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Economic and Distributional Impacts of Biofuels in Mali

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Abstract: A biofuels race has been observed around the world with rising cost of oil and the increasing concerns over climate change. Unfortunately, this growth is associated with rising food prices, which is a major concern in developing countries like Mali. The development of biofuels in Mali should contribute to reducing dependency on imported fossil fuels and avoiding competing for land used for food production. This study carries out an economic and distributional impact analysis with a microsimulation and CGE model of the prospects of large-scale expansion jatropha to produce biofuels in Mali. We also investigate the impacts of promoting biofuels through a tax-subsidy scheme. Our results reveal that macro effects are slightly negative or weakly positive but generate reductions in poverty at the national level and for rural households. The pro-poor analysis does not reveal a clear trend with proportional, progressive and regressive outcomes.

Keyword: Biofuels, agriculture, computable general equilibrium model, micro-simulation, distributional analysis.

JEL: D58, D31, I32, Q17

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1 Introduction

A number of developing countries have set targets for supplying energy from biofuels. For example, India plans to meet 20% of its total transportation fuel demand through biofuels by 2017 while Brazil is planning to expand its biofuel exports. However, the 2007-2008 food crisis has generated some concerns with respect to the expansion of biofuels. Although there is no clear consensus on the cause of the food crisis, analysts suggest that the production of biofuels is one of the key reasons for the increase in global food prices (Mitchell, 2008; Headey and Fan, 2008; Baier *et al* 2009). Moreover, the environmental friendliness of biofuels (has also been questioned as biofuels could cause deforestation thereby resulting in CO_2 emissions biodiversity loss (Doornbosch and Steenblik, 2007; Searchinger et al. 2008; Fargione et al. 2008; OECD, 2008). On the other hand, biofuels are regarded as an important source for clean energy that provide employment opportunities to rural poor, enhance agricultural productivity and increase the prospects of the agricultural sector, which has been suffered with low prices for its products over several decades.

Some Sub-Saharan African countries, such as Mali, have expressed interest in biofuels because these countries do not have significant land supply constraints for producing biofuels and they are dependent on imported fossil fuels for meeting their transportation fuel demand. The energy consumption of Mali, in 2007, was 3.6 million tons oil equivalent (Mtoe) of which biomass (wood, charcoal, agricultural wastes) was the predominant (80%). Also, the country is strongly dependent on petroleum products imported primarily via the ports of Abidjan and Dakar. These petroleum products account for 18% of energy consumption (DNE-Mali 2009). The average rates of annual increase in the hydrocarbon imports during the decade 1994-2003 were approximately +33% for super gasoline, +4% for regular gas and +13% for gas oil. According to estimates, the national demand for hydrocarbons will reach one million tons in 2010, nearly 2 million in 2015 and more than 3 million in 2020. As for electricity, its share is 3% in the national energy balance. In 2004 only 13% of the Malian population had access to electricity, with strong disparities between urban and rural areas. Moreover, this weak access is compounded by a weak share of renewable energies. However, Mali has strong potential in this field with solar energy, wind energy and bioenergy (pourghère,[5] cotton stems, etc). It is only in 2006 that Mali ironed out its national strategy to develop biofuels over the 2008-2023 period. The creation of the National Agency for the Development of Biofuels (ANADEB)[6] in 2009 was an essential tool for this strategy. Another reason behind the government promotion of this agricultural product these last few years is that this feedstock does not directly compete with food

[5] Pourghere is the French word for *Jatropha curcas L.* In English, this plant is called physic nut or purging nut. In Bambara (Mali), the usual term is *bagani*. In this article, we used jatropha, bagani and pourghère, wich are the common names in Mali.

[6] ANADEB was created in March 2009 with the mandate to: i) define technical and quality norms for biofuels, and monitor and evaluate these norms, ii) initiate research and development of biofuels, iii) train and support private operators in the field and iv) improve institutional frameworks for biofuels and ensure national and international partnerships.

supply. Although large-scale jatropha plantations look attractive from a project perspective, their indirect impacts on the economy and the environment are not clear. The economic and environmental issues associated with jatropha, such as food security, energy dependency and the fight against soil erosion, could be significant. In terms of food security, the main concern is to maintain cereal production, which is the main staple for rural Malian households (République du Mali, 2008). There are major concerns that land and labor mobilization in the biofuel sectors would be taken away from the cereal production sectors, with considerable impacts on food. These concerns were raised in a June 2008 consultation, leading to a reflection on the risks and opportunities of the jatropha industry in the country and represented by the MaliFolke Center,[7] Mali Biocarburant SA,[8] Jatropha Mali Initiative (JMI)[9] and the Groupe Energies Renouvelables, Environnement et Solidarités **(**GERES)[10] (Pallière et al., 2009).

Thus, it is crucial gain better understanding of the impacts of the growth of jatropha and biofuels sectors, such as how they affect food prices in the long run. How would such a scaling up of biofuels affect the production of other tradable as well as non-tradable commodities? How would it alter the terms of trade? Would large-scale diversion of land for biofuel production help reduce poverty and inequality in Mali?

The overall objective of this study is to assess the economic and distributional impact of large-scale expansion of jatropha production and biofuels linked to this output in Mali. This analysis will contribute valuable information for the debate on the potential gainers and losers. The economy-wide impacts of the large-scale expansion of biofuels are modeled using a CGE microsimulation model. The distributional impacts are captured using a micro-simulation model. They are measured with a range of indices such as decomposable poverty indices and inequality indices. Pro-poor analyses are also presented to verify whether the simulated scenarios benefit or penalize the poorest Malian households. The Malian model includes 18 production sectors among which six are agricultural sectors, and 4,494 households from the 2006 household survey are included in the micro-simulation model. The approach allows various types of household decomposition. In our analysis, we have considered a rural/urban decomposition.

The rest of this paper is structured as follows. We first introduce the biofuel context and challenges in Mali, followed by a presentation of the model used for the analysis including a brief review of CGE microsimulation models. In the next section, we describe the scenarios

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7 A Malian NGO following the initiative of a communal industry producing jatropha oil for rural electrical distribution (Garalo Commune).

8 A private business producing biodiesel for the Malian transportation sector in partnership with the Union Locale des Sociétés Coopératives des Producteurs de Poughère (Koulikoro Cercle).

9 JMI is a private business producing pure vegetable oil for the Malian industrial market, in partnership with the farmers of the Kita Cercle.

10 A French NGO supporting a village industry producing oil in view of rural electrical distribution (commune of Yorosso).

simulated and move on to the analysis of our macro and distributional impact. We provide concluding remarks in the final section.

2 Biofuels in Mali: an overview

In the last few decades, Mali and development partners have implemented numerous projects and programs that aimed to develop alternative energy sources (alcohol biofuel and pourghère, etc.). Recently, Mali undertook a reform of its energy sector by setting up a national strategy for the development of biofuels. This strategy resulted in the establishment of a program for valuing pourghère cultivated areas (2004-2008),[11] the elaboration of the National energy policy[12] (2005) and the creation of the National agency for the development of biofuels (ANADEB) (2009). The jatropha industry is still in its infancy stages. According to GEXSI (2008), very few projects in 2008 exceeded two years in length and involved significant oil production. Although the market for the formal commercial sales and trade of jatropha and its oil are weak, many countries including Mali are realizing the large potential of this plant to produce green energy and substituting fossil fuels (hydrocarbons).

2.1 Jatropha around the world and in Mali

The cultivation of pourghère was introduced in Mali by the French at the end of the 1930s in the Office du Niger and popularized in 1990s by the German development cooperation (GTZ). The plant came to be used as a barrier protecting agricultural areas from livestock (sheep, goats, etc.), soil erosion due to water run-off and wind, particularly in rural areas. It was also used by women as traditional medicine against malaria or general pain. On a global scale in 2008, approximately 900,000 ha were planted, of which 85% were in Asia (Indonesia, Myanmar, India, China). The shrub was thought to cover 120,000 ha in Africa, primarily in Madagascar, Zambia, Tanzania and Mozambique. World production is expected to reach 13 million hectares by 2015. For Africa, Ghana and Madagascar alone will account for 1.1 million of the two million hectares expected for the continent (GEXSI, 2008).[13] It is also interesting to note that farm sizes are on the rise. In 2008, only 11% of jatropha production in Africa was accounted for by large plantations. GEXSI (2008) predicts that in 2013, 38% of production on the continent will be done in large farms, including 23% in plantations of more than 1000 hectares. In 2002, Mali had at its disposal roughly 10,000 kilometers of jatropha shrubs, with a growth rate estimated at approximately 2,000

[11] The Programme National de Valorisation Énergétique de la Plante Pourghère (PNVEP) comes within the scope of Malian policies and strategies presented in the Programme National d'Action Environnementale (PNAE), the Cadre Stratégique de Lutte contre la Pauvreté (CSLP) and the promotion of the Stratégie Nationale des Énergies Renouvelables. It is implemented by the Centre national de l'énergie solaire et des énergies renouvelables (CNESOLER) under the supervision of the Direction Nationale de l'Énergie of the ministère de l'Énergie, des Mines, et de l'Eau.

[12] The National energy policy aims to increase local production of energy by developing biofuels to satisfy the socioeconomic needs of the country at a lower cost.

[13] These figures were estimated by the Global Exchange for Social Investment (GEXSI) sponsored by the World Wildlife Fund (WWF) to carry out a global market study on jatropha. The goal was to present the situation of jatropha cultivation in 2008 and to foresee the development of projects from now to 2015 for Latin America, Africa and Asia. (Cf. http://www.jatropha-platform.org/index.htm).

kilometers per year (Latapie, 2007). In 2008, field experts estimated that 1,800 hectares of pourghère shrubs were planted, with an objective for producers to reach 23,000 hectares by 2015 (GEXSI, 2008). However, as stated in the OECD and FAO joint paper (OCDE-FAO, 2009), African projects tied to the expansion of the industry are still modest in Africa. In 2009, Pallière et al. estimated that the total cultivated surface reached 3,730 ha In Mali, the quest for transforming grain into biofuel is not a new issue, since it started in the early part of the 20th century in the region of Segou (Haïdara, 1996). The properties of this biofuel are very close to those of some diesel fuels. Furthermore, the renewed interest in this plant is not surprising since it can contribute to producing 1,900 liters of oil per hectare versus 572 liters/ha with colza, 662 liters/ha with sunflower or 446 liters/ha with soya (Legendre, 2008).

