systems only.

There have been ongoing debates on the impact of jatropha production on food security. Some believe that sustainable production of jatropha is possible without negative impacts on food security, solely depending on operation management. On the other hand, doubters argue that production of biofuels will threaten food supplies for the poor. However, the model of collecting jatropha seeds from outgrowers (smallholder farmers and contract farmers) does not have much effect on food security for smallholders, as jatropha is most commonly planted in hedges and in some cases intercropped with other local crops (maize, sweet potatoes, onions, and sunflower; Fig. 10.5).

Some biofuel companies in Africa which use outgrower models to process oil from jatropha do not own any land. Instead, they buy jatropha seeds produced or collected by local farmers according to contracts or outgrower arrangements. These companies are able to start producing biofuels earlier, avoiding delays and costs incurred in acquiring land. However, these companies may face other challenges, such as ensuring that enough biofuel feedstock at the right quality is supplied by local farmers in order to meet production targets. The smallholder farmers under this kind of arrangements, are not compensated for their lands because they do not lose rights of their lands. They can decide on the allocation of land for the production of crops and other (food) crops (Luoga et al. 2011).

Although women in Africa inherently have limited access to resources such as land, water, fertilizers, and pesticides, they have the right to collect, process, and sell seeds from family hedges, and keep the money earned. The government can allocate plots to women where they can plant jatropha. In general, often unequal opportunities and benefits for men and women headed households exist. Sometimes women extract oil which they use to make soap or sell to companies for various uses, thereby improving their income and livelihoods.

10.4.4 Independent, Small-Scale Farmers

Independent small-scale farmers may be organized in associations or cooperatives in order to locally produce, process, and use jatropha oil for the production of soap and energy. Under this model socio-economic impacts depend on the management setup and price of jatropha seeds. This model could be the most beneficial option for smallholder farmers in Africa, if well organized and managed.

Jatropha production by small-scale farmers has the potential to provide farmers and communities in Africa with extra income and improve access to energy services such as electricity, fuels for lighting, cooking for income, educational activities, and water pumping. Key issues need to be considered in the sustainable development of jatropha by small-scale, independent farmers based on experience from different villages in Tanzania, such as the village Leguruki in the vicinity of Arusha. In such villages, farmers intercrop jatropha with other crops, and significant economic opportunities have been realized. The communities have derived income from processing and use of jatropha oil for soap production, seed cake application as fertilizer and stationary engines for electricity, and motive power production.

Independent small-scale farmers are playing an important role in developing markets for jatropha seeds, soap, and energy produced from energy service platforms (ESP). Energy service platforms, also called multifunctional platforms (see Chap. 11, Fig. 11.2), are devices that are powered by an engine (e.g., oil, gas, power) and provide several small-scale services such as cereals grinding, pressing, cutting, etc. Energy service platforms owned by village enterprises or individuals are facilitating access to modern energy services to rural populations who previously lacked access to such services. Jatropha oil has thus contributed to small-scale power production in rural areas, substituting more expensive fossil fuels. New small and medium enterprises have emerged including, metal welding and soap production.

Ensuring that the economic and social benefits of biofuels are realized and sustained by independent and small-scale farmers requires improved knowledge of technologies and business management. It further requires support by competent local institution and governments to provide the necessary enabling environment.

In many African countries, small-scale jatropha models have shown positive results, providing access to energy services, increased income for local communities, higher agricultural productivity, improvement of women's working and living conditions, more efficient management of natural resources, and general quality of life improvements.

Further experiences have also shown that small-scale jatropha-growing models driven by local ownership (in which small-scale farmers produce fuel for their own use or community applications) appear likely to sustain benefits for rural communities. The transfer of technology, the building of technical and managerial capacity, improvements in farming practices, better farm inputs, and marketing will not only help rural communities to gain energy access but also increase food production, improve capacities to embark on income generating activities, add value to products, empower women, and protect soil from erosion.

Therefore, small-scale jatropha models have a large potential to provide modern energy services that contribute to increased employment and income opportunities, technological improvement, cleaner environment, energy security, gender equality and overall, enhanced economic and social well-being.

10.5 Environmental Impacts

A number of environmental impacts are usually associated with the production and use of biomass for biofuels, bioenergy, or biomaterials. These include impacts on human health (release of toxic substances, emission of photo-oxidants and ozone-depleting gases), on the quality of ecosystems (release of toxic substances, emission of acidifying and atrophying gases, land-use impacts on biodiversity, water, and soil) on climate change (global warming) and on resources (nonrenewable energy carriers and minerals).

Africa is facing serious interrelated environmental problems, including deforestation, soil erosion, water shortage and degraded water quality, and greenhouse gas emissions. Climate change is an important issue for all investors, as alongside high oil prices, and GHG mitigation is one of the main drivers for biofuels. Most investors in Africa have not yet carried out greenhouse gas assessments in order to calculate actual emission savings.

A jatropha tree absorbs around 8 kg of CO_2 every year. However, changes in land use for jatropha production can have dramatic effects on greenhouse gas emissions. When forest or grassland is converted to jatropha plantations, carbon stored in the soil is released into the atmosphere (Luoga et al. 2011).

Under the outgrower model, jatropha is principally produced through networks of small local farmers without associated land use change. The potential impact on biodiversity values will arise if natural habitats such as forests, woodlands, and indigenous grasslands are cleared. Significant areas of natural habitat also occur outside protected areas, which is important for biodiversity.

10.6 Conclusion

Global demands of biofuels are among the drivers for potential biofuel production in Africa. In addition, several African countries have been motivated to explore the opportunities of biofuels by concerns over unprecedented increases in fossil fuel prices and hence increasing import bills. Furthermore, biofuels may mitigate the problem of climate change through reduction of greenhouse gases, create employment markets for agricultural energy crops, and diversify rural economy.

African governments have been engaged in the promotion of biofuel investments, and many foreign companies have indicated interest and are in different stages of the investment process. While this is happening, few African countries have established suitable policies for governing investment decisions, a situation that has contributed to ad hoc investment arrangements creating threats for sustainable biofuels development.

This comparative analysis of different business models for jatropha development in Africa has outlined potential socio-economic impacts. The implementation of such business models may however vary from one to another African country. They can be integrated into local economies and adapted to the needs of different stakeholders, yielding a wide range of small, but crucial, social and economic benefits. Although large-scale production of jatropha seems not to be successful, other business models (involvement of small farmers) may well contribute to positive socio-economic development in African countries.

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