Global Assessment of Biomass and Bioproduct Impacts
on Socio-economics and Sustainability

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Global-Bio-Pact Case Study Socio-Economic Impacts of the Jatropha chain in Mali

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List of Abbreviations

AMADER	Mali Agency for the Development of Household Energy and Rural Electrification
ANADEB	National Agency for the Development of Biofuels
CNESOLER	National Centre for Solar and Renewable Energy
DNE	National Directorate of Energy
EDM	Energie du Mali
GEF	Global Environment Facility
GERES	Groupe Energies Renouvelables, Environnement et Solidarités
HDI	Human Development Index
JME	Jatropha Methyl Ester
JMI	Jatropha Mali Initiative
KWh	Kilowatt-hour
LOA	Low on the Orientation of Agriculture
MBSA	Mali Biocarburant SA
MFC-Nyetaa	Mali-Folkecenter Nyetaa
SJO	Straight Jatropha Oil
Toe	Ton of oil equivalent

Preface

This report was elaborated in the framework of the Global-Bio-Pact project (Global Assessment of Biomass and Bioproduct Impacts on Socio-economics and Sustainability) which is supported by the European Commission in the Seventh Framework Programme for Research (FP7). Global-Bio-Pact is coordinated by WIP Renewable Energies and runs from February 2010 to January 2013.

The main aim of Global-Bio-Pact is the improvement and harmonisation of global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts. Thereby, emphasis is placed on a detailed assessment of the socio-economic impacts of raw material production and a variety of biomass conversion chains. The impact of biomass production on global and local food security and the links between environmental and socio-economic impacts are analysed. Furthermore, the Global-Bio-Pact project investigates the impact of biomass production on food security and the interrelationship of global sustainability certification systems with international trade of biomass and bioproducts as well as with public perception of biomass production for industrial uses. Finally, Global-Bio-Pact focuses on socio-economic sustainability criteria and indicators for inclusion into certification schemes, and the project elaborates recommendations on how to best integrate socio-economic sustainability criteria in European legislation and policies on biomass and bioproducts.

A core activity of Global-Bio-Pact is the description of socio-economic impacts in different countries and continents in order to collect practical experience about socio-economic impacts of bioproducts and biofuels under different environmental, legal, social, and economical framework conditions. The results of these surveys are described in different case studies.

This report presents the Global-Bio-Pact Case Study for the Jatropha value chain in Mali. This Case Study was elaborated by Mali Folkecenter-Nyetaa.

1. Introduction

A strong public debate on sustainability aspects for biomass use for energy and products emerged in the last few years. This debate focused mainly on negative social and environmental impacts. In consequence, several initiatives were set-up, which are engaged in developing tools to ensure sustainability of biofuels. One option to ensure the sustainability of biofuels is the application of certification systems.
The main aim of the Global-Bio-Pact project is the improvement of global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative and to promote positive socio-economic impacts. Thereby, emphasis is placed on a detailed assessment of the socio-economic impacts of feedstock production and a variety of biomass conversion chains.
In order to generate data on the ground, five in-depth case studies for socio-economic impacts were investigated in the framework of Global-Bio-Pact:

- Biodiesel from soy in Argentina
- Palm oil and biodiesel in Indonesia
- Bioethanol from sugarcane in Brazil
- Bioethanol from sugarcane in Costa Rica
- Jatropha oil and biodiesel in Tanzania
- Jatropha oil and biodiesel in Mali
- 2^{nd} generation biofuels and products from lignocellulosic material in Canada

This report presents the Global-Bio-Pact Case Study for the Jatropha value chain in Mali. This Case Study was elaborated by Mali Folkecenter-Nyetaa. The case study will shed some light on the different pathways adopted in the country in increasing the local production and use of biofuels in meeting the country's energy need.

2. Case Study selection

Since the impacts of the production of biofuels and bioproducts depends on the investigated scale, different levels were investigated in all Global-Bio-Pact Case Studies, including the national, regional, and local/company/project level (Figure 1). In each Case Study country of the Global-Bio-Pact project the following assessments were made:

- One study at national level
- One study at regional level
- Two studies at local, company or project level

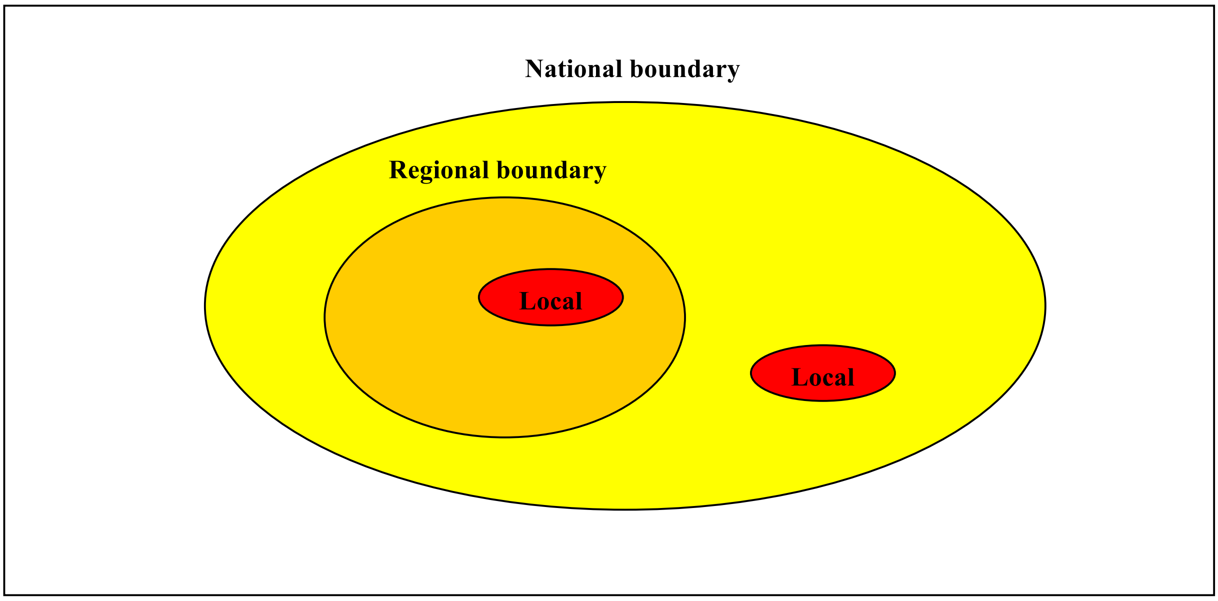


Figure 1: System boundaries of the Global-Bio-Pact project

2.1 Case Studies at national level

The Case Studies at the national level were selected in order to balance the geographical distribution (Africa, Latin America, Asia, Europe, N-America), feedstock sources (soy, palm oil, Jatropha, sugarcane, lignocellulosic feedstock), conversion technologies (e.g. fermentation, pressing, transesterification, hydrolysis, gasification) and products (biodiesel, pure plant oil, ethanol, bioproducts, 2nd generation technologies). Thereby, the assessment focuses on existing conversion technologies since these are the current hotspots of socio-economic concern, but also include impacts of future technologies which are not yet commercially available.
The present report shows the Global-Bio-Pact Case Study for the Jatropha value chain in Mali.

2.2 Case Studies at regional level

In this project, the regional level was defined as a homogenous region in climate, soil, and socio-economic parameters. The size of the region depends on the country and can be a province or district.
In the present report, the region of Koulikoro was selected as Case Study region since it is one of the main regions where different Jatropha initiatives have been taken from the public, civil society and private sector.

2.3 Case Studies at local level

At the local level the system boundary is a local area from an e.g. farmer, company, association or project level. The local area refers to the area where the biomass feedstock (including by-products) is produced and converted into the final or intermediate product. In each Global-Bio-Pact Case Study country two different local Case Studies (projects, companies) were selected and investigated. Thereby, these two local Case Studies can be within or outside the regional boundary. In the present report, the com-

pany Mali Biocarburant SA and the rural electrification project of the town of Garalo (Garalo Bagani Yeleen) were selected as case studies.
Mali Biocarburant SA was selected because it is the only company producing bio-diesel for the local Malian Market and has been a major innovator in the Jatropha value chain.
The Garalo Bagani Yeleen was selected since this project is aimed at providing electricity to 10,000 inhabitants in the rural municipality of Garalo through locally grown and processed Jatropha oil.

3. General description of Case Study

3.1 Country Description

3.1.1 Land use

Mali is a vast landlocked West African country, located between 10° and 25° N and 4° and 12° E with a total land area of 1,241, 231 km^2. The country is characterized by an inter-tropical climate that can be divided in three main climatic zones that are: arid Saharan in the North, semi-arid Sahelian in the central belt and cultivated Sudanese in the South. Mali's total land area consist of 5 % arable lands, with 6.36 million ha (of which 0.1 million ha of permanent crops), 10% is covered by forests, with 12.96 million ha and the remaining 85% is desert and semi-desert land primarily in the north, subjecting the country to drought and desertification (FAO, 2009). The country has pursued a decentralization policy, leading to the division of the country into 8 administrative regions, 49 circles and 703 communes while the capital city of Bamako is the sole district. See map of Mali below (Figure 1).

