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# Cassava as an energy crop: A case study of the potential for an expansion of cassava cultivation for bioethanol production in Southern Mali

Søren Bech Pilgaard Kristensen [a,*], Torben Birch-Thomsen [a], Kjeld Rasmussen [a], Laura Vang Rasmussen [a], Oumar Traoré [b]

[a] Department of Geosciences and Natural Resource Management, University of Copenhagen, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark
[b] Mali Folkecenter, Faladié, SEMA, Rue 800, Porte 1293, Bamako, Mali

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ABSTRACT

Cassava based bioethanol production is a promising alternative to conventional fossil fuels and commercial production is already well established in several countries. A production based on small holder production may involve a transformation of the existing production system and it is therefore imperative to investigate opportunities and barriers for expansion of cassava production. This paper investigates the potential for an expansion of cassava cultivation for bioethanol production in Southern Mali. It is based on a questionnaire survey with 65 households in 2 villages in Loulouni municipality, which represent two major agro-ecological environments in the Soudan-zone in Mali. The results reveal that farmers are experienced cassava producers and are interested in an expansion of cassava cultivation for bioethanol production and that suitable areas are available, especially for an expansion of the *Attieké* cassava variety. Little competition with food crops is likely, as cassava most likely would replace cotton as primary cash crop, following the decline of cotton production since 2005 and hence food security concerns appear not to be an issue. Stated price levels to motivate an expansion of cassava production are close to acceptable levels to make bioethanol production profitable and the advantages of a continuous demand at agreed prices may motivate farmers to accept prices which would make bioethanol production competitive.


## 1. Introduction

Within the past decades, there has been an increased interest in the potential of bioethanol as a substitute to conventional fossil fuels – but equally a number of concerns have been raised regarding the possible negative impacts. One of the early arguments for the substitution was the ability of biofuels to mitigate climate change through a reduction in the emissions of greenhouse gasses (GHG). However, it is still discussed whether first-generation biofuels actually leads to a reduction of GHG emission [1–4]. The interest for bioethanol production has been driven by both a 'Northern' as well as a 'Southern' agenda [5]. The Northern agenda refers to concerns regarding fuel security, high oil prices and climate change while the Southern agenda focuses on the potential of biofuel production to promote economic development and create employment in rural areas as well as reducing imports of fossil fuels [6–8]. Recent discussions related to GHG reduction potential have focused on the land use change aspect. It has been stated that clearing of forest land for production of biofuel feedstock can incur large carbon losses – referred to as 'carbon debt' [2,9]. Therefore, some argue that, in order to capitalize the reduction potential, cultivation of biofuel feedstock should be constrained to areas with low carbon content [4], e.g. depleted or waste lands, fallowed land, or land presently under cultivation. Recent research has shown that the size of the carbon debt might be overestimated as useful trees are left untouched in many agricultural systems, e.g., in Southern Mali [10].

In terms of the economy of biofuels, Rosegrant et al. [6] states that price levels of crude oil well above $60–70 per barrel will enable biofuels to become competitive with fossil fuels. Prices within the past ten years have for most of the period been above this level. However, price fluctuations have been significant, varying from a maximum of $121 per barrel in the second quarter of 2008 to a minimum of $44 in the first quarter of 2009 [11], yet most of the time above $75. An important addition to the fluctuations in oil prices is the fact that prices on major agricultural commodities

* Corresponding author. Tel.: +45 256 788351 859, +45 353 22500; fax: +45 353 22501.
*E-mail address:* sk@geo.ku.dk (S.B.P. Kristensen).

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are increasingly correlated to oil prices (so when competitive compared to petroleum, it also has to compete with high prices on food crops – e.g. cassava in this study).This discussion leads to one of the main concerns related to increased biofuel production – the competition between production of biofuel and food production [5,12–17]. The concerns are directed towards a potential competition for land and other resources between food and fuel production. If biofuel production out-competes the production of food crops, it may lead to reduced food availability and decreased food security – a threat to poor, and particularly urban, communities in developing countries. However, it has been argued that crops cultivated for biofuels are no different from other commercial crops, at least from the farmer's perspective [18]. Although not always the case, development of cash crop production may lead to improved food security. A review of small holder cotton production in Mali between 1960 and 2003 found an increase of 70% in cereal production per capita compared to non-cotton farmers [19]. Furthermore, a recent study from Cambodia of the expansion of cassava cultivation as a biofuel feedstock showed no competition over land between the new cash-crop cultivated on upland fields, and the traditional stable food, rice, cultivated in low-land flood-irrigated fields [20]. This highlights the importance of local specific studies with regards to, among other factors, local farming traditions and landscape conditions when evaluating the impact of biofuel production on food security.