The production of phougère is likely to expend in the regions where is it concentrated (Kita, Koulikoro, Yorosso and Garodo). In 2006, the Mali FolkeCenter developed a project targeting the production of jatropha oil destined for rural electrical production with power generators in the agricultural and cotton region of Garolo. Besides cotton, this region is also known for the production of peanuts and important food crops (corn, sorghhum, rice, etc.). In its project launched in 2007, Mali biocarburant SA used jatropha to produce biodiesel intended for the domestic market in the Koulikoro region. This region, which stretches over 7,000 km^2, combines the production of commercial crops (cotton, peanut and tobacco), food crops (corn, millet and rice) and truck farming given its proximity to the Niger River. In the same year, the Jatropha Mali Initiative (JMI) project was also launched in Kita in the region of Kayes. The project initially targeted the production of biodiesel. Since 2009, jatropha vegetable oil destined for the Malian industrial market has become the first output resulting from this seed transformation. Finally, in 2008, the Groupe Énergies Renouvelables, Environnement et Solidarités (GERES) implemented a jatropha production project in the Koutiala region for rural electrical distribution purposes. In light of this information, jatropha production appears to be an interesting avenue for different types of end users. However, he literature reveals little consensus in terms of its concrete economic benefits. The challenges facing policy makers are to evaluate the tradeoffs between benefits and cost of promoting the expansion of the sector.

2.2 Jatropha development: the controversy

Among the objectives most often associated with projects for developing jatropha are the advancement of women (production of soap and sale of oil), the reduction of village poverty (crop protection, sale of seeds, oil, soap), soil erosion control (planting of live shrubs) and the production of renewable energy are most often cited (Henning, 2009). Finally, impact analysis of introducing and developing this crop in rural settings on the welfare of households and communities is also beginning to generate growing interest in the current context of Millenium Development Goals (Pallière et al., 2009). Some researchers such as Matthews (2007) see the production of biodiesel from jatropha as a means to industrialize poor countries and help them overcome poverty. Planted on a large scale, jatropha may even enable these countries to achieve energy autonomy, as well as increase their production and exportation. Renner (2007) summarizes the perception of many "Jatropha seems to offer the benefits of biofuels without the pitfalls."

However, others raise some doubts on the benefits of producing biofuels from agricultural products. They raise concerns over biodiversity loss (Raizon, 2009) or endangering the food sovereignty of countries that are already struggling (Luoma, 2009; Raizon, 2009; Campa and Valentin, 2009). Other concerns include the possible influence of pourghère plantations on soil fertility or the risks of diseases or parasites transmission that could annihilate not only jatropha but also other cultures (Campa et al., 2009).[14] This literature shows that two opposing views are at odds when it comes to jatropha production and promotion. Nevertheless, as Benge (2006) states, "there is no indication that any scientific studies have been conducted to prove or disprove any of the above concerns." Based on the fact that the African continent still disposes significant surface of unexploited agricultural land (approximately 58% according to GEXSI, 2008), it appears relevant in our view to contribute to this debate with a focus in economic and distributional impact which is what we propose in this case of Mali.

3 The Malian model

3.1 The model

Since the late 1990s researchers have been using CGE to analyze the impact of policy reforms on poverty and income distribution. Three main categories of these models have been used during this period: the representative household approach (RH), the integrated multi-household approach (IMH) and the multi-household sequential approach (MHS).

The CGE-RH approach divides households into groups, choosing a representative household for each group and using that representative household in the CGE model. The variations in income of the representative agents generated with the CGE model are applied to households within their respective group from a household survey. This assumption does not allow the analyst to take into account within-group changes in income distribution, even though studies (Huppi and Ravallion 1991 and Savard 2005, for example) have shown that such changes can be greater than between-group inequality changes. This is true both for the static measure and for variations following policy simulations. Savard (2005) demonstrated that the results of poverty and income distribution analysis can be completely reversed by taking into account within-group distributional effects.

[14] The authors would like to recall the African coffee plant (arabica) introduced to the entire intertropical area by colonists and whose plantations were decimated in the early 20th century by orange rust.

To solve this problem, a second approach was proposed by Decaluwé, Dumont and Savard (1999) and applied by Cogneau and Robilliard (2000), Gørtz et al. (2000) and Cockburn (2001), namely the CGE integrated multi-household approach (CGE-IMH). This method incorporates a large number of households from a household survey (and sometimes all of them) into the CGE model. The approach takes into account within-group distributional effects and has the further advantage of providing coherence between the micro and macro parts of the model, but at a cost. First, data reconciliation can be very problematic (Rutherford, Tarr and Shepotylo, 2005); second, numerical resolution can be challenging (Chen and Ravallion, 2004).

The third approach is referred to as the CGE micro-simulation sequential method (MSS) and could be subdivided into two variants. The first, micro-accounting, was formally presented by Chen and Ravallion (2004) and has been extensively applied in recent years.[15] The second variant, proposed by Bourguignon, Robilliard and Robinson (2005), consists of integrating, at an individual level, rich micro behavior observed at a household level such as consumption or labor supply. This version introduces more heterogeneity between households with the application of a microeconometric model. The general idea of the MSS approach is that a CGE module feeds market and factor price changes into a micro-simulation household model. The main criticism leveled at this approach is that the micro-feedback effect is not fully taken into account; the question has been raised in two literature reviews of macro-micro modeling for poverty analysis (Hertel and Reimer (2005) as well as Bourguignon and Spadaro (2006)). However, Bourguignon and Savard (2008) found that the loss of information associated with using the MSS approach can be relatively small and policy conclusions were robust between the two approaches.[16] In this paper we apply the micro-accounting version of the MSS approach.[17]

The last two approaches (IMH, MSS) allow for rich analysis of income distribution and poverty because they include a large number of households in the modeling exercise. This in turn allows the modeler to apply poverty and income distribution measures and indexes following policy simulations. As already mentioned, the IMH approach is the soundest on a theoretical basis. However, with this approach, it is necessary to construct a balanced sub-matrix for household accounts in a standard social accounting matrix. On the other hand, with the CGE-MSS approach, the household income and expenditure do not require balancing. This gain in flexibility comes from the fact that the micro module is solved sequentially and that we use price percentage changes to link the CGE module to the micro household module. This constraint is one of the two reasons behind our choice to select the

[15] Among early applications of this approach are Vos and De Jong (2003) and King and Henda (2003).

[16] Bourguignon and Savard's (2008) comparative analysis of the IMH and MSS approaches was applied to the Filipino economy. In this study, the labor supply was endogenous and the largest portion of the gap in the results obtained from the two approaches came from the labor supply. In our application, the labor supply will be held constant.

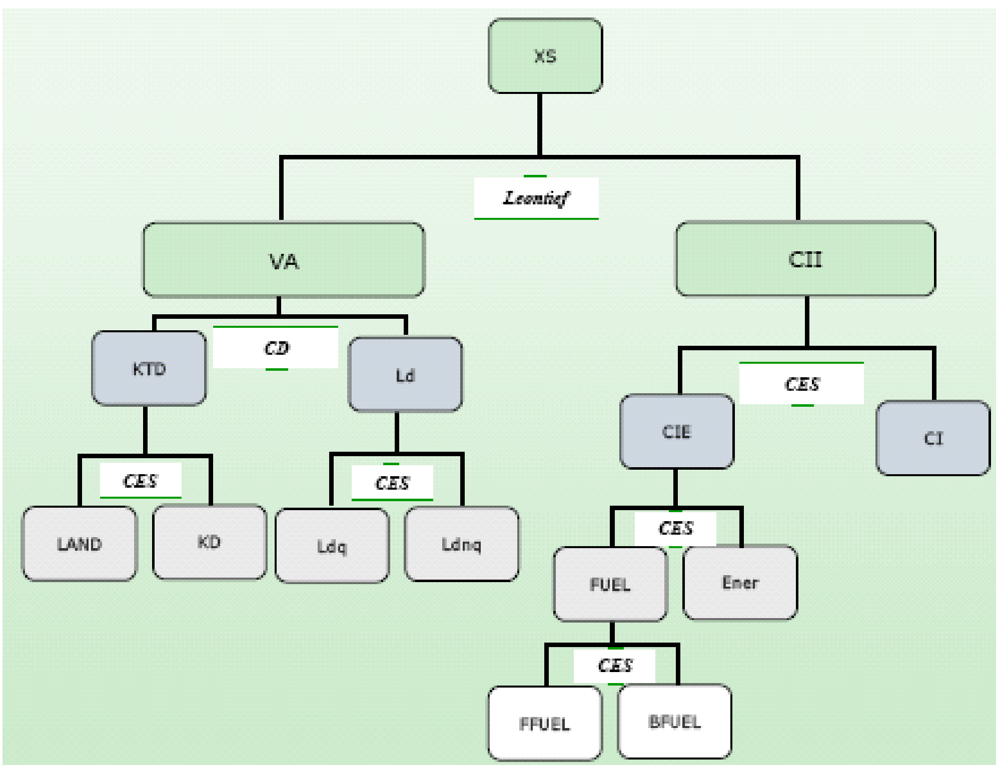
[17] The main reason for selecting this approach is the lack of adequate data to apply the microeconometric approach.

CGE-MSS approach for our analysis. The second argument for this approach is that some households will increase their labor supply and land use. This will involve in some cases discrete changes or important increases in factor effective endowments. This type of behavior cannot be models in the IMH approach that only allows for marginal changes in factor endowments. We will refer to the household sub matrix database as the household module. To capture the impact of jatropha and biofuel policies on the welfare of individual households and distributional effects, we had to adapt a standard model to specificities of these two sectors in the Malian economy. The presentation of the model is decomposed into the CGE module and household micro household module.