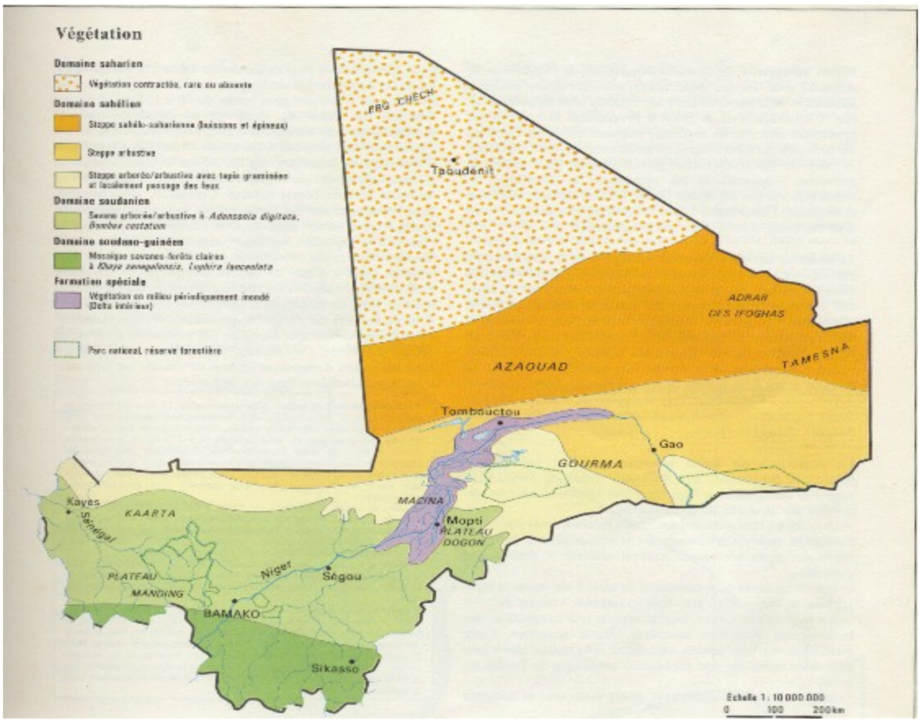


Figure 2: Map of Mali

3.1.2 Economy

Mali is classified as a low income country evidenced by its low Human Development Index [1](HDI) of 0.309 making it rank at 160 out of a total of 169 countries (UNDP, 2010). The country's real GDP growth remained constant despite the global recession (4.3 % in 2007, 5% in 2008 and 4.5% in 2009) and high compared to the West African Economic and Monetary Union (WAEMU) average (3.3 percent in 2007, 3.7 percent in 2008, and 2.9 percent in 2009) (MEF, 2010). Mali's GDP was estimated in 2009 at US$ 8.7 billion while GDP per capita at US$ 1,200 (CIA, 2011). The primary and tertiary sectors, respectively at 36.5 % and 35%, were the main GDP contributors and did not change much in 2010 (AEO, 2011). The primary sector, where more than 80% of the country's workforce is involved consists for the most part of farming (mainly subsistence) and livestock (respectively 20.6% and 8.1% of GDP), the tertiary sector is dominated by commerce (14.4 %), non-traded services (8.7%) telecommunication and transport (5.4%), while mining (essentially gold) and construction (respectively 5.6% and 5.2%) accounted for most of the secondary sector (Ibid). With the global soaring prices of gold, the secondary sector is expected to pick up in the coming years. However, the reliance of the Malian economy on sectors that are exposed to trends and shocks (climate and water variability, fluctuating commodities prices) makes the country still dependent on foreign aid which constitutes a major portion of the state budget. In addition, an estimated 51.4% of the population live below the poverty line of $1.25 a day and the country's GINI index was estimated at 40.1(World Bank, 2011).

3.1.3 Population

The population of Mali was estimated in 2009 at 14.5 million with an annual growth rate of 3.6% (MEF, 2010). Although the major part of the population still remain rural (75% of total population), urban growth is 5% mainly toward the capital city Bamako while rural growth is 2% (World Bank, 2011). The country overall population density is estimated at 13 inhabitants/km^2 and is not evenly distributed, with high concentration in the southern and central regions at 27.86 inhabitants/km^2 (where most of the agricultural activities occurs) while being low and sparse in the northern regions at 1.43 inhabitants/km^2. Mali is an ethnically diverse society, and is composed of the Mande representing the larger portion of the population (mainly farmers, including Bambara, Malinke, Soninke), seconded by the Peulh (also known as Fula, traditionally nomadic cattle herders but tending to be sedentary), while the Voltaic, Songhai, Tuareg and Moor composed the remaining portion. There has traditionally been some friction between the farmers and nomads (roughly 10% of the population), but generally disputes are resolved peacefully. However, climate change is increasing pressure on land and water resources that may aggravate tensions.

Mali has adopted French as the official language of the country, but is however characterized by one of the lowest adult literacy rate estimated at 26% of the adult population (15 years and up), urging the government to take serious actions to increase literacy rate. In a population slightly dominated by women (52% women versus 48% men), gender inequality is high and present in all major socio-economic spheres evidenced by a high gender inequality index of 0.712 (UNDP, 2010).

[1] The UNDP Human Development Report Index measures a country's achievements in terms of a long and healthy life, knowledge, and a decent standard of living)

3.1.4 Agricultural Sector

Agriculture is fundamental to Mali's economy, as the vast majority of the population is directly dependent of their surrounding environment for their livelihoods (through farming, herding and fishing). The country arable land is estimated at 4,850,000 ha of (representing 4% of total land area) of which only 0.1 % is permanent cropland mainly along the Niger and Senegal rivers and their affluent (FAO, 2009). Agricultural development has been focussed on two crops, rice in the zone of the Niger Office (in the Niger River interior delta) of the central administrative region of Segou and cotton in the CMDT zone (Malian state cotton company) in the southern administrative region of Sikasso. Although the country has a tremendous potential for irrigated agriculture, it is currently still highly dependent on rain-fed agriculture. The country receives an annual average rainfall of 200 mm in the northern arid region, 800 mm in the middle Sahelian belt and 1200 mm in the southern sub-tropical climatic region (Kanoute, 2010). Cotton is the main cash crop and is the country second export (behind gold) with a 2009 production of 141,738 tons (FAOSTAT, 2011). Cereals are the main food crops with an average annual growth rate of 4.6% (USAID, 2011). The main cereals produced are rice, maize, sorghum and millet with a 2009 production of 1,950,810 tons of rice, 1,476,990 tons of maize, 1,465,620 tons of sorghum and 1,390,410 tons of millet (FAOSTAT, 2011). The main exported agricultural products in addition to cotton are groundnuts, fruits (mangoes and guavas) and potatoes while the main imported ones are refined sugar, broken and milled rice, palm oil and wheat flour.

3.1.5 Forestry sector

The national forest estate covers 12.96 million ha corresponding to 10 percent of total land area and contains 282 million tons of carbon in living forest biomass (FAO-STAT, 2011). Malian forest plays an important role in socio-economic development and in maintaining ecological equilibrium. The standing volumes is estimated at 520 million m^3 with an average productivity of 0.86 m^3/ha/year out of which 10 m^3/ ha of shrubby savannah mainly in the north, 20 to 40 m^3/ ha of tiger bush in the central belt and 50 to 80 m^3/ha (up to a 100 $m^{3)}$ of forest in the south (Kanoute, 2010). The major forest products in Mali are of two types, the ligneous forest products which include wood fuel, charcoal, construction wood and timber, and non-ligneous forest products consisting of tamarind (*Tamarindus indica*), shea (*Vitellaria paradoxa*), nere (*Parkia biglobosa*) and Arabic gum (*Accacia spp.*) used for various foodstuffs, drugs and cosmetics. The total quantity of the non-ligneous products exported between 2005 and 2008 amounted to 22,664 tons representing a value of 224.25 million FCFA (Ibid). The wood produced does not meet the demand for construction and furniture making causing a significant amount of imported wood specially rafters, boards and plywood which amounted in 2009 at 25,026 tons with a value of 3,000 millions CFA (Ibid). Although forests have been protected due to its sacred status in certain regions of the country, its progressive conversion to agricultural land coupled with overexploitation for wood fuels have been the major contributors to forest decline, desertification and GHG emissions.

3.1.6 Land ownership concentration

Malian land tenure system is quite complex and is governed by the "Code Dominial et Foncier" established in 2002. The law recognizes both customary and modern land tenure laws in an intricate system. In fact ownership of land is of the state while individuals or group of individuals only have usufruct rights. Land can thus be access by rental, allocation or grant. However, the customary law which are oral, variable and mainly based on kinship, gerontocracy, seniority and gender often conflicts with the modern laws. The country agricultural land ownership has traditionally been of the small holder type as 68% of farmers cultivate on 5 ha or less (FARA, 2010). In the Niger Office zone, the availability of more than 3 million acres in the inland Niger delta of which only 200,000 acres are exploited have driven foreign direct investment specially form China, Libya and South Africa for the production of rice and sugar cane. This is expected to cause the displacement of many farmers who are cultivating in these fertile lands for their subsistence (Baxter, 2011).