Cassava (*Manihot esculenta Crantz*) is increasingly attractive as an energy crop due to its high rate of $CO_2$ fixation, high water-use efficiency, high carbohydrate content, and superior starch conversion ratio for ethanol compared to other crops [21]. The plant thrives and yields well under conditions of low rainfall and in acidic, marginal soils, and has the potential for continuous harvesting. All these characteristics make it a commonly grown low-cost crop, well suited for small-scale biofuel feedstock production [11]. Cassava has been used for bioethanol production in Brazil and Asia for several years [21] and several studies have investigated the potential in sub-Saharan Africa [22].

As cassava is already widely cultivated in parts of Mali, it is pertinent to analyze the potential for increased cassava production for bioethanol production. Therefore, the overall objective of the paper is to investigate the potential for an expansion of production for bioethanol production. This will be done by addressing the following five questions:

- What is the present situation of cassava production in a study area in Southern Mali?
- What are the potentials and barriers for increased cassava production for bioethanol production? In particular, is land availability a constraint?
- On which areas and which farmers are likely to expand cassava production?
- Will an expansion of cassava production have negative effects on food security?
- What economic conditions would facilitate an increased production?

## 2. Materials and methods

The research reported in this paper is based on fieldwork carried out in Loulouni municipality, Kadiolo District, Sikasso Region in Southern Mali in February 2010 (see Fig. 1). The area enabled us to study the potential for expansion of cassava production in different physical environments. The fieldwork included a questionnaire survey with farmers in 2 different agro-ecological zones supplemented by interviews with key informants (farmers, farmers associations, local authorities). 65 respondents were selected for the questionnaire survey using a systematic stratified sampling scheme. The questionnaire survey investigated issues on farming system and opportunities for cassava expansion and was part of a larger study on the potential for cassava-based bioethanol production in Southern Mali [10,23]. In addition, a Worldview-2 multispectral high resolution satellite image with approx. 2 m spatial resolution from January 2010 supplemented by 1999 Landsat TM images with 15 m resolution, were used to map land use, supported by field observations.

It was intended to gain an impression of wealth distribution in the study areas, as an indicator of the level of assets and means available in individual households. This is hypothesized to be linked with farmer's willingness and attitude towards changes in the current production system. Thus, it is assumed that farmers who are relatively well-off are already engaged in cash crop production (as this is generally the main source of income in the area) and therefore interested in further income generation. As accurate income figures are difficult to establish, a proxy was used which describes the relative wealth of households based on a composite indicator: housing standard, ownership of means of transport. Both types of assets contain a range of options which require less or more capital investment (e.g. oxcart and a car being examples of the extremes for means of transport) and thus indicators of the level of household or respondent wealth status. Households commonly owned several assets at different wealth levels (e.g. both an oxcart and a bicycle), and the interpretation focuses on the most valuable means of transport and ignores the less costly to make it manageable.

A two-step cluster analysis was performed to identify groups of farmers with similar wealth indicators. Three clusters were retained, as information on the quality of the classification showed this number of clusters to yield meaningful information.

### 2.1. Study area and data

Cassava has been one of the main food staples in this area of southern Mali for decades [23]. National yields are estimated to be 15–20 T/ha [24]. It is an important tuber crop, which has many different uses. One of the main advantages of the crop is the ability for *in situ* storage in the field, allowing fresh tubers to be harvested during periods of the year where demand is high. Most production takes place in the Sudan Zone of Mali (900–1100 mm/year), yet cassava is exported to other regions in the country [23].

The study area is a complex landscape with large differences in soil type, topography and humidity conditions. Fig. 2 presents the main landscape units in the case area. The classification was done on the basis of the QuickBird image. The following four landscape units have been identified:

*A) Flat alluvial plain*

Most dryland crop production occurs in a flat plain situated in between the elevated areas and the low-lying seasonally flooded areas – this unit is by far the largest within the study area (see Table 1). Many fields are cultivated in a shifting cultivation or rotational system, where fields are left fallow for a number of years after being cultivated in a crop rotation of cereals and cash crops (previously cotton).

*B) Lateritic plain*

Elevated areas, only marginally suited for arable production. These areas are mostly covered with shrubs and forests and are used for firewood collection and as grazing areas. There is limited cultivation within this second largest landscape unit, yet fields