3.1.1 CGE module

The CGE component of our model (hereafter referred to as the CGE module) is based on the EXTER model of Decaluwé et al. (2001), with significant adjustments, which we describe herein. The production structure is substantially modified.[18] We adopted a multilayered production structure as illustrated in Figure 2.

Figure 1: The CGE model and its structure



Starting at the top level, we have total production of the sector (*XS*), which is made up of fixed value-added shares (*VA*) and intermediate consumption (*CII*), as generally assumed in standard CGE modeling. The relationship determining the level of *VA* is a Cobb-Douglas production function between composite labor (*LD*) and total capital (*KDT*). Producers

[18] We provide the complete set of equations in the appendix.

minimize their cost of generating *VA* subject to the Cobb-Douglas function. First order conditions from this process are used to determine the optimal labor demand equations. Labor (*LD*) is then decomposed into skilled (*LDQ*) and unskilled (*LDNQ*) labor, with the combination of these two factors being determined by a constant elasticity of substitution (CES) function, once again through a process of cost minimization. This assumption implies that changes in the relative wages of the two types of labor will lead the producer to modify the ratio between the two types of workers, subject to constraints on substitution linked to his production capacities. The total capital (*KDT*) is decomposed into land (*LAND*) and capital (*KD*). The same CES function is used to link these two factors.

The capital is mobile between agricultural sectors and the land is fixed[19] Moving on to intermediate consumptions, we significantly enrich the EXTER model by decomposing these inputs into various sub-inputs. We first have the total intermediate consumption (*CII*) that is decomposed into energy (*CIE)* and other intermediate consumptions (*CI)*. These two sub-inputs are linked with a CES function. The *CIE* is further decomposed into fuels (*FUEL*) and other energies (*ENER*)[20]. These two inputs are linked with a CES function, therefore allowing for substitution in these inputs. The fuels are further decomposed into fossil fuels (*FFUEL*) and biofuels (BFUEL) with the same functional form (CES)[21]. Other intermediate consumption (*CI*) was modeled as fixed shares from the input/output ratios computed from the data in the SAM. The rich structure will allow biofuels to increase their market share to replace two types of energies as an intermediate input in the production processes of other sectors of the economy[22]. Given the CES function, the market share will be gained through a reduction in price of biofuels compared to the fossil fuels. Sector-specific elasticities of substitution are used to reflect differences among sectors in determining the mix of factors in each CES function.

In the CGE model, four agents are included (government, aggregate household, firms and the rest of the world). The government draws its revenues from goods and services tax, import duties, households' and private firms' income taxes as well as from transfers from the rest of the world (budgetary assistance). Its expenditure is made up of the consumption of public services and of transfers to other agents. The aggregate private firm draws its income from capital remuneration. It spends its income by paying taxes; making transfers to other agents and saves for investment. The rest of the world is considered as an agent in a

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[19] This assumption was necessary to perform exogenous changes is use of land for jatropha production.

[20] Energy sector is essentially electricity. It does not correspond to energies presented in our introduction. Other sources of energies such wood and charcoal is essentially used by households and it is included in the forestry sector.

[21] We focus our analysis on biodiesel. This does exclude ethanol from biofuels but they will implicitly be held constant and all variations will come from the expansion of the biodiesel produced from jatropha. It is important to recall that biodiesel can by use by many sector in generators for electricity. More than a thousand multiuse platforms are used in Mali and can run on biodiesel. These platforms are used to pump water in well, grind cereals and generate electricity among other uses.

[22] We postulated high elasticities between biofuel and fossil fuels since biofuels or biodiesel can be used in most motors up to 10% and even more for some types of motors. Hence, given the small initial share in total fuel, the market share can increase with little constraint up to 10% which we won't be able to reach with our simulations.

standard fashion as it is used to model economic relations between Mali and the rest of the world including imports, exports and transfers to and from agents in Mali. Finally, we include a single representative household in the CGE module.

Our hypotheses reflect the fact that Mali is a small open economy for which world prices of imports and exports are exogenous. We posit the Armington hypothesis (1969) for import demand, whereby domestic consumers can substitute domestically produced goods with imports (imperfectly) according to an elasticity of substitution that is sector specific. Where local consumers have no preference between imported and local goods, we use a high elasticity of substitution; conversely, the elasticity of substitution is low where consumers prefer one good over another.[23] The relative price of the two goods is the other determinant of the ratio of demand for imported goods versus demand for local goods. On the export side, producers can sell the goods on the local market or export their production and are influenced by relative prices on each market and by their respective elasticity of transformation of the good for one or the other market. We used the GDP deflator as a numeraire.

Our model's equilibrium conditions are also standard. The commodity market is balanced by an adjustment of the market price of each commodity. The labor market is perfectly segmented and balances out with an adjustment of the nominal wage on each of the respective markets (skilled and unskilled). It is therefore possible for workers to move from one sector to another, but not from one market to another. We use two closures for the labor markets in simulation. In the first option, labor supply is fixed and in the second it is endogenous. We use a standard wage curve as in Carneira and Arbache (2003) and Annabi et al (2005) where labor supply increases (decreases) with an increase (decrease) in real wage on each market[24]. The increase in labour can come either from the extensive margin (number of hours worked) or the intensive margin (more workers enter the market). The current account balance is exogenous, and it balances out with an adjustment of the nominal exchange rate. Finally, investment is savings driven in the model.

3.1.1.1 The data

The social accounting matrix (SAM) necessary for the implementation of a CGE mode was constructed with the main data drawn from an input–output table with 18 productive sectors.[25] The reference year for the SAM is 2006. As noted earlier, our model for Mali covers 20 production sectors, including jatropha, biofuels, fossil fuels and other energies (mainly electricity). Jatropha and biofuels were not found in the initial SAM (Coulibaly 2009). We used information from the sectoral analysis presented in Coulibaly et al (2010) to

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[23] Elasticities of substitution were selected after a consultation process with civil servants from the ministry of finances, statistics office and trade ministry.

[24] This type of endogenous labour supply is common in CGE modeling and draws on Blanchflower and Oswald (1998).

[25] The original input-output matrix was obtained from the "Direction nationale de la statistique et de l'informatique."

disaggregate the sectors from crop agriculture and fuel sectors. The size of these sectors is relatively small in Mali but they present substantial potential for growth. The micro-household data base for 4494 households was constructed from the 2006 *Enquête légère intégrée auprès des ménages* (ELIM-2006) survey. The main task for constructing this database is to modify the income and expenditure structures for the households based on the nomenclature of the SAM.

3.1.2 Micro Household module

In the micro household module, we include all of the 4,494 households from the survey (ELIM-2006). We have specified income and expenditure functions for the households, which are parameterized on the household-specific information found in the survey. As mentioned, the module is solved sequentially (CGE module and household module). Let us now describe this sequence. We first specify an income equation that reflects income structure for each household in the ELIM-2006 survey. We assume that the endowments of factors are exogenous and are modified exogenously when necessary. We use the factor payment variations generated by the CGE module and apply them to the factor endowments. The two wage rates are also applied to labor endowments of households.[26] As in the CGE module, we assume that the transfers from other agents to the households are exogenous. When changes in factors such as land increases in the jatropha production are necessary, we computed the number of households concerned based on shares of land involved in the simulations. From there, we isolated farm households in our sample and performs random draws of households to select the ones benefiting from the growth in land. We applied the growth to these households[27].

This procedure provides us with the new household-specific income. We can then move on to the expenditure side. The important component for welfare analysis is the change in household consumption. The demand functions are derived from a utility maximization process (Cobb-Douglas utility function), and this demand equation is a function of market prices and household income. The final step in the sequential resolution of the household module consists in computing the change in welfare. Implicitly, this allows us to take into account simultaneously the income and price effects on each household's welfare.[28] As in Bourguignon and Savard (2008), we use the variation of the real income to measure the change in welfare. The household-specific value shares for consumption are computed from

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[26] The survey included information that allowed us to decompose the labor into qualified and non qualified labor.

[27] We repeated this procedure a number of times and our distributional analysis was robust to this random draw procedure. This can be explained by the fact that poverty rates in rural areas are very large and the random draw produced sample of households with similar compositions.

[28] This approach is different from the endogenous poverty line proposed by Decaluwé et al. (2005) as it captures the price effect of the simulation through specific household preference and not through a basic needs approach. For a discussion of the advantages and disadvantages of the two approaches, see Ravallion (1994).

observed figures in ELIM-2006. These shares are then used to specify a household-specific price index that is in turn used with the nominal income change to compute welfare changes.

3.1.3 Poverty and distributional analysis

After selecting our criteria for household decomposition (rural/urban devide) we can applied any type of distributional analysis. The indices can be applied using the reference period directly from ELIM-2006 data and then for the various simulations. The indices selected for our distributive analysis are the Foster, Greer and Thorbecke[29] (F-G-T, 1984) P_α indices for poverty analysis and the Gini index for inequality changes. In addition to these indices, we applied pro-poor growth analysis with the growth incidence curves (GIC) proposed by Ravallion and Chen (2003).

4 Simulations

The main objective of this paper is to investigate the distributional impact of an expansion of the jatropha and biofuel from jatropha in Mali. Hence, we perform two sets of simulation with three scenarios in the first set and four in the second set to achieve this objective. In our first set of simulations we focus on our main objective and hence we look at three scenarios of increasing production of jatropha. These simulations are performed by increasing the land in the jatropha sector and capital in the biofuel sector. We performed a fifteen fold increase in land for jatropha production going from 3,000 to 45,000 hectares[30]. The capital in the biofuel sector is increased exogenously by XX percent. It is important to keep in mind that this set of simulation mimics an extension of the expansion of the two sectors based on what was observed over the last two years and in light of the objectives established by the ANADEB at 23,000 hectares for 2015[31]. In this first set of simulations, no direct policy intervention is required since this expansion is taking place given the profitability of the sector[32]. Within this first set of simulations we perform the increase with three set of assumptions. In the first case, we assume that the additional land used for cultivating jatropha comes from unused idle land (Sim1a) and in the second case; the expansion of the sector is done on arable land used to produce other agricultural products (Sim1b). These two extreme case scenarios provide us with upper and lower bounds for our comparative analysis. Additional capital used in the jatropha sector and biofuel sector is

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[29]FGT poverty indices are additively decomposable; as such, they are interesting within the framework of this analysis and make it possible to measure the proportion of the poor among the population but also of this poverty depth and severity. The higher the degree of poverty aversion, the greater the importance granted to the poorest. For detailed information on this index family, read Ravallion (1994).