3.1.7 Food security

Food security is a critical issue in Mali, where half of the population lives below the poverty line of 1.25 $ a day impedes access to enough food resulting to an estimated 28% of undernourished Malians (USAID, 2008). A high number of people is involved in subsistence or near-subsistence agriculture and depend directly on rainfall patterns that are for the most part unreliable, and are getting worse under the vicious effects of climate change. Every year at the end of the dry season, farming families face a hunger period known as "la soudure" characterized by the complete use of stocked crops and high food market prices (mostly imported) while new season crops have not yet yielded. This hard period every year affect a great number of people especially in rural areas. About a fourth of Malian households are estimated to be experiencing yearly food insecurities and 30% are undernourished (Green, 2009). The main drivers for food insecurity include increasing cost of agricultural inputs, changing rainfall patterns (due to climate change) and speculation on international food markets.

3.1.8 Energy Sector

Like many other Sahelian countries, the energy profile of Mali is characterised by an excessive exploitation of forestry resources and the heavy reliance on imported petroleum products due to inexistent indigenous fossil fuel resources. In 2007, the total final energy consumption was estimated to 2,249 ktoe, of which biomass accounted for 78%, followed by petroleum products at 18%, and electricity at 4% (DNE, 2007). The consumption per habitant is estimated to 0.18toe, which is very low compared to the average in West Africa, which is 0.45toe and further exacerbating the energy poverty of the country. The final energy use per sector is as follows:

- Residential sector consumes about 72% of the total energy, of which 85% form firewood and 13% from charcoal. These two energy sources are used for cooking. LPG, mainly consumed in urban cities account for 0.4% of the households energy consumption. Kerosene for lighting account for 1% of the total energy consumed by the residential sector and electricity account for less than 2% of the households energy consumption.

- The transport sector account for 17% of which 94% is used in road transport and 5% for air transport and 1% for railways transport. Diesel oil account for 72% of the total energy consumed in the transport sector.
- Industries consume about 3% of the total energy mainly in the form of electricity (96%), followed by heavy fuel 3%. The bulk of the consumption in the industrial sector is in the mining industries as small and medium size enterprise for agro processing is at it naissance phase.
- Other sectors consume about 8% of the total energy

Table 1 below shows the distribution of production and supply of energy in 2007. Petroleum products were entirely imported and accounted for 647 kto. Electricity supplied totalled 159 ktoe of which 83 ktoe were generated in the country and 76 ktoe was imported from neighbouring countries. This highlights the gap between the national production and the demand, which is increasing rapidly at a rate of 10% per year.

Table 1. Mali Energy production and supply

	Petroleum products (ktoe)	Biomass (ktoe)	Electricity (ktoe)	Total (ktoe)
Production	0	2,737	83	2,819
Import	647	0	76	723
Supply	647	2,737	159	3,543

Source: Energy Information System (DNE, 2007)

The production, transport and distribution of electricity in Mali has been the responsibility of Energie du Mali (EDM) since the independence. Electricity and modern energy services are seen to be catalysts for local development and growth but still in Mali it remains a luxury to have electricity, and prohibitively expensive for the poor. Considering that the number of poor people is increasing, it is becoming more and more difficult for the population to have access to electricity in spite of initiatives taken by the Government of Mali to increase the national electrification rate. This has mainly be the mission of the Malian Agency for the Development of Domestic Energy and Rural Electrification (AMADER) in the framework of the GoM, World Bank, UNDP, GEF programme called Household Energy and Universal Rural Access. This has been created to try to reach a much greater level of rural access to electricity. The programme has had some level of success, but with such a huge demand, there is still much to be done.

3.1.9 Policy framework

The main overarching policy document in Mali is the Strategic Framework for Growth and Poverty Reduction (SFGPR). It constitutes a four years reference frame for all the country's development policies. The overall objective of the SFGPR for the period 2007 - 2011 was to foster a strong and sustained growth (around 7%) and significantly reduce poverty. The objectives and strategies of the SFGPR related to energy include: i) the production and distribution of electricity at lower costs; ii) increased access to electricity; iii) the reduction of wood consumption by the use of improved equipment and substitution; iv) the implementation of a program that will promote solar energy and photovoltaic equipment.

Energy policy

To materialize these objectives, the government of Mali adopted in 2006 the National Energy Policy (NEP) elaborated by the Ministry of Energy and Water, through the National Energy Directorate (DNE) in collaboration with the ministries of Finance, Agriculture, Environment, Industry and Commerce whom are all affected by the cross-cutting issue of energy. The main objective of the energy policy of Mali is to contribute to sustainable development of the country, through the supply of affordable energy services to the majority of the population to stimulate socio-economic activities. In this respect the priority of the NEP is the development of economically viable national energy sources, including the hydro-potential, solar energy, and biomass. The specific targets for the various subsectors include: i) increasing the country's electricity coverage from 14% in 2004 to 45% in 2010 and 55% in 2015; ii) to bring the rural electrification rate of 1% in 2005 to 12% in 2010 and 55% in 2015, iii) to reduce the contribution of wood fuels in total energy consumption in the country from 81% in 2004 to 70% in 2010 and 60% in 2015, iv) to increase the share of renewable energies in national production of electricity from less than 1% in 2004 to 6% in 2010 and 10% in 2015 v) to develop the biofuels industry including Jatropha, for various uses (electricity generation, transportation, agricultural engine) (DNE, 2006). The main policy instruments used to attain the NEP objectives are the suppression of import taxes and duties on all renewable energy and energy efficiency equipments and the provision of investment subsidies for rural electrification projects.

Agricultural policy

The Malian agricultural policy is defined by the Agriculture Guidelines Law (LOA) adopted in 2006. The main objective of the law is to foster a transition from subsistence agriculture to a modern, sustainable and competitive agriculture centred on local farmers. It aims at improving rural population socio-economic conditions by ensuring food security, improving farmers working conditions and agricultural yields, improving agricultural production and transformation value chain and better managing the agricultural sector to protect natural resources and the environment. Modernising the agricultural sector requires ‘energizing’ it along its value chain, therefore the LOA recognize the need to further mainstream energy in the agricultural sector by developing coherent strategies with the national energy policy, especially with the one of bio-energy.

Forestry policy

The main objective of the Malian forestry is to protect natural forestry resources from the constant degradation that is due to human activity and climate variations. The country has been subjected to frequent droughts that have had negative impacts on biodiversity and forestry resources, while the constant logging for woodfuels and land clearing for agricultural activities is further exacerbating the problem. The main forestry policy in line with the energy policy consist of a better management of wood logging by the provision of wood cutting permits and the establishment of rural wood markets to engage local communities in woodfuels management and reforestation activities.