[30] This surface represents less than 1% of arable land in Mali and corresponds to 60% of the governments' objective for 2013 (Coulibaly et al (2010)). We were limited to a 15% increase to run all our simulations. Given the small initial size of the sector, we had numerical resolution problems with larger scale increases.

[31] We fixed the objective to double this 23,000hectares surface in order to generate observable changes in our CGE model. One can interpret this as an optimist scenario or a longer term scenario.

[32] See Coulibaly et al 2010 for more detail on this. One can also consider that the different interventions made by the ANADEB such as enumerated section 2 and in Coulibaly et al (2010). One example for these interventions is the education of farmers regarding the benefits of jatropha.

taken for other sectors of the economy[33]. For the last simulation of the first set we repeat Sim1b and introduce endogenous labor supply. For this assumption we use a standard wage curve as in Annabi et al (2005). In this scenario, the additional workers needed to produce jatropha can come from new labor (extra workers and/or more hours worked by active workers). However, if the scenario produces a downward pressure on the real wage, we will observe an increase in unemployment.

In the next set of simulations, we consider a policy intervention to promote the biofuel sector. This policy consists in subsidizing biofuel market prices by 20%. This is performed to applying a negative tax rate of 20% on the biofuel sector. This policy should provide an additional comparative advantage to this sector compared to fossil fuels. We fund this subsidy with a 1% tax on fossil fuels[34]. We compare 4 case scenarios. The first one (sim2a) is a 20% subsidy and the tax without an increase in land and capital in the jatropha and biofuel sectors. This allows us to isolate the impact of the tax and subsidy from other effects of the next simulations. For the next simulation (sim2b), we combine the tax and subsidy with a tenfold increase in land for jatropha production where the land comes from idle land. The third simulation (sim2c) in the same as sim2b but the land is taken from other agricultural sectors and the last one (sim2d) in this group is sim2c with endogenous labor supply[35].

The main challenge with performing sim1c and 2d with the endogenous labor supply is to attribute the increase in labor supply to specific households. For this procedure we randomly draw households from a group of selected households on the basis of characteristics found in the household survey. Table 1 summarizes these simulations.

Table 1: Simulation descriptions

Code	Simulations presentation
1a	15 x increase of land for jatropha using idle land in Mali
1b	15 x increase of land for jatropha using agriculture land
1c	15 x increase of land for jatropha using agriculture land with endegenous labour supply
2a	1% tax on fossil fuels & 20% subsidy to biofuel no exogenous increase in jatropha land
2b	1% tax on fossil fuels & 20% subsidy to biofuel & 10% x jatropha land with idle land
2c	1% tax on fossil fuels & 20% subsidy to biofuel & 10% x jatropha land with exploited land
2d	1% tax on fossil fuels & 20% subsidy to biofuel & 10% x jatropha land with endegenous labour supply

5 Results

We proceed with a brief description of our macro and a few sectoral results. As we focus our analysis on a distributional impact of these scenarios, we select some key variables that play an important role in this distributional impact analysis.

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33 For this assumption, the volume of capital is so small that is has little effect on other sectors since it constitutes less than 0.05% of capital of the rest of the economy.

34 A small tax was required to fund the subsidy given the small relative size of biofuels compared to fossil fuels. Hence, applying a small tax on fossil fuels will produce little general equilibrium effects.

35 For this set of simulations we used and 10 fold increase since the combination of the subsidy and 15 fold increase in land would not run as we encountered numerical resolution problems.

5.1 Macroeconomic and sectoral impacts

From our results presented in Table 2 below, the first general statement we can formulate is that the impact on macro variables is relatively small. This is not surprising as the two main sectors of interest are relatively small at the reference period. In the first set of simulations, the first simulation is the one with the weakest impact at the macro level. Hence, using idle land produces a slight positive impact on most macro variables. Firms seem to be the losers since income increases for households and government while it decreases for firms. The first simulation produces a small appreciation of the real exchange rate which is expected given the substitution of fossil fuels by biofuels produced locally. When the jatropha sector competes with other agricultural sectors for land, we observe a reduction in most macro variables with the exception of the qualified wage. The endogenous labor supply assumption (sim1c) does not have a strong impact when comparing results with the sim1b given the small pressure on wages. We also reiterate that the capital required by the jatropha sector will be drawn from all other sectors. Hence, the competition comes from the land and capital side for other agricultural sectors. The sector also competes for workers in simulation 1a and 1b. In simulation 1b and 1c, the impact on the real exchange rate is almost twice as strong compared to the first simulation. For simulation 1b and 1c, the reduction in land available for other agricultural sectors that in turn reduce output for theses products. The reduction in supply produces (see table 4) and increase in market price and hence produce a better returns to capital for agricultural sectors compared to simulation 1a.

Table 2: Macro level results of the CGE model

Variables	Definition	Sim 1a	Sim 1b	Sim 1c	Sim 2a	Sim 2b	Sim 2c	Sim 2d
Yh	Household income	0,03	-0,15	-0,16	0,07	0,07	-0,11	-0,10
w^1	qualifed wage	0,16	0,05	0,04	0,06	0,33	0,22	0,17
w^2	non qualifed wage	0,12	-0,07	-0,05	0,09	0,26	0,06	0,04
rr	rental rate of agricultural capital	-0,56	-0,39	-0,39	-0,53	-0,64	-0,46	-0,45
Yg	Government income	0,01	-0,14	-0,14	0,00	-0,46	-0,60	-0,60
Sg	Government savings	0,03	-0,51	-0,52	-0,01	-1,71	-2,24	-2,21
Ye	Firms' income	-0,04	-0,21	-0,21	0,07	-0,01	-0,18	-0,18
Se	Firms' savings	-0,08	-0,44	-0,44	0,14	-0,03	-0,38	-0,37
It	total investment	-0,03	-0,50	-0,51	0,01	-1,40	-1,87	-1,84
u	unemployment	na	na	0,11	na	na	na	-0,23
e	real exchange rate	-0,15	-0,24	-0,25	0,04	-0,08	-0,17	-0,17

The fourth simulation (2a) is interesting as it provides positive results for most variables with the exception of the rental rate of capital in agricultural sector. It is the only simulation where we observe a depreciation of the real exchange rate. As was expected the simulation is neutral for government since the fossil fuel tax funds the subsidy to biofuels. The impact on wages is slightly positive. Simulation 2b is interesting since it produces strongest positive effects on wages and relatively strong negative impact on rental rate of agricultural capital. When comparing the government situation we notice a relatively strong deterioration of the situation. This is a result of the strong expansion of the biofuel sector which pushes the subsidy bill higher. This produces a reduction in public savings and hence in total investment in the economy.

The relatively large gap between wage and rental rate of capital should produce stronger distributional impact compared to other simulations. When comparing simulation 2b and 2c, we notice that the competition for land produces stronger negative impact on most variables and a reduction of positive effects on others. This specific effect should benefit the poorer households versus the richer ones as the latter are more prevalent in the qualified market.

It is interesting to see that the addition of the endogenous labour supply in the model produces only small effects on most macro variables and the change in unemployment is only 0.11% increase in simulation 1c and a decrease of 0.23% for simulation 2d. This illustrates that increasing production of jatropha with competition for land is not favorable to job creation where as the introduction of the subsidy as a policy reverses the negative impact on unemployed.

Moving on to the sectoral results, once again we have limited impact with the exception of the jatropha and biofuel sectors. This is the direct result of the fifteen fold and tenfold increase in land used in the latter sector that produces more input for the biofuel sector at lower cost. Looking at the output/value added changes (in Table 3) we note that for the first simulations, the sectors decreasing output the most are the fossil fuels, and to a lesser extent the construction, and service sectors.

Table 3: Value added results of the CGE model

Variables	branches	Sim 1a	Sim 1b	Sim 1c	Sim 2a	Sim 2b	Sim 2c	Sim 2d
Va (value added)	crop agriculture	0,21	-0,50	-0,51	0,22	0,17	-0,54	-0,53
	rice	0,13	-0,28	-0,29	0,18	0,23	-0,18	-0,17
	export agriculture	0,14	-0,46	-0,47	0,04	0,09	-0,52	-0,51
	jatropha	1069,18	1068,76	1068,62	20,48	729,40	729,09	729,30
	coton	-0,13	-0,93	-0,93	0,13	-0,33	-1,13	-1,12
	Livestock	0,03	-0,25	-0,26	0,14	-0,05	-0,33	-0,30
	forestry	0,25	-0,44	-0,44	0,28	0,31	-0,38	-0,38
	mining	-0,09	-0,08	-0,08	-0,01	-0,09	-0,08	-0,07
	agoindustry	-0,08	-0,08	-0,09	0,01	0,01	0,01	0,02
	textile	-0,05	-0,06	-0,07	-0,01	-0,13	-0,13	-0,11
	other industries	-0,19	-0,18	-0,18	-0,01	-0,09	-0,07	-0,06
	other energy	-0,05	-0,06	-0,06	0,00	-0,09	-0,09	-0,09
	biofuel	1089,94	1089,51	1089,37	21,39	743,56	743,25	743,47
	construction	-0,80	-0,87	-0,88	-0,03	-0,84	-0,91	-0,90
	commerce	0,02	0,00	0,00	0,00	-0,03	-0,05	-0,04
	transport	-0,02	-0,01	-0,01	0,00	-0,03	-0,02	-0,02
	services	-0,64	-0,62	-0,62	-0,01	-0,39	-0,38	-0,37
	banking & finance	-0,43	-0,50	-0,50	-0,01	-0,42	-0,48	-0,47
	public services	-0,20	-0,10	-0,10	-0,05	-0,29	-0,18	-0,16
	fossil fuels	-1,36	-1,38	-1,39	-0,03	-0,89	-0,91	-0,90

The cotton sector exhibit a slight decrease in production and other agricultural sectors very slightly increase their production. In the second and third simulations (1b and 1c), drawing land from other sectors has a negative impact on these agricultural sectors and effects on other sectors are quite similar to simulation 1a. However, the transport and commercial sectors are not negatively affected by this scenario. In these two simulations, the two sectors most negatively affected are the fossil fuels, cotton and construction sector. For the second set of simulations, we note that the subsidy is fairly efficient in generating an increase in output for the jatropha sector and biofuel sectors, which were both increased by more than 20% in simulation 2a.

The price effects follow a similar trend with weak effects in general for all sectors but jatropha and biofuels. As we can see from Table 4, the strongest impact is on jatropha with decreases in price between 23 to 29% for all simulations with increase in land use for the sector. For simulation 2a, the subsidy to biofuels strongly increases the demand for jatropha and the producers are constrained here in their land and capital. The price of biofuels decreases in all simulations given the surge in output. However, these price increases are small considering the very high increase in supply on the market.

Table 4: Market price results of the CGE model

Variables	branches	Sim 1a	Sim 1b	Sim 1c	Sim 2a	Sim 2b	Sim 2c	Sim 2d
Pq (market price)	crop agriculture	-0,19	0,31	0,30	-0,15	-0,27	0,22	0,23
	rice	-0,10	0,13	0,13	-0,10	-0,07	0,16	0,16
	export agriculture	0,12	0,47	0,47	0,03	0,12	0,47	0,47
	jatropha	-29,58	-29,71	-29,72	33,08	-23,33	-23,48	-23,47
	coton	-0,19	0,00	-0,01	-0,05	-0,52	-0,33	-0,33
	Livestock	-0,02	0,04	0,05	-0,06	0,02	0,08	0,07
	forestry	-0,22	0,23	0,23	-0,18	-0,22	0,23	0,24
	mining	-0,06	-0,19	-0,19	0,05	0,01	-0,12	-0,12
	agoindustry	0,09	-0,05	-0,05	0,07	0,21	0,07	0,06
	textile	0,11	-0,07	-0,07	0,08	0,14	-0,04	-0,05
	other industries	-0,10	-0,23	-0,23	0,05	-0,01	-0,14	-0,14
	other energy	0,04	-0,18	-0,19	0,08	-0,07	-0,29	-0,28
	biofuel	-3,45	-3,65	-3,65	-0,08	-2,86	-3,06	-3,06
	construction	-0,43	-0,65	-0,65	0,05	-0,45	-0,67	-0,67
	commerce	0,83	0,41	0,40	0,10	0,20	-0,22	-0,19
	transport	0,23	0,08	0,07	0,06	0,14	-0,02	-0,01
	services	0,15	-0,10	-0,10	0,07	0,04	-0,20	-0,19
	banking & finance	-0,04	-0,26	-0,27	0,06	-0,06	-0,28	-0,29
	public services	0,21	0,05	0,04	0,06	0,24	0,08	0,06
	fossil fuels	-0,28	-0,48	-0,48	0,06	-0,27	-0,47	-0,47

The strong price decreases for jatropha has a positive impact on the biofuel sector. It is also very interesting to note that the subsidy to biofuel has a positive effect on jatropha production and price. The subsidy also allows for a low decrease in price of biofuel in combination with a more than 20% increase in output by the sector. When we combine this simulation 2a with the increase in land for jatropha production (sim2b), we greatly reduce the demand side pressure on jatropha with the supply effect and we observe a strong decrease in the price of jatropha (-23%). It is also interesting to highlight that the market prices of other agricultural goods all increase when jatropha competes with these sectors of land and these prices decrease for most sectors when there is no competition (sim1a and sim 2b). These differentiated effects will play an important role in determining the distributional impact of these simulations.

The results for changes in the rental rate of capital for the non agricultural sectors are presented in Table 5. Since the capital is fixed, each sector has a specific rental rate of capital. Not surprisingly the biofuel sector experiences a very strong increase in returns in all simulations since all scenarios are favorable to this sector. In the first simulation (sim1a), the fossil fuels, the construction and service sectors exhibit decreases around or above 2%.

Table 5: Rental rate of capital results of the CGE model

Variables	branches	Sim 1a	Sim 1b	Sim1c	Sim2a	Sim2b	Sim2c	Sim2d
r (rental rate of capital)	mining	-0,37	-0,39	-0,40	0,02	-0,19	-0,21	-0,21
	agoindustry	0,01	-0,15	-0,15	0,09	0,39	0,22	0,22
	textile	0,08	-0,11	-0,11	0,07	0,08	-0,11	-0,10
	other industries	-0,46	-0,58	-0,58	0,07	0,07	-0,05	-0,06
	other energy	-0,01	-0,23	-0,24	0,08	-0,14	-0,36	-0,35
	biofuel	437,25	436,04	435,98	45,69	1530,65	1526,93	1527,18
	construction	-2,37	-2,78	-2,78	-0,01	-2,38	-2,78	-2,77
	commerce	1,14	0,61	0,59	0,12	0,26	-0,27	-0,22
	transport	0,35	0,31	0,31	0,05	0,34	0,30	0,30
	services	-1,94	-2,08	-2,07	0,06	-0,98	-1,12	-1,12
	banking & finance	-0,97	-1,25	-1,26	0,04	-0,77	-1,05	-1,06
	fossil fuels	-4,24	-4,42	-4,44	-0,04	-2,53	-2,71	-2,72

This simulation has some sectors benefiting namely the commerce and transport sectors. The competition from the biofuels toward fossil fuels is clearly observed in all simulations. Moreover, in all simulations, the transport sector benefits from the lower fuel prices. The subsidy (sim2a) produces a positive impact on the biofuel sector but with a much smaller impact compared to the first three simulations. The trends within each set of simulations are quite similar (with the exception of sim2a). We only observe a few qualitative differences within each set of simulations such as in the textile, commerce and other industries sectors.

We complete the section with a brief description of the market penetration of biofuel in the context of our simulations. In the first set of simulation, the exogenous expansion of the jatropha production allows biofuel to take up just over 3.7% of market share compared to fossil fuel from an initial share of just over 0.3%. The simulation 2a which is a policy intervention without exogenous growth of the jatropha sector produces an increase in market share to 0.38%. This represents a 23% increase in its market share. On the other hand, the 10 fold increase in land use for jatropha production (sim 2b to 2d), allows biofuels to achieve a market share of 2.65%.

Table 6: Market penetration of biofuel

	Market penetration of biofuel in % of share
Reference	0,31
sim1a	3,74
sim1b	3,74
sim1c	3,73
sim2a	0,38
sim2b	2,65
sim2c	2,65
sim2c	2,65

We will follow this section with the distributional analysis. It will be important to keep in mind the variations presented in the previous tables.

5.2 Distributional impacts

In this section, we present and analyze poverty and income distribution changes following the different scenarios. We perform this analysis at the national level and also present a rural-urban decomposition analysis. It is important to restate that the CGE model does not take into account this household decomposition. The decomposition is performed at the distributional analysis level. The CGE-microsimulation model allows us to compute changes in real income and equivalent variations for each 4,494 household in the model. Table 7 presents the share of households as well as average per capita expenditure for each of the two groups. We observe that 31.70% of Malian households live in urban area and 68.3% in the rural zone. The average per capita expenditure of urban households is more than double (631 064 Fcfa) compared to what is observed for rural households (225 416 Fcfa).

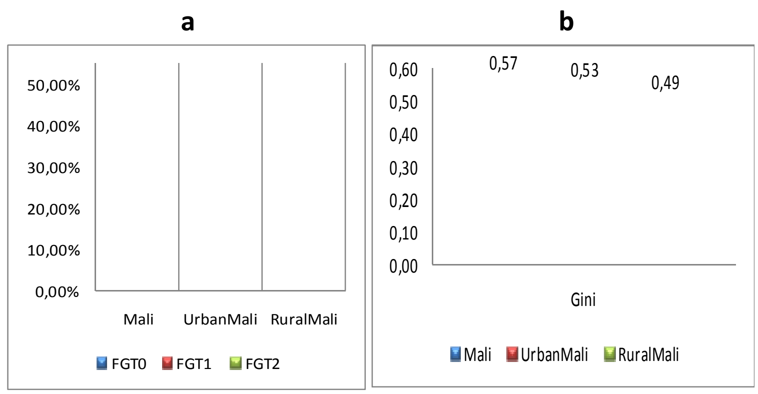
Table 7: Descriptive statistics for groups

	% of households	Mean of *per capita* expenditure (Fcfa)
Urban	31.7%	631064.8
Rural	68.3%	225416.8
Mali	100%	377035.72

Sources: Elim, 2006

Let us begin with the analysis of poverty and inequality for the reference period at the national level and for the two groups of interest (Figure 2).[36] While poverty at the national level is slightly inferior to 40%, the rural area exhibits a poverty rate slightly higher at 42% while the poverty rate is much lower in urban zones at 14.5%. When analyzing the poverty depth (FGT1) and severity (FGT2), the indices for rural areas are just below the national level and the urban zones have much lower levels for these two indices. Mali is a country with relatively high level of inequality with a Gini value of 0.57 for the country. However, the decomposition analysis reveals lower inequality within the two zones at 0.53 for the urban areas and even lower in rural Mali at 0.49.