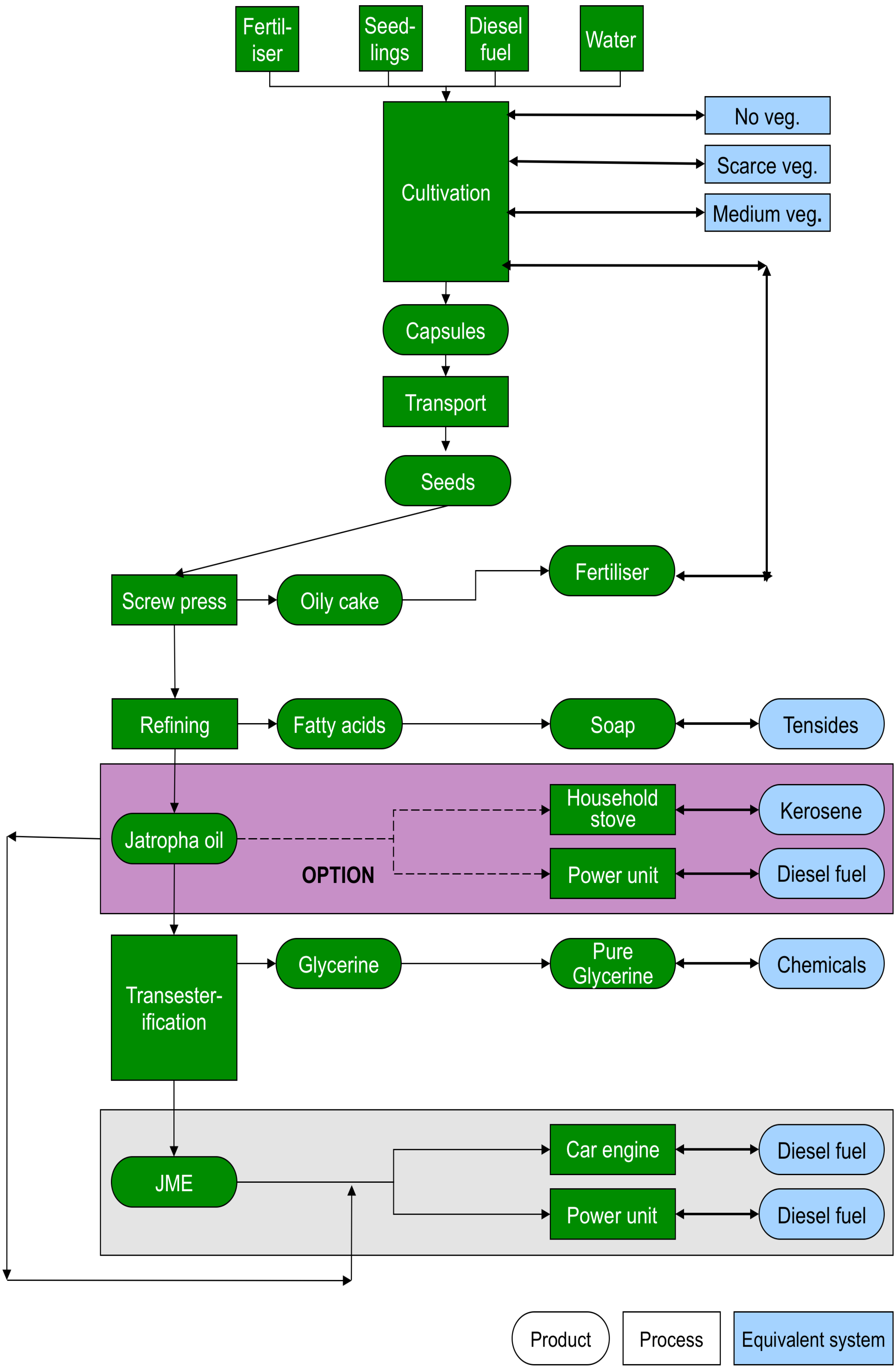
Given these different strategies being implemented in Mali, biofuels can play a major role in all three sectors previously discussed and contribute to the country's sustainable development. Potential biofuels crops that have been produced in Mali are sugar cane, Jatropha and vegetables oils (such as peanut, cotton, sorghum and maize). However, vegetable crops and oils are highly demanded in the local food consumption market and would thus not be suitable. Sugar cane is mainly produced in the Office of Niger region on a total land area of 5,000 ha for sugar and ethanol production for the food and pharmaceuticals industries (FARA, 2010). Two government projects have been formalized to boost the Niger Office sugar cane and ethanol production. It must be noted that ethanol produced from current and future projects have high water content and would need further treatment to make it suitable as fuel additive. Jatropha has been one of the most discussed and experimented crops in the Malian biofuels sector mainly because of its non-edible aspect (important in the Food vs. Fuel debate), and its resilience on marginal lands, its adoption by farmers as living fence and soil erosion protection potential.

In 2007, the government of Mali has adopted the national strategy for the development of biofuels which is based on the energy policy and the renewable energy strategy. The objective of the national biofuels strategy, steered by the National Agency for Biofuels Development (ANADEB), is to replace 20% of diesel oil consumption with biofuels by 2022. Jatropha oil and ethanol have been identified as the most promising crops for biofuels. The objective of ANADEB for Jatropha oil supply is to produce 39, 2 million litres by 2012, 56 million litres in 2017 and 84 million litres by 2022. This will require the production of 224,000 tons of seeds from 71,680 ha (with a yield of 5 kg/tree) in 2012, 336,000 tons from 53,760 (with a yield of 10 kg/tree) by 2017 and 448,000 tons from 47,787 ha (with a yield of 15 kg/tree) by 2022 while ethanol supply is aimed at 25 million litres per year (ANADEB, 2010).

3.1.10 The Jatropha supply chain in Mali

Jatropha curcas is a tropical drought resistant plant that produces seeds that are toxic to both humans and animals. It can grow and survive on marginal lands with low rainfall (250 to 300 mm/ year) and will only produce fruits at a minimum rainfall of 600 mm per year up to 3,000 mm/year (Brittaine & Lutaladio, 2010). Furthermore, Jatropha is a perennial shrub that will thrive for 30 to 50 years. The Jatropha production chain is depicted in the following diagram and will be followed by a description of the principal stages of the production chain.

Figure 3: Flowchart of the supply chain of Jatropha in Mali



Jatropha can grow in moderate sub-tropical and tropical climates and on low to medium vegetation lands. The main Jatropha farming systems that are used are large monoculture plantation, intercropped (with food crops) or in living fences (around plantations). The latter two have been the most dominant Jatropha cultivation systems in Mali. The plant produce seeds annually but under optimum conditions (adequate fertilizer and water) can produce twice a month.
Once seeds are harvested, the next step consists of oil extraction which can be done by mechanical pressing or chemical extraction. Mechanical pressing can be done on plantation site and the cake (residue) can be used as organic fertilizer. This is followed by purification or cleaning of the oil, generally by sedimentation, centrifugation, filtration, or by refining.

The pure plant oil produced is known as Straight Jatropha Oil (SJO) and can be used in converted engines (by adding a pre-heating device, generally a heat exchanger) for electricity generation or motorization, and could also be use on oil stove and lamps, while the removed fatty acids can be used for soap manufacturing. The SJO can be further esterified to produce biodiesel (Jatropha Methyl- Ester), thereby converting the fuel to the needs of the engine. Glycerine is the by-product of the esterification and could be used in cosmetics and pharmaceuticals. Processing costs and embedded energy for SJO production are lower, but there is the disadvantage of the needed engine modifications. Biodiesel requires highly purified methanol, which is not available on the local market in Mali and is currently being imported. Therefore a decision needs to be made as to which technology pathway to adopt. Generally, for the use of biofuels in the transportation sector it would be better to use biodiesel as the cost of converting all the car engines would be prohibitively high. Alternatively, to produce electricity from decentralized power stations, it would be more economical to convert those engines and benefit from the lower cost of SJO production.

In Mali the two main production systems that have been experimented are the decentralised community approach and the centralized model.
The decentralized community based approach is characterized by the cultivation of Jatropha by local farmers in living fences or intercropped (on land areas of 1 to 5 ha). This system allows the farmer to keep on cultivating their main food or cash crops, thus making Jatropha yield an additional income. Traditionally, farmers have been cultivating in mono-culture system crops such as cotton, peanut, maize, millet which prices depends on the national and international markets (as was the case of cotton for the last couple of years) and leave them with close to no revenue where there prices dramatically drops. The harvested seed are sold at local seed collection points usually managed by farmer cooperatives or unions, whom then sell it to a decentralized private electricity provider or a multifunctional platform operator equipped with SJO processing equipment. The SJO is then directly used to generate electrical and mechanical energy services to the community from the local fuel thereby reducing the provider's operation costs. The main by-product of this approach is the Jatropha press cake that is usually given back to the farmers for them to use it as organic fertilizer due to its high nitrogen content. The most important characteristic of this approach is that it represents a local bio-energy (SJO) production and consumption known as the "Jatropha short value chain".

The centralised model currently follows the same underlying principle as the decentralized based approach with the exception that the Jatropha seeds are used to produce biodiesel (Jatropha Methyl-Ester) by a private company to be sold in the local, regional or national market as a fuel that can be used in any conventional diesel engine. The centralised model is also intended for large scale Jatropha plantation. In addition to the pressed cake, glycerine is a by-product of the esterification process and can be either use in pharmaceutics or in soap manufacturing. This centralized model is known as the "Jatropha long value chain".

So far in Mali, no Jatropha plantation has yet been owned by fuel producing companies (although large land deals agreement with private companies are in the process), but are rather cultivated on farmers' land (fencing and intercropping). These approaches require minimum extra labour time for the farmers as if intercropped with food or cash crops; Jatropha reaps indirect benefits from the necessary labour (watering, pruning, weeding etc.) and inputs (fertilizers) of the cash and food crops.
Couple of experimental Jatropha fields exist in the country as research is on-going to identify the best varieties in term of yields, seeds oil content and appropriate soil condition by research institute NGOs and the private sector. The latter two also provide support to farmer's organizations in accessing seeds and seedlings, transfer best cultivation practices. However, the fact that the Jatropha sector is still in a niche stage, the total current amount of Jatropha plantation in the country is still unknown and no average annual yields has yet been assessed.

3.1.11 Trends in production, supply and demand

National production, supply and demand trends in Mali are scarce due to the infancy stage of the Jatropha sector. As stated earlier an estimated 20,000 km of Jatropha living fences have been planted in Mali (from 1970 to 1996) with an average annual yield of 0.8 kg per linear meter (conservative value), totalling to an annual production of 16,000 tons (Khennas, 2006). In 2010, the total Jatropha land area was estimated at 7,342 ha giving 115,839 tons of seeds to produce 74,829 litres of straight Jatropha oil (ANADEB, 2010a). Demand for Jatropha based biofuels is increasing in the country faster than the supply due to the proliferation of niche markets involve in biodiesel production and rural electrification. In order to meet the national Biofuels strategy objective an estimated 75,000 ha need to be planted to meet the 2012 target. Efforts are thus being pursued in the private and non-profit sector to plant and produce SJO and Biodiesel for the local consumption. In the private sector the leading company is Mali Biocarburant SA (MBSA) which has been supporting about 3,000 farmers since 2007 regrouped in a union and planting Jatropha (intercropping and live fences) producing 200,000 tons of biodiesel per year. In addition other local private companies such as Jatropha Mali Initiative, Sud Agro-industrie, Tomota Group have prospected to plant respectively 12,000, 50,000 and 100,000 ha in different part of the country to mainly produce SJO.