Figure 2: Poverty and inequality analysis for Mali and the groups



Source: Resutlts obtained by authors with DASP 2.1

For the distributional impact analysis for national poverty (see Table 8), we see that the country would experience a decrease in poverty for all indices and all simulations. In the first set of simulations, the one with the weakest positive impact is sim1b. Looking at poverty serverity, we observe the strongest reduction for the first simulation (sim1a) , while sim1c exhibits the highest reduction in poverty depth index. In the second set of simulations, the sim2a seems to be the most interesting in terms of the three poverty indices and the subsidy using idle land (sim2b) is the second best option. The sim2c produces the weakest positive results. The positive effects are a the results of increasing wages in most simulations and the decrease in price of key goods for poor households (food prices, forestry, fuel, manufactured goods). The returns to agricultral capital and land are qualitatively different between simulations and hence in some cases it will attenuate the positive effects of other variables and in other it will amplify the positive effects of other variables. The two simulations with endogenous labor supply contribute to significantly improvings the situation of the

[36] The welfare indicator used is the annual expenditures after private net transfers (monetary and non monetary), expressed per capita. The literature shows that income transfers between households can be considered a source of poverty reduction as well as a means to attenuate inequalities between households (Adams and He, 1995). Coulibaly (2010) shows that in the absence of transfers, poverty would be much higher in Mali and its regions. It is also worth noting that the national threshold chosen is the one suggested by the World Bank, based on the basic needs methodology. The poverty threshold is different in the two zones. The "Institut National de Statistique du Mali" computed 18 poverty lines that are decomposed between urban and rural areas for the 9 departments of the country. We computed rural and urban lines with the weighted averages on the nine rural and nine urban zones. This gave us a poverty line of 148 152 Fcfa for the urban and 120 091 Fcfa for the rural areas.

households benefiting from new or more work (sim1c versus sim1b and sim2d versus sim 2c).

Table 8: Variation of poverty indices by groups[37]

		Mali	UrbanMali	RuralMali
Référence	FGT0	39,72%	14,54%	42,05%
	FGT1	17,42%	5,10%	17,03%
	FGT2	9,96%	2,67%	9,14%
Sim 1a	Δ % FGT0	-0,05%	0,18%	*-0,31%*
	Δ % FGT1	*-0,24%*	*0,54%*	*-0,44%*
	Δ % FGT2	*-0,34%*	*0,39%*	*-0,51%*
Sim 1b	Δ % FGT0	*-0,11%*	0,41%	-0,13%
	Δ % FGT1	*-0,23%*	-0,07%	*-0,28%*
	Δ % FGT2	*-0,25%*	-0,03%	*-0,31%*
Sim 1c	Δ % FGT0	*-0,18%*	-0,63%	-0,20%
	Δ % FGT1	*-0,25%*	-0,20%	*-0,30%*
	Δ % FGT2	*-0,28%*	-0,08%	*-0,31%*
Sim 2a	Δ % FGT0	*-0,44%*	-0,25%	*-1,02%*
	Δ % FGT1	*-0,77%*	*0,13%*	*-1,00%*
	Δ % FGT2	*-0,85%*	*0,13%*	*-1,01%*
Sim 2b	Δ % FGT0	-0,05%	0,18%	-0,26%
	Δ % FGT1	*-0,28%*	*0,42%*	*-0,48%*
	Δ % FGT2	*-0,38%*	*0,30%*	*-0,56%*
Sim 2c	Δ % FGT0	*-0,11%*	-0,16%	-0,13%
	Δ % FGT1	*-0,21%*	-0,05%	*-0,27%*
	Δ % FGT2	*-0,23%*	0,00%	*-0,29%*
Sim 2d	Δ % FGT0	*-0,18%*	-0,39%	-0,20%
	Δ % FGT1	*-0,26%*	-0,18%	*-0,28%*
	Δ % FGT2	*-0,26%*	-0,06%	*-0,29%*

When analyzing the impact of the simulations on the two groups, we observe quite intuitive results where the rural households on an aggregate basis, benefit in all simulations for all indices while urban households benefit in some simulations and for some indices. In fact, the positive results observed for urban households are insignificant (standard errors are greater than the variation of the indices). We observe significant negative impact for urban households for simulations 1a, 2a and 2b. In none of the cases do we have a significant result for the headcount index (FGT0) for urban households. For rural households all simulations produce significant results for depth and poverty indices. However, for the headcount index, only sim1a and sim2a produce significant results.

It is interesting to observe that the strongest positive effects overall for the country and rural households is the tax and subsidy option (sim2a). In simulations with an expansion of jatropha production, we have two opposing effects being confronted namely the increase in income from new production but the increase in supply decreases the prices and returns on factors.

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[37] We present complete poverty analysis for each group. However, we indicate significant results (at 0.05%) in italic character. When variations are not in italic, it indicates that the results are not significant.

Table 9 presents the variation of the inequalities. Only one option produces a reduction in inequality for the country and the two groups, namely sim1c. Two simulations produce across the board increase in inequality (sim2c and sim2d). Other simulations (sim1a, sim1b and sim2a) produce benefits to one group and for the national level. Finally, in one simulation (sim2b), we observe a reduction of inequality at the national level but not for subgroups.

Table 9: Variation of Gini index by groups

	Mali	UrbanMali	RuralMali
Gini	0,57	0,53	0,49
Δ% Gini - Sim 1a	-0,090%	0,019%	-0,057%
Δ% Gini - Sim 1b	-0,002%	0,004%	-0,036%
Δ% Gini - Sim 1c	-0,033%	-0,137%	-0,041%
Δ% Gini - Sim 2a	-0,155%	-0,033%	0,156%
Δ% Gini - Sim 2b	-0,015%	0,018%	0,320%
Δ% Gini - Sim 2c	0,154%	0,248%	0,762%
Δ% Gini - Sim 2d	0,123%	0,107%	0,072%

In terms of the effects on the groups, the positive results obtained for poverty in rural areas do not translate in reduction in inequality in all simulations. It is only the case for simulations of the first set while all simulations in the second set increase inequality in that zone. For urban zones, the negative results for poverty translate into increase in inequality for most simulations.

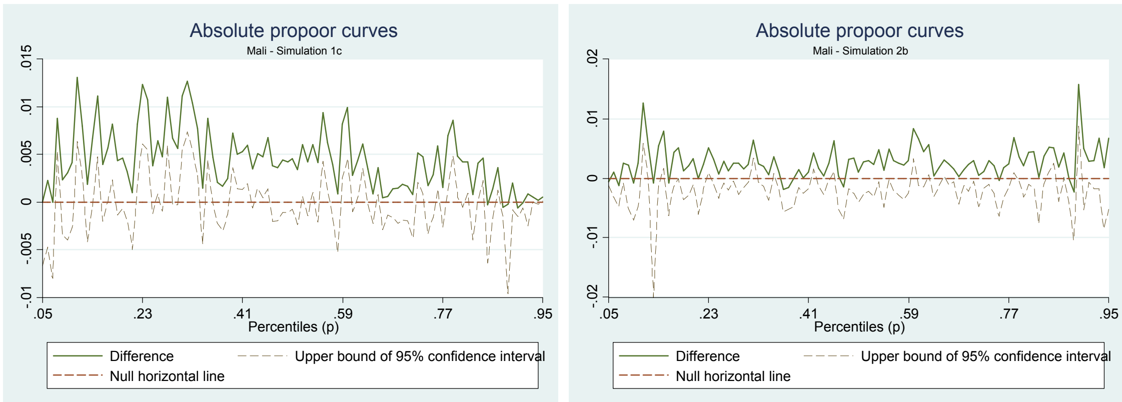
5.3 Pro-poor analysis

To complete our distributional impact analysis, we examined whether the simulations can be classified as pro-poor or pro-rich. To conduct this analysis, we used the growth incidence curve (GIC) developed by Ravallion and Chen (2003). This analysis allows us to see whether the variation in real income (or expenditure) generated by the model is distributed across the distribution. The curve represents the change in real income for each percentile of the sample of households. Hence, a negatively sloped curve represents a pro-poor policy and a positively sloped curve a pro-rich simulation.

Figure 3 panel a depicts the GIC for Mali for sim1c. The curve exhibit a slight negative slope and hence this simulation is more favorable to poorer households (below 60^{th} percentile) compared to households above this 60^{th} percentile. We recall that this simulation produce a reduction for the three poverty indices and a reduction in the Gini index at the national level and for the two subgroups. In Figure 4, panel b, the GIC curve for sim2b reveals a proportional impact since we cannot identify a slope for the curve while poverty indices decreases and the Gini index at that national level also decreased albeit this decrease was extremely small.

Figure 3: Growth incidence curve for Mali

(a) Simulation 1c **(b) Simulation 2b**

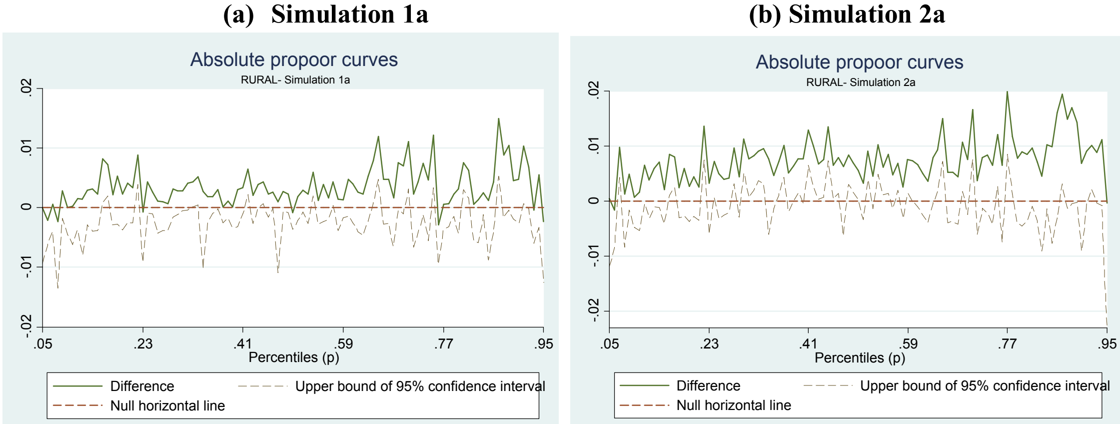


Source: Computed by authors from ELIM 2006 with DASP package

Figure 4 depicts the GIC for the rural households for simulation 1a (panel a) and simulation 2a (panel b). In panel a, we have a relatively horizontal curve with the exception of the two tails where the poorest are just below the 0 line and households between the 80th and 93rd percentile are the winners of this simulation. On the other hand, the simulation 2a consisting of taxing fossil fuels and subsidizing biofuel has a very slight positive slope. Interestingly, this simulations was the most efficient to reduce poverty in rural areas. The positive slope is coherent with the increase in inequality measured with the Gini index (+0.16).

Figure 4: Growth incidence curve for Rural

(a) Simulation 1a **(b) Simulation 2a**

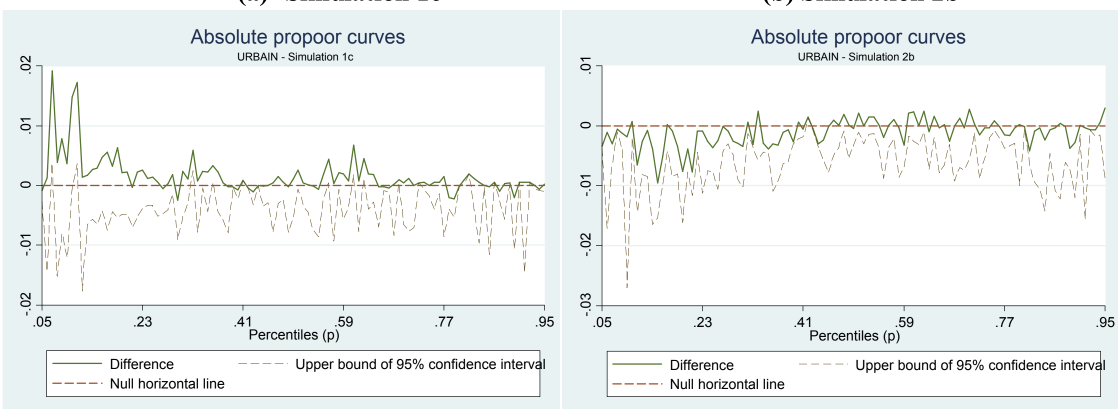


Source: Computed by authors from ELIM 2006 with DASP package

The other curves presented were computed for urban households for simulations 1c and 2b. These two curves are interesting insofar as the trend observed is not consistent through the entire distribution. For sim1c (panel a) we have a negative slope from the bottom of the distribution up to the 30th percentile and a flat curve to the top of the distribution. Hence, this simulation is favorable to the poorest households with little distributional impact for the richest 70% of the population in urban areas. On the other hand, the sim2b (panel b) is slightly positively sloped below the 50th percentile and slightly negatively sloped above this 50th poverty line. In this case, the simulation is most favorable to the center of the distribution (between the 40th to the 70th percentile.

Figure 6: Growth incidence curve for Urban

(a) Simulation 1c **(b) Simulation 2b**



Source: Computed by authors from ELIM 2006 with DASP package

6 Conclusion and recommendations

In this paper, we construct a CGE model with a microsimulation model to analyze the distributional impact of the expansion of the jatropha and biofuel sectors in Mali. We also provide macro and sector effects of such scenarios. Given the small initial size of the sector, we show that a fifteen fold expansion of the sector will produce positive impact on other agricultural sectors if the sector does not compete for land and a slight negative effect if it competes for land. Similar trends are observed for macro results. We can highlight that the substitution effect between biofuels and fossil fuels produce a real exchange rate appreciation. An important result we found is that the positive effects of the expansion of jatropha and biofuel are countered by a drop in market prices and returns to the sector. In light of this, policy makers pursuing the promotion of these two sectors should insure that biofuels will have proper outlets to tamper returns reduction. Moreover, the distributional impact analysis is more favorable to rural households and is also positive at the national level when considering poverty indices. The urban households are the losers from the expansion of the two sectors as these households face price increase for other food staples and don't get the benefits from expanding jatropha and biofuel output. It is also interesting to note that the small fossil fuel tax that funds biofuel produces the strongest positive effects for poverty reduction.

This analysis can be extended for improved distributional analysis. The small size of the sector at the reference period constraints us in the size of the expansion of the sector.

Converting the model into a sequential dynamic CGE model would help us introduce an incremental growth of the sector. However, performing distributional analysis with dynamic CGE model presents important challenges as one needs to determine who will benefit from the growth and depreciation of production factors. Very few authors have proposed convincing methodology to perform such an analysis. Another interesting extension of this model would be to introduce some endogeneity in the agricultural households' behavior allowing them to switch from one crop to the other. The exogenous land endowment limits this type of behavior. This type of application will require some further investigation on the household behavior at the micro level for which we lack adequate databases.

7 Bibliography

Achten, W. M. J., L. Verchot, Y. J. Franken, E. Mathijs, V. P. Singh, R. Aerts and B. Muys, (2008), "Jatropha bio-diesel production and use", *Biomass and Bioenergy*, Vol 32(12), pp. 1063-1084.

Adams, R. H. Jr. and J. J. He, (1995), "Sources of income inequality and poverty in rural Pakistan", Research reports 102, International Food Policy Research Institute (IFPRI).

Annabi, N. (2003), Modeling Labour Markets in CGE Models: Endogenous Labor Supply, Unions and Efficiency Wage. Mimeo, Pep-net, CIRPEE, Laval, University.

Armington P. S. (1969) « A Theory of Demand for Products Distinguished by Place of Production », *IMF staff paper,* nº 16, p. 159-176.

Baier, S. L., M. Clements, C. W. Griffiths, and J. E. Ihrig, (2009), "Biofuels Impact on Crop and Food Prices: Using an Interactive Spreadsheet", FRB International Finance Discussion Paper No. 967. Available at SSRN: http://ssrn.com/abstract=1372839.

Benge, M., 2006. "Assessment of the potential of *Jatropha curcas*, (biodiesel tree) for energy production and other uses in developing countries", ECHO's website: 2006. Available at http://www.echotech.org/mambo/index.php?option=com_docman&task=doc_view&gid=179&Itemid=68.

Blanchflower, D. G., & Oswald, A. J. (1998). The wage curve. Cambridge: MIT Press.

Bourguignon F., A. S. Robilliard, and S. Robinson. (2005). "Representative Versus Real Households in the Macroeconomic Modeling of Inequality." In T. J. Kehoe, T.N. Srinivasan, and J. Whalley (eds.), *Frontiers in Applied General Equilibrium Modeling*. Cambridge: Cambridge University Press.

Bourguignon, F. and A. Spadaro. (2006). "Microsimulation as a Tool for Evaluating Redistribution Policies." *Journal of Economic Inequality*, 4(1): 77-106.

Bourguignon, F., and L. Savard, (2008) "Distributional Effects of Trade Reform: An Integrated Macro-Micro Model Applied to the Philippines" in (eds) Bourguignon, F. L.A. Pereira da Silva, and M. Bussolo, eds. "*The Impact of Macroeconomic Policies on Poverty and Income Distribution Macro-Micro Evaluation Techniques and Tools*" Palgrave-Macmillan Publishers Limited, Houndmills.

Brittaine R. and N. Lutaladio, (2010), "Jatropha: A Smallholder Bioenergy Crop - The Potential for Pro-Poor Development", FAO Integrated Crop Management Vol. 8, 116 pg ISBN: 9789251064382. Available at: http://www.fao.org/docrep/012/i1219e/i1219e.pdf.

Campa, C. and C. Valentin, (2009), "Le jatropha, une plante miracle?" in Sciences au Sud n°49 – Tribune. Available at: http://www.ird.fr/content/download/7330/76701/version/1/file/sas49_tribune.pdf.

Carneiro, F.G., and J.S Arbache (2003), The Impacts of Trade on the Brazilian Labor Market: A CGE Model Approach, World Development, Vol 31 (9), pp. 1581-1595.

Chen, S. and M. Ravallion. (2004). Welfare Impacts of China's Accession to the World Trade Organization. *World Bank Economic Review* 18(1): 29–57.

Cockburn, J. (2001). "Trade Liberalization and Poverty in Nepal: A Computable General Equilibrium Microsimulation Analysis." Working paper 01-18, CREFA, University of Laval, Québec.

Cogneau, D. and A.-S. Robilliard. (2000). "Income Distribution, Poverty and Growth in Madagascar: Micro Simulations in a General Equilibrium Framework." IFPRI TMD Discussion Paper 61, International Food Policy Research Institute, Washington, DC.

Coulibaly, M. D. Boccanfuso, D. and L. Savard (2010), "Mali: Economic and environmental stakes of the biofuels, mimeo, GREAT-Mali & GREDI, Université de Sherbrooke.

Decaluwé, B. J.-C. Dumont, and L. Savard. (1999). "How to Measure Poverty and Inequality in General Equilibrium Framework." Working Paper 9920, CREFA, University of Laval, Québec.

Decaluwé, B., A. Martens, and L. Savard. (2001a). "*La politique economique du développement et les modèles d'equilibre général calculabl*"*e*. Montréal: Montréal University Press.

Direction National de l'Énergie du Mali (2009), Indicateur Énergétique du Mali 2007, available online at : http://www.dnemali.org/upload_document/Indicateurs_Energetiques.pdf

Dornbosch R. and R. Steenblik (2007), *Biofuels: Is the cure worse than the disease?* OECD, Round Table on Sustainable Development, Paris, 11-12 September 2007, [SG/SD/RT(2007)3/REV1], Organisation for Economic Development and Cooperation (OECD), Paris.

Fargione, F.; Hill, J.; Tilman, D.; Polasky, S. and Hawthorne, P., (2008), "Land clearing and the biofuel carbon debt", *Science* Vol. 319, pp. 1235 – 1238.