3.1.12 Supply chain actors and governance

The Jatropha sector is currently steered by ANADEB which is an agency attached to the Ministry of Energy and Water with the mandate of harmonizing the promotion of biofuels (both from Jatropha and sugar cane) for the local market. ANADEB has benefited from the technical experience of the National Research Centre on Solar and Renewable Energies of Mali (CNESOLER) on biofuels (especially Jatropha) from its National program for the Energetic Valorisation of Jatropha and is using economic and legal policy instruments such duty and as tax free importation of biofuels producing equipment, 5 year tax break for private investors in the renewable energy sector and the establishment of minimum quality standards and quotas.

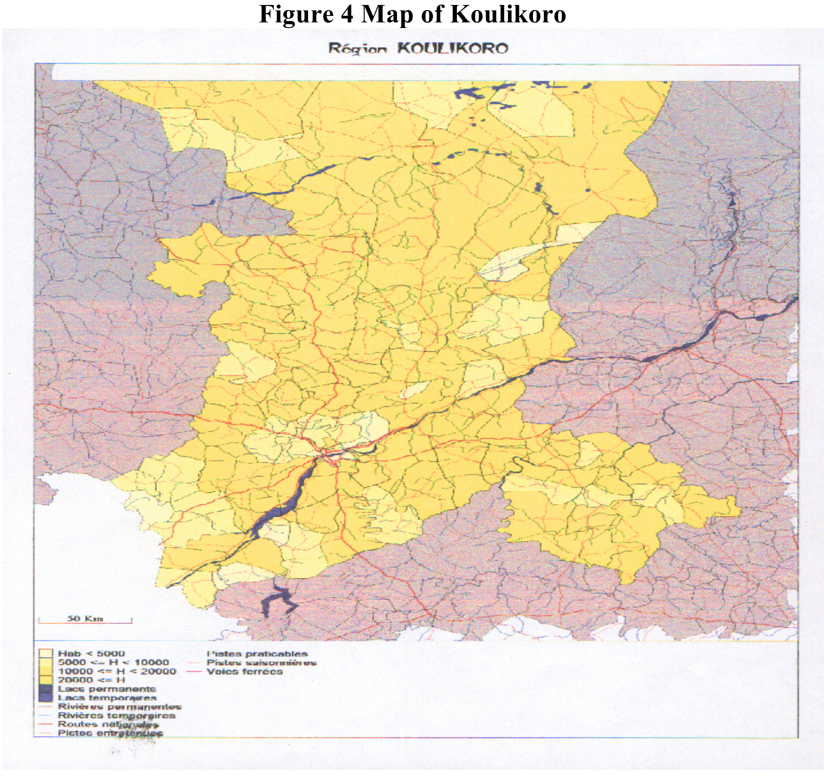
The Non-governmental sector have been the main sector involved in supporting farmers in growing Jatropha and some in using the SJO for rural electrification. In terms of out-growers schemes the NGO's that have been leading the sector are Mali-Folkecenter Nyetta, AEDR-Teriyabugu and GERES. All three organizations are also involved in rural electrification from SJO in the regions of Segou and Sikasso. As stated earlier the private sector has also been playing an increasing role in the Jatropha supply chain by supporting out-growers (seedling, technical knowhow) and buying their production at a guaranteed price. So far only Mali Biocarburant SA has been producing biodiesel from Jatropha with a daily production of 2,000 l. There is also an increasing growth of farmers cooperatives involved in Jatropha cultivation and being supported by ANADEB.

3.2 Case Study at the regional level: Koulikoro region, Central Mali

3.2.1 Land use

The region of Koulikoro is the second administrative region of Mali within which the district of Bamako (capital city) is situated. The region surface area is 90 120 km^2 and is limited to the North by Mauritania, to the West by the region of Kayes, to the South by Guinea and the region of Sikasso, and to the east by the region of Segou. The region is situated within two climatic regions that are Sahelian in the northern and central part and Sudanese in the southern part. It is irrigated by the Niger River and tributaries (Baole, Bafing, Bani etc.) and contains 12 classified forest and reserves covering 200,841 ha (CSA, 2009).

Figure 4 Map of Koulikoro



3.2.2 Economy

The region of Koulikoro main economic activities are concentrated around agro-silvo-pastoral and forestry as more than 80 percent of the population is involved in the sector for their livelihoods These rural activities are being supported by extension services provided by the Office of the Niger Upper Valley (OHVN) and the Malian Company for the Development of Textile (CMDT) in accessing inputs and credits to increase farmers' revenues. The presence of iron ore and gold has sparked mining prospects that are due to take large proportions in the near future while gold is currently exploited in an artisanal manner. The distirict of Bamako (capital of the country) is located in the heart of the region and represents the country's major consumption market for the industrial sector. In the region of Koulikoro industry includes the leading edible oil producing plant (Huicoma), flower mills (GMM, Moulins du Sahel), breweries (Bramali, NBB) and CMDT's cotton processing plant.

3.2.3 Population

The population of Koulikoro was estimated in 2009 at 2,418,305 habitants with a density of 22.8 hab/km^2 with high concentration in the districts of Koulikoro, Kati and Dioila (Instat, 2009). The major ethnic groups are the Malinke and Bambara in the center, the Somono along the Niger River, the Soninke, Maures and Fulani in the North. The city of Bamako is the major migrating destination for the population of Koulikoro in search for job and better opportunities than that offered in the country side further exacerbating rural exodus.

3.2.4 Agricultural sector

The main agriculture products in the region are food crops with an annual cereal production of 413,427 tons (sorghum, millet, maize and rice), 76,902 tons of peanuts, 37,275 tons of beans and 36,404 tons of tubers (cassava, yam and potato) and cash crops with 11,711 tons of cotton (CSA, 2009). Sesame and Jatropha are two emerging crops in the region and are expected to increase due to the growing local and international demand. An estimated 2,060 ha of Jatropha is currently being cultivated in the region by farmers supported by Mali Biocarburant, Mali Folkecenter Nyetaa and Jatropha Mali Initiative (ANADEB, 2010b).

3.2.5 Forestry sector

The vast forest cover of the region allows for the use of non-ligneous forest products such as Shea, Nere, and Tamarind which represent a major source of income for women. Wood logging and charcoal production are predominant in the region to satisfy local cooking needs and to supply the district of Bamako. The intensification of agriculture and abusive wood cutting has led to the clearing and depletion of forest resources.

3.2.6 Land ownership concentration

The land ownership rights are the same as the one recognized at the national level that is a mix of custom and modern land tenure laws. Farmers land size for feedstock range from 0.5 ha to 5 ha while large scale commercial farms have yet to spur in the region. All of the crops cultivated in the region are therefore produced by small holder farmers mainly for subsistence.

3.2.7 Food security

Cereals constitute the main staple food while dairy, fish and forestry products play an important role in ensuring a balanced diet while providing income. One of the main indicators used to measure food security in the region is the cereal balance which consists of comparing the needed net production to the available supply (including lost). This indicator has been positive in the region on average, but there are still areas where there is significant deficit of cereals to meet food security. The average cereal consumption norm for adequate food security was estimated by the Inter-State Permanent committee to Fight Droughts in the Sahel (CILLS) at 214 kg/hbt/year (CSA, 2009).

3.2.8 Energy sector

The region is home of the country's second largest hydropower station (Selingue Dam) with an installed capacity of 44 MW providing 200 GWh/year of electricity to the national grid while its retention pond with a volume of 22 billion m^3 allow for the irrigation of agriculture land and fishery. However the bulk of the electricity only serves the major urban towns living the bulk of the region's population with no access to electricity. Wood fuels and kerosene are the most used sources of energy to meet cooking and lighting needs and illustrate the energy poverty of the region. Although the government has helped established rural wood markets to control wood fuels logging there is no clear monitoring mechanism in place to ensure sustainable management.

3.2.9 Policy Framework

The region of Koulikoro is divided in 7 districts sub-divided in 108 municipalities. The decentralization process in which the government has been engaged for the past decade has mandated municipal officials to elaborate every five years their social, cultural and economic development plans (PDSEC) according to their local needs and to be financed by the government through a specialized agency or by international donors. The PDSEC usually focus on aspect such as health care, education and support to agriculture activities with little respect to natural resources management and access to modern form of energy partly due to the low awareness of the local leaders.