Foster J., J. Greer and E. Thorbecke, 1984 – "*A class of Decomposable Poverty Measures",* Econometrica, 52(3), pp. 761-766.

GEXSI, (2008), *Global Market Study on Jatropha. Final Report*. Prepared for the World Wide Fund for Nature (WWF). London/Berlin: Global Exchange for Social Investment.Available at: http://www.jatropha-platform.org/index.htm.

Gørtz, M., G. Harrison, C. Neilsen, and T. Rutherford. (2000). Welfare gains of extending opening hours in Denmark. Economic working paper B-00-03, University of South Carolina, Darla Moore School of Business, Columbia, South Carolina.

Haïdara, A., O., (1996), "Valorisation d'une huile végétale tropicale : l'huile de pourghère », Mémoire de maîtrise es sciences appliquées, Génie Chimique, Université de Sherbrooke. Available at: http://www.phpage.fr/bioenergies/doc/hvc-mq21766.pdf.

Headey D. and S. Fan, (2008), "Anatomy of a crisis: the causes and consequences of surging food prices", *Agricultural Economics*, Vol. 39, supplement, pp. 375–391.

Henning, R.,K., (2009), "The Jatropha System – an integrated approach of rural development", Weissensberg, Germany. Available at:
http://www.jatropha.de/documents/The%20Jatropha%20Book-2009.pdf.

Hertel, T., and J. Reimer. (2005). "Predicting the poverty impacts of trade reform, " *Journal of International Trade & Economic Development*, 14(4), pp. 377-405.

Huppi, M., and M. Ravallion. (1991). "The Sectoral Structure of Poverty During an Adjustment Period: Evidence for Indonesia in the Mid-1980s". *World Development* 19(2): 1653–1678.

King, D., and Handa S. (2003). "The welfare effects of balance of payments reforms: A macro-micro simulation of the cost of rent-seeking.? " *The Journal of Development Studies*, 39(3): 101-128.

Latapie, R., (2007), "La culture du pourghère : une activité génératrice de revenus qui permet de faire face aux enjeux énergétiques du Mali. Le cas du projet Garalo Bagani Yelen", Université de Rennes 1 et MaliFolkcenter, 107 pages. Available at: http://www.riaed.net/IMG/pdf/La_culture_du_pourghère_au_Mali_0108.pdf.

Legendre, B., (2008), “Jatropha Curcas (Tabanani) : Note agronomique”, Technologies for hman development, Dakar, Senegal. Available at: http://www.riaed.net/IMG/pdf/Article_Culture_du_Jatropha_Curcas_080611.pdf.

Luoma J. R., (2009), “Hailed as a Miracle Biofuel, Jatropha Falls Short of Hype”, Yale Environment 360, publication of the Yale School of Forestry & Environmental Studies. Avalaible at: http://e360.yale.edu/content/feature.msp?id=2147.

Mathews, J., (2007), “Prospects for a biofuels industry in Australia”, MGSM working papers in management, Macquarie University. Graduate School of Management, no. 13.

Mitchell, D., (2008),” A Note on rising food prices”, The World Bank, Development Prospects Group, Policy research working paper #4682.

OECD, (2008), “Biofuel Support Policies: An Economic Assessment “, Available at http://puck.sourceoecd.org/vl=1884709/cl=13/nw=1/rpsv/cw/vhosts/oecdthemes/99980002/v2008n12/contp1-1.htm.

OECD-FAO, (2009), “Agricultural Outlook 2009-2018”, 276 pages, Available at: http://www.agri-outlook.org/pages/0,2987,en_36774715_36775671_1_1_1_1_1,00.html.

Pallière, G. and S. Fauveaud, (2009), « Les enjeux des agrocarburants pour le monde paysan au Mali », GERES, AMEDD, ICD, Available at : http://www.geres.eu/images/stories/publis/Enjeux-jatropha-paysans-maliens.

Raizon, D., (2009), « Culture intensive de Jatropha : Manne ou catastrophe? », RFI, In line on 23/06/2009, http://www.rfi.fr/sciencefr/articles/114/article_82102.asp.

Ravallion, M., (1994), « Poverty Comparisons », Harwood academic publishers, 143 pages.

Ravallion, M. and S. Chen (2003). "Measuring Pro-Poor Growth", World Bank, Policy Research Working Paper 2666.

République du Mali, (2008), “Orientations stratégiques et priorités d'investissements agricoles », Conférence de Table Ronde des bailleurs de fonds du Mali, Bamako, http://www.tablerondemali2008.org/html/orientation.pdf.

Renner , R., (2007), “Green Gold in a Shrub: Entrepreneurs target the jatropha plant as the next big biofuel”, Green Gold in a Shrub, Scientific American, June. Available at: http://www.scientificamerican.com/article.cfm?id=green-gold-in-a-shrub&page=1.

Rutherford, T., D. Tarr, and O. Shepotylo. (2005). “Poverty Effects of Russia’s WTO Accession: Modeling ‘Real’ Household and Endogenous Productivity Effects.” World Bank Policy Research Working Paper 3473, Washington, DC.

Savard, L. (2005). “Poverty and Inequality Analysis within a CGE Framework: A Comparative Analysis of the Representative Agent and Microsimulation Approaches”. *Development Policy Review* 23(3): 313–332.

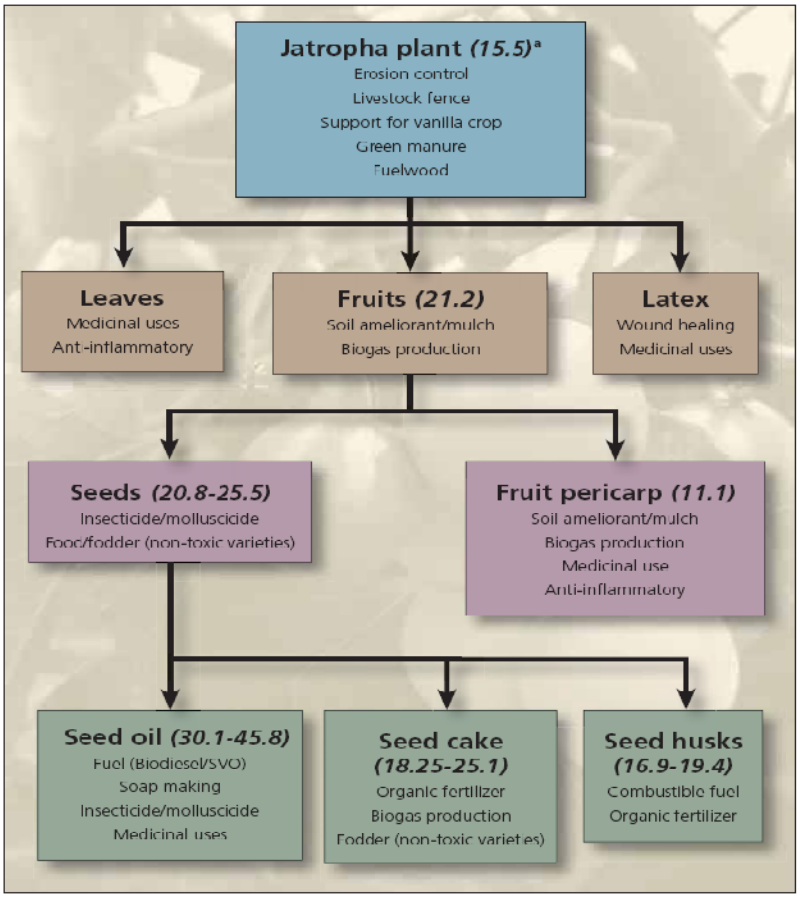
Searchinger, T.; Heimlich, R.; Houghton, R.A.; Dong, F.; Elobeid, A.; Fabiosa, J.; Tokgoz, S.; Hayes, D. and Yu, T. (2008), “Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land use change”, *Science* Vol. 319, pp. 1238 – 1240.

Vos, R, De Jong N. (2003) “Trade liberalization and poverty in Ecuador: a CGE macro-microsimulation analysis”. *Economic System Research*, 15(2): 211-232.

Word Bank, (2007), “*Mali - Second poverty reduction strategy paper and joint IDA-IMF staff advisory note*”, Report # 40724, 241 pages. Avalaible at http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2007/10/10/000310607_20071010132454/Rendered/PDF/407240ML0IDA1SecM200710584main.pdf.

Appendix

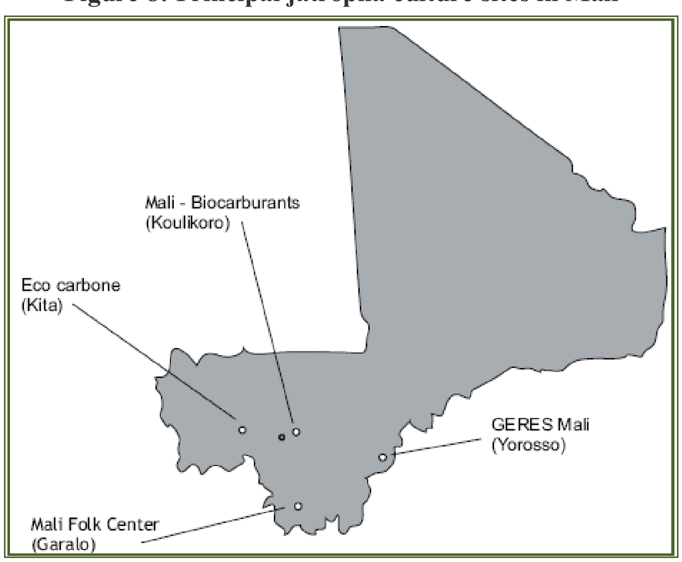
Figure 7: The uses of *Jatropha curcas* and the energy values of its components



Source: Brittaine R. and N. Lutaladio (2010)

[a] Energy values of the components are given in MJ/ kg

Figure 8: Principal jatropha culture sites in Mali



Source: Pallière et al. (2009)