3.3 Case Study at the local level: Mali Biocarburant SA

3.3.1 Location of the Case Study

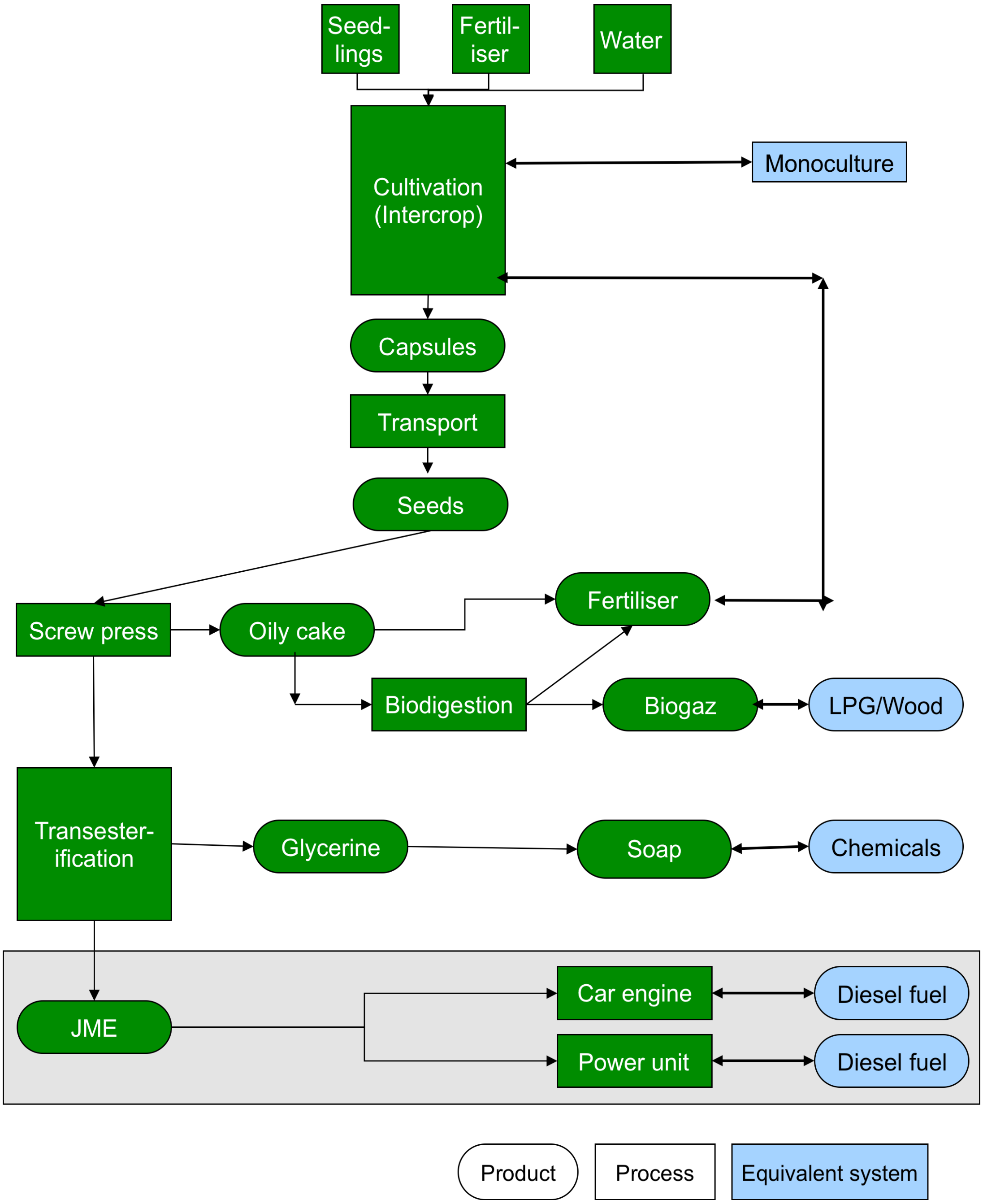
Mali Biocarburant SA is located in the region, district and municipality of Koulikoro about 57 km of East of Bamako. Information gathered from the case study was done through literature review and site visits.

3.3.2 Description of project/company

Mali Biocarburant SA (MBSA) defines itself as being a pro-poor commercial enterprise. The company was founded in 2007 with the aim of producing Jatropha based biodiesel for the local and national market. As Jatropha takes 3 to 4 years to reach ma-

turity the company started making biodiesel with imported palm oil. Now, the company is being supplied seeds from 4,500 local farmers grouped in a union (owning 20% of the share of the company) and who cultivate Jatropha intercropped with food and crops (peanut, cotton, maize, sorghum, etc.). One of the key guiding principles of MBSA's approach is their reluctance to possess and operate large scale mono-crop Jatropha plantations, but rather focus on experimentation and seedling nurseries to provide adequate support (sound nursing and pruning techniques) to local farmers. In that respect the company employs 30 fields agents to promote intercropping and land reclamation activities, monitor closely fields, land use changes through GPS technology and agronomic production (improved and drought resistant seeds). The company is producing 2,000 l of biodiesel per day in a continuous process and have a stocking capacity of 55,000 l. The biodiesel is sold at 0.79 Euro while diesel is currently being sold at 0.93 Euro. Among the customers are car and diesel gensets owner as well as small and medium scale industries. MBSA has been able to tap into the voluntary carbon market by promoting the carbon sequestered from established farmers' plantation and use the carbon revenues to further train and assist farmers. A number of farmers working with MBSA are women who greatly benefits from the additional income which contribute to their empowerment. Overall the households with Jatropha intercropped farms have increased the revenue by either a minimum of 15% in five years or an average of 76 Euro per ha. In term of the valorisation of by-products, the press cake is currently use as a fertilizer for the plantation, but plans are made for developing bio-digesters with a mix of press cake and cow dung to produce biogas to run small scale decentralized engines (multi-functional platforms) in rural areas. Pilot installations have already started on site and should be expanded soon. Glycerine is used for soap production by women further contributing to increase women revenues.
One of the major components to produce Biodiesel (Jatropha Methyl Ester) is methanol which is from fossil sources and thus not produced in Mali. MBSA imports its entire consumed methanol, which is a major cost in the JME production cost. However, ethanol is produced in the country from sugar cane refineries and the supply is expected to increase with on-going public-private partnerships projects in the sugar cane sector. This locally produced ethanol could be further processed in anhydrous ethanol and can be a good substitute to the imported methanol. The company is currently experimenting the dehydration and use of ethanol on site and assessing its economic feasibility.

3.3.3 Flowchart of MBSA supply chain



3.4 Case Study at the local level: Garalo Bagani Yeelen

3.4.1 Location of the Case Study

The municipality of Garalo is located in the region of Sikasso, the southernmost region of the country.

3.4.2 Description of project/company

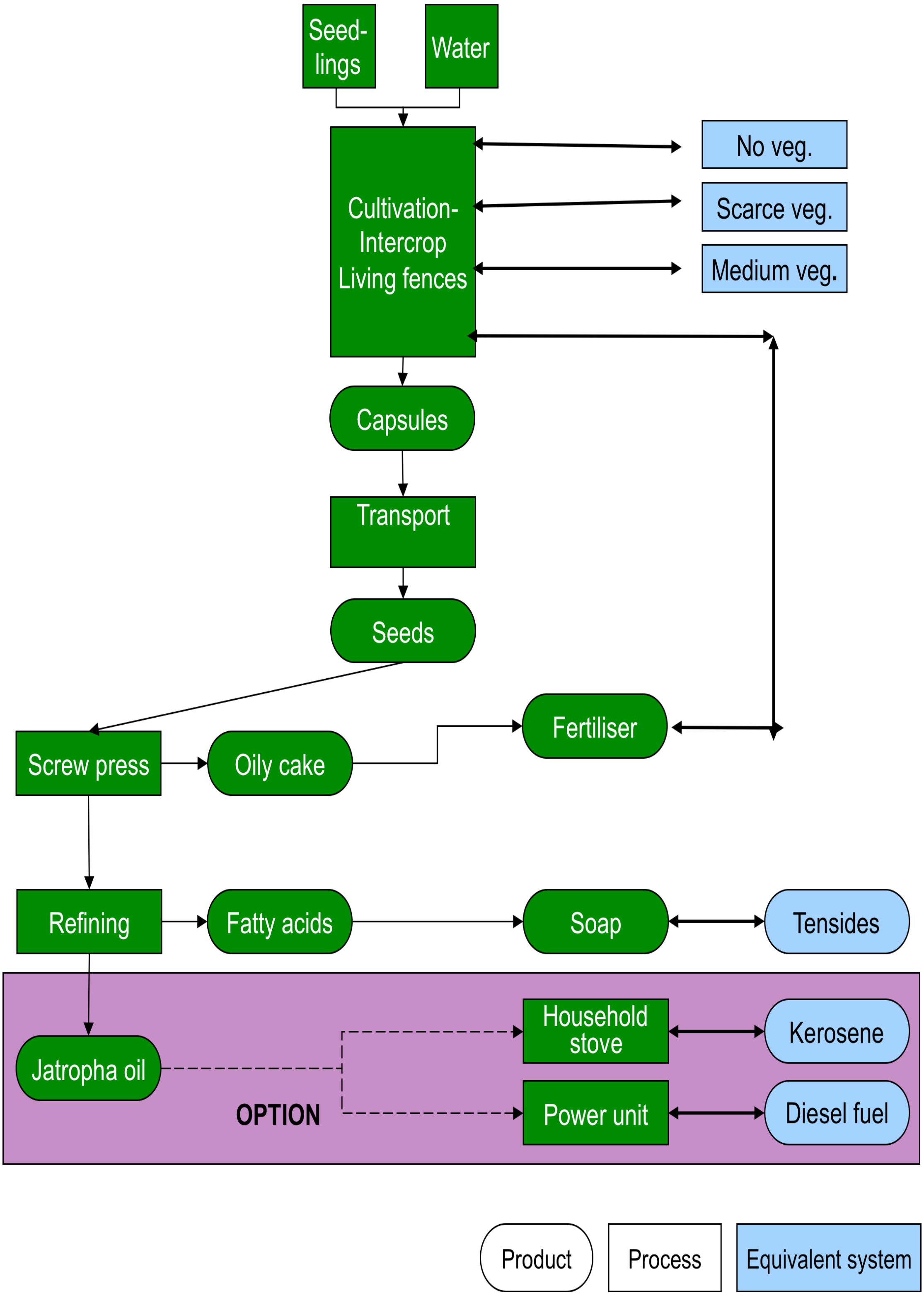
The Garalo Bagani Yeelen (meaning Garalo Jatropha Lighting in Bambara) is a project that resulted from the desire of the municipality of Garalo and its inhabitants to finally have access to electricity. The project was developed by Mali Folkecenter Nyetaa in partnership with AMADER (Malian Agency for Domestic Energy and Rural Electrification), ACCESS (a local rural energy service company), FACT Foundation, Stichting Het Groene Woudt and Stichting DOEN (Dutch technical and financial partners).

The project started in 2006 with the objective of providing electricity to 10,000 inhabitants in the commune through a hybrid power station (using both diesel and SJO). The system includes seed-oil extraction presses and filtration equipment. The installed capacity of the electric power system is 300 KW and is designed to serve around 400 connections of which most are village households and small businesses. Activities that have been carried out in Garalo in the production of Jatropha have consisted of the setting up of a 2 ha nursery that produced 320,000 seedlings in 2007 followed by 100,000 more in 2008 using organic fertilizers and well prepared beds. The seedlings were transferred to farmers' field and were initially planted using a 3 by 3 meters spacing but were later changed to 4 by 4, 4 by 5, and to 5 by 5 metres to allow for adequate intercropping and allow for possible future mechanization of agriculture. All fields planted GPS coordinates were taken in order to have accurate record and to monitor the evolution of the various plantations. In 2008, the total planted area was 440 ha from which 80 ha was unsuccessful (82% success rate) due to bush fires damages, bad maintenance of plants and high density. Also, 95% of the 440 ha (418 ha) were planted by individual farmers (of which 6% were owned by women) while the remaining 22 ha were collective farmers field of which 40% (9 ha) were managed by women's group while the rest (13 ha) were managed by men's group. It is interesting to note that women owned plantations are better managed than men's. About 27% of the groups have put together accounting system to managed funds (largely women's groups) that will be perceived from the future sale of Jatropha to the power plant.

However, Jatropha is currently only marginally profitable for farmers in Garalo although the cost of labour for harvesting and de-husking the seeds was considered being lower than the selling price of 0.08 Euro per kg. Mali-Folkcenter Nyetta and ACCESS are thus considering increasing the selling price to 0.11 Euro per kg to provide higher revenue to farmers. Also the main stakeholders are looking into installing de-husking hardware on the SJO processing site to reduce farmer's labour cost. It is important to note, however, that yields have been lower than expected but cannot be taken to be the total yield of Jatropha crops, because nearly all farmers did not carry out a full harvest in 2010. The highest yield harvested in Garalo was 800 kg/ha and the second highest was just 100 kg/ha. At three years old, the plants should be producing much higher yields according to the scientific literature (typically estimated at 1,500 kg/ha for an intercropped field). Another problem that farmers are facing is the threat of termites, and, in general, they are not using pesticides to prevent

attacks. Therefore termites thus represent a threat to the viability of Jatropha in Garalo.
In light of this situation, it is important that significant improvements are made for the economic viability of the cultivation of Jatropha before up-scaling it nationally. Despite the production problems encountered many farmers are supportive of the project and this provides further opportunities to work with the farmers of Garalo to try and produce a model for Jatropha production that is profitable and successful.
Regarding the power plant, the generator have been set up around the same time as agricultural activities started and have been running on diesel for 9 hours a day (16:00 to 01:00). A full mechanical press with filtration system was installed in 2010 with a maximum pressing capacity of 7 tons per day. The currently used diesel (which represents 70 to 80% of ACCESS operating costs) will be progressively replaced with SJO as adequate amount of feedstock is supplied. The current price of the kWh is set at 0.32 Euro by AMADER. As of September 2011 the number of connected client amounted to 350 increasing from 230 in June 2008. More than 90% of the connected clients are households while the remaining 10% is divided between micro and small scale enterprises, health services, local government building and places of worship. In addition public lighting is provided and every client is charged a small public lighting fee to cover the costs. Although the bill recovery rate is quite high with an average of 90%, it is often the case that they are collected in several instalments (delay of up to 6 months) which can hinder operations. This is partly due to the fact that the major income generating activity of households in the municipality is agriculture, characterized by seasonal income (with low to no disposable income at the end of the dry season). Therefore there is a need to find new and innovative means of supporting households in diversifying their source of income, increase their yields (food or cash crop) or access to credit for bill payments in order to maintain operation.

3.4.3 Flowchart of the Garalo Bagani Yeleen supply chain



4. Socio-economic impacts of the Jatropha chain

4.1 Economics

4.1.1 Macroeconomics in the Jatropha chain in Mali

The bioenergy sector at national level currently does not yet have a significant impact on trade and GDP as it is still a small niche under development. However for the past decade about 4 million Euros have been invested in the country by the different stakeholders creating about 3,000 direct and indirect jobs[2]. The production price of a kilogram of Jatropha was estimated at varying between 0.03 to 0.06 Euro depending of the methods used (intercropping or living fence) and have not varied much (Maiga & Togola, 2008). However this price might go up with the introduction of large scale Jatropha farms as the sector is becoming attractive to local vegetable oil companies and international biodiesel producing firms. The selling price of a liter of SJO is on average 0.46 Euro and has been mainly determined by the demand for soap manufacturing and have allow for Mali Biocarburant to produce and sell biofuels at 0.79 Euro per litre. The country currently imports all petroleum products which are mainly composed of gasoline and mainly diesel and corresponded in 2007 to 697 ktoe costing the country approximately 525 million Euro and have been increasing constantly affecting the trade balance. In addition the presence of Shell, who supply 6 million litres of diesel per month to the country, and have adopted a global strategy to blend diesel with biodiesel (up to 20%) within the next decade present a prospective national market of 1.2 million litres of biodiesel per month in the country (Lengkeek, u.d.) There is a thus a growing need and demand for a cheaper locally made alternative to diesel import. Food prices have been increasing in the past 5 years due to the fact that the bulk of farmers rely on rainfall (which have been low due to climate variation) with seldom use of mineral fertilizers resulting to low yields that caused food price to grow.

4.1.2 Microeconomics of the Jatropha chain in Koulikoro (MBSA) and Sikasso (Garalo)

A 2007 study by Maiga & Togola entitled "Etude de faisabilite socio-economique et financiere de l' exploitation du Pourghere" investigated the financial and socio-economic aspects of Jatropha production by conducting an extensive survey in 20 villages in the region of Koulikoro and Sikasso. The study baseline was on the traditional Jatropha value chain that was used to make soap (mainly by women in the region of Koulikoro). The findings show that yields per ha was not quantifiable as many growers had no systematic ways of planting and rarely kept a log of the yields. However it was estimated that 60 kg of seed were needed to produce 25 l of oil, giving 20 kg of seedcake and 5 kg of residue as by-products. It was also found that women play a major role in the Jatropha market as they were the main seed collector and use the seed to make soap for personal uses and sell the surplus (of seed) at the market for 0.14 Euro/kg. Therefore Jatropha seed production is profitable at a selling price between 0.11 and 0.14 Euro/kg (depending on cultivation technique and labour time). It was also found that a production ranging between 1.5 to 4.5 tons/ha of seed can give revenues between 114 to 344 Euro/ha/year, and which are comparable (and

[2] Direct communication with ANADEB

in some cases higher) to the revenues of staple food crops production like rice that range between 114 to 152 Euro/ha/year.

4.2 Summary of measurable units and indicators

The growth of the Jatropha sector needs to be steered by the gathering and monitoring of baseline data on different steps in the Jatropha to fuel value chain. The following indicators are of importance:

- Different varieties of seeds being cultivated at national, regional and local level and the associated method of production.
- Standardized data on national, regional and local yields (kg or tons/ ha).
- Standardized data of oil content per varieties (litre of oil per kg of seed)
- Inputs and labour costs for feedstock production and transformation (in SJO and Biodiesel) and retail prices.

All these data would be best collected by a national agency like ANADEB in collaboration with research institutes.

4.3 Employment generation

As stated earlier, the Jatropha sector is currently employing about 3,000 people along its value chain. This number is expected to grow as the Jatropha market pick up. One particularity of the generation of employment in the Jatropha value chain is that the bulk is at at the local level where producers and transformers are nearby to decrease transportation costs and losses associated with bad roads infrastructures. Also in the short value chain the SJO used for decentralized rural electrification generate local employment creating rural demand for skills that were traditionally only demanded in urban areas. Currently the feedstock production is done by farmers who in addition to their cash crops or staple crops plant Jatropha either by intercropping it or planting it as living fences. Therefore the employment is usually generated at the harvesting season where additional people usually family members or seasonal workers collect the seeds. With regard to conversion, as MBSA is the only company producing biodiesel in the country, it currently employs about 40 people, including office staff, plant staff, extension service providers and a women cooperation working on soap manufacturing. Decentralized electricity generation employ about 5 people taking care of the transformation of the seeds in SJO and to run the power plant.

4.3.1 Summary of measurable units and indicators

The creation of jobs in the Jatropha value chain is still very little due to the infancy of the sector. However as large companies start to get involved there will be a growing workforce demand along the value chain creating numerous opportunities especially at the local level. Therefore the following set of indicators could be measures to monitor Jatropha value chain related employment:

- Numbers of farmers planting and harvesting Jatropha and number of seasonal workers they employ.
- Numbers of skilled workers involved in extension service provision and feedstock conversion.

- Number of new employment created in the Jatropha value chain.
- Gender disaggregated data on employment in the Jatropha value chain.

4.4 Food issues in the Jatropha value chain in Mali

Presently in Mali the preferred Jatropha production method by the key stakeholders is intercropping Jatropha with cash crops or in living fences. It has only a little impact on food security. Food crops yields in Mali is dependent on factors such as rainfall and the extremely low use of modern agricultural fertilizers with less than 0.1 kg per ha of arable land (Gajigo & Stampini, 2011). In addition, the low mechanization of the agriculture sector is another factor that explains the low yields and requires high investments that small holder farmers cannot afford. Climate variations and low modern inputs therefore have more effect on food production than the current methods used for energy crops production. However, if large scale Jatropha mono-crop plantations on arable land are introduced by large scale producers, this might weaken food security and cause land grab issues as is currently the case in the Office of Niger where large land leases have been awarded to foreign countries (through foreign direct investment) for the production of food crops entirely for export. Also, the previously claimed fact that Jatropha requires minimum inputs and water for optimum seed yields has long been dismissed and could cause potential competition between food and energy crops further exacerbating food security.

4.5 Land use competition and conflicts

There is little updated available data on land use changes in the Jatropha sector, but given the different schemes being implemented, no fertile arable land previously used for cash or food crops have been used solely for the purpose of growing Jatropha. In the region of Sikasso, in addition to intercropping and living fences, Jatropha have been planted on bare lands but seldom trees survived due to the extremely poor soil quality. In Koulikoro the major scheme used was intercropping and living fences which both reduce any competition between food crops and energy crops. However, as there is a growing interest from large scale local and foreign agro-industries to venture in energy crop production in the region of the Office du Niger, where already land conflicts and tension are occurring between small holder farmers and these industries due to the non-transparent and inequitable land deals that are occurring (Oakland Institute, 2011).

4.6 Gender issues in the Jatropha chain in Mali

Amidst the lack of gender disaggregated data in the national Jatropha chain, findings from the local case studies show important involvement of women especially in the production of seeds (nurseries and small plantations) as well as in the transformation of by-products for soap manufacturing. A growing number of women are also being trained for extension services that they provide to both male and female small-holders, although the latter are usually more involved in gardening. Jatropha can strongly empower women by providing them additional income generating pathways that will be entirely managed by them and will get support from the different initiatives in perfecting their skills in order to produce quality feedstock and soap for the local market. This can be best achieved by engendering policies and projects in the Jatropha sector, as well as the entire energy sector, to best maximize positive impacts on both gender and contribute to a sustained local development.

5. Environmental Impacts

The environmental impacts from Jatropha production crops depend mainly on the type of soils and cultivation methods use by farmers. Life cycle assessment (LCA) of Jatropha from cultivation to end-uses in Mali has proven that it reduces more greenhouse gases (GHGs) emissions than fossil fuels and alternatives biofuels (Ndong et al., 2009). Jatropha deep taproot system enables the plant to 'pump' minerals from the depths of the soil to the surface and leaf litter helps to increase the soils organic matter. On marginal lands, Jatropha helps prevent erosion and desertification processes through canopy cover and by its deep root system binding the soil together. Also, it helps in fixing the soil and increases the nitrogen content as it is a nitrogen fixing plant and therefore can contribute in reclaiming lands. As the bulk of Jatropha is currently grown on fertile lands (as living fences or in an intercropping scheme) Jatropha plants indirectly benefits from the maintenance of main crops while contributing to carbon sequestration. Downstream, the displacement of diesel by SJO or biodiesel for rural electrification or to power engines contributes in cleaner energy usage in the country while reducing greenhouse gases emission. It thus presents interesting climate change mitigation option for Mali and could attract carbon credit financing by Clean Development Mechanism (CDM) or Nationally Appropriate Mitigation Actions (NAMAs) thereby contributes in reducing global GHGs emissions and to the sustainable development of the country.

5.1.1 Greenhouse gas emissions in the Jatropha chain in Garalo Bagani Yeleen and Mali Biocarburant SA

The Garalo Bagani Yeleen project is situated in the southern region of Sikasso corresponding to the tropical moist climate zone with average rain fall of 1,100 mm per year. The main soil types in the region are of a mix of high and low activity clay soils with several sandy soils areas. The main cash crop cultivated in the region is cotton and is followed by staple food crops such as corn, millet and sorghum. The total vegetation formation is composed of 12% forest land (10-30% canopy cover), 15% woodland, 15% grassland, 28% bushland and 30% shrubby savannah (MFC, 2011). The region contains 26 classified forests covering an area of 474,596 ha corresponding to 7% of the total land area and below the 15% FAO norm (Ibid).

The MBSA project is situated in the Koulikoro region which was presented in detail in the regional case study section of this document. With regard to the MBSA model the bulk of the plantation have been registered in the voluntary carbon market generating 20 $/ha of planted Jatropha trees.
In depth data were not available to carry out an adequate Life Cycle Assessment of the Jatropha value chain from feedstock production to conversion into SJO and Biodiesel in both cases. An attempt was however made based on the latest data available on the Garalo Project to fill out the tables below in order to have an appreciation of the greenhouse gas emissions from carbon stock changes.

Table 2: Greenhouse gas emissions from biomass cultivation (2010)

Yield per ha per year		
Average Yield	1.50	T per ha per year
Size of the cultivation area		
Size	1600	ha
Fertilizer applied per ha per year		
N-fertiliser	0	kg N per ha per year
P_2O_5-fertiliser	0	kg P_2O_5 per ha per year
K_2O-fertiliser	0	kg K_2O per ha per year
CaO-fertiliser	0	kg CaO per ha per year
Pesticides applied per ha per year		
Pesticides	0	kg active ingredient per ha per year
Diesel use per ha per year		
Diesel	0	L per ha per year

Table 3: Greenhouse gas emissions from biomass transport

Average distance from the energy crop plantation to the conversion facility		
	50	km
Type of vehicle used to transport the biomass		
		Donkey Carts
Fuel used by this vehicle		
	0	none

Table 4: Greenhouse gas emissions from biomass conversion

Tons of feedstock processed per year		
Currently only a few feedstock are being tested.	300	Feedstock is converted using an electrical powered pressed

Table 5: Greenhouse gas emissions from intermediate transport

Average distance from the intermediate conversion facility to the end conversion facility		
	0	km
Type of vehicle used to transport the biomass		
		Donkey Carts
Fuel used by this vehicle		
	0	

Table 6: Greenhouse gas emissions from final product transport

Average distance from the final conversion facility to the end sales point		
	0	km
Type of vehicle used to transport the biomass		
		On site consumption

6. Conclusion

This study shows that Jatropha production in Mali offers a great opportunity to create local supply of energy, create additional income to rural farmers, contribute to local development, increase women participation in the value chain and increase their income, while contributing to a pathway towards a green economy. Although the models currently being developed have not caused any land conflicts or food security issues, the development of sustainability criteria based on these models is necessary to avoid any future negative impacts that are warranted due to the growing interest of large corporation in the sector. In addition, the expected growing prices of fuels will make the Jatropha market more and more attractive and competitive. In the production side, data on yields are sparse and inconsistent partly due to the fact that the plant is not yet fully domesticated stressing the need for stronger agricultural research. Finally, the government through the Biofuel agency must put in place a robust monitoring mechanism and develop sustainability criteria to ensure the sustainable growth of the field from established best practises.

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