Development Cooperation
Ministry of Foreign Affairs

Contractual arrangements for smallholders in biofuel chains; a case study of Jatropha in Mozambique

Jos Bijman, Maja Slingerland, Sander van Baren

2009

competing claims

WAGENINGEN UR
For quality of life

This series of Policy Briefs is a result of the Partnership Programme between the Netherlands' Ministry of Foreign Affairs Government and Wageningen UR

The Netherlands' Directorate-General for International Cooperation and Wageningen UR are implementing the Partnership Programme 'Globalisation and Sustainable Rural Development'. In the context of conflicting local, national and global interests and drivers of change processes, the programme aims, among other things, to generate options for the sustainable use of natural resources, pro-poor agro-supply chains and agro-biodiversity. Capacty strengthening and institutional development form cross-cutting issues in of the Partnership programme. The programme's activities contribute to improved rural livelihoods, poverty alleviation and economic development in countries in the south. Farmers and other small-scale entrepreneurs in the agricultural sector form the primary target group. The program has a strong -but not exclusive- focus on countries in Sub-Sahara Africa.

c/o Wageningen International
Wageningen University and Research Centre
P.O. Box 88, 6700 AB Wageningen, The Netherlands
Phone: +31 317 486807
E-mail: africa.wi@wur.nl, Internet : http://www.dgis.wur.nl

Contractual arrangements for smallholders in biofuel chains; A case study of jatropha in Mozambique[1]

Jos Bijman, Maja Slingerland, Sander van Baren
Wageningen University

Abstract

Mozambique experiences many investments in the production of bio-energy crops such as jatropha. These crops are promoted as an opportunity for smallholder producers. Developing jatropha supply chains from scratch requires coordinated investments by different chain participants and/or public agencies. Such jatropha chains may not easily be developed due to high transaction costs, particularly for smallholder farmers. We analyze the organization of existing supply chains for cotton, tobacco, and cashew, and project these outcomes on the new jatropha production and processing chains, to identify challenges that smallholders and firms are likely to face when engaging in jatropha production and processing. We distinguish three contract farming models that may be used for organizing the transaction between jatropha producers and processors: the centralized model, the nucleus estate model, and the multipartite model. We assess the strengths and weaknesses of each model for the particular situation of jatropha production in Mozambique.

1. Introduction

As the biofuel industry is an emerging industry in most developing countries, fully developed supply chains hardly exist. Many state-lead or NGO-lead biofuel projects are being initiated, either starting with building a processing plant and then finding raw material, or starting with supporting farmers in planting a biofuel crop and then linking these producers to new or existing processing facilities. Establishing linkages between farmers and processing industry (which consisting of a first stage of crushing and a second stage of refining) is often a matter of trial and error, seeking the technical and organizational configurations of the most efficient supply chain.

Many NGOs and donor organizations promote jatropha production by smallholder farmers as this crop can link farmers to the emerging biofuel market (e.g. FACT, 2006). Jatropha-oil is a multipurpose oil that can be used directly in cooking stoves and lamps, can be used directly in certain engines and can be processed into biodiesel. Using jatropha for biodiesel is an interesting option for those developing countries that rely on imported fossil energy for their transportation fuels. The cultivation of jatropha is claimed to be relatively easy, as the crop grows on marginal soils and is drought tolerant. However, as jatropha is a new crop for most farmers and as processing facilities hardly exist, the jatropha supply chain has to be established from scratch.

[1] The research reported in this paper was carried out in the framework of a project named "Competing Claims, Competing Models. Understanding (the benefits of) bio-fuel-based development models and their impact on resource use negotiations and rural livelihoods in southern Africa". This project has been initiated within the partnership between Wageningen University and Research Centre and the Netherlands Ministry of Foreign Affairs (DGIS). Financial support from DGIS is gratefully acknowledged

Linking smallholder farmers to the emerging bio-energy market requires an understanding of the advantages and disadvantages of small farms. The competitive advantages of smallholders over large commercial farms lie principally in their low transaction costs in accessing and supervising motivated family labor and in their intensive local knowledge (Poulton et al., 2005). However, smallholders face high transaction costs in almost all non-labor transactions, such as for obtaining inputs, marketing produce and accessing credit and other services. These transaction costs are exacerbated by most small farmer's poverty, their dispersion, the production and health uncertainty, their low levels of education, and by poor physical and communication infrastructure.

Economic and physical conditions that lead to high transaction costs are a serious obstacle for smallholders to be able and willing to become involved in bioenergy production. This implies that both commercial and development projects that seek to promote smallholder biomass production for the emerging biofuel market need to address the various sources of transaction costs that smallholders face.

Contract farming is an important organizational solution for reducing transaction costs for smallholders (Dorward et al., 1998). Contract farming models are able to provide interlinkages between input markets (for seeds, pesticides, fertilizers, credit) and output markets (for marketing the farmers' products). Contract farming can provide the coordination that is needed in newly developing supply chains where the complementary investments by different participants need to be coordinated and protected in order to reduce the transaction risks.

This paper aims to explore different contract models that could be used for linking smallholder farmers to biofuel supply chains. The paper focuses on the emerging jatropha supply chains in Mozambique and assesses different contract farming models in reducing transaction costs that relate to the characteristics of the producers, the production technology, the product, and the institutional environment.

The paper is structured as follows. First, we will discuss the literature on contract farming and assess the options and limitations of contracts in linking smallholders to the emerging biofuel markets. Second, we focus on the situation in Mozambique by discussing the institutional environment, but also by investigating the use of contract farming models in other industries, such as tobacco, cashew and cotton. Finally, we discuss the usefulness of different contract farming models for developing jatropha supply chains.

2. Transaction costs and contractual arrangements

Poulton et al. (2006) argue that smallholder agricultural growth and intensification in Africa will only be achieved when there is enhanced provision of pre- and post-harvest services to smallholder agricultural producers. Moreover, they claim that it is important not just that these services are provided, but that their provision is *coordinated* so that individual investors are assured that their investment will not fail as a result of other investors either failing to make complementary investments or behaving opportunistically. One of the solutions presented by these authors is supply chain coordination, which means the coordination of activities and investments by the providers of inputs, the farmers, and the firms that market and process the farm products.

Transaction costs exist because markets are incomplete or even missing, economic actors are limited in their cognitive capabilities and may behave opportunistically, or complementary activities and investments are not well-coordinated. The classical explanations for the existence of transaction costs are asymmetric information and uncertainty, often in combination with investment that is transaction-specific (Williamson, 1985). Firms incur transaction costs in acquiring information and in taking protective measures against the risk of loss in transactions. These risk reduction measures may involve the use of contractual forms that reduce the risk of opportunistic behavior by other parties, at the cost of reduced incentives, reduced production efficiency, or less favorable prices. Exposure to risk is a key determinant of transaction costs, as the greater the exposure to risk the greater the costs a firm will be willing to incur in order to reduce the risks (Dorward, 2001).

Poulton et al. (2006) distinguish three components of transaction risks and costs: (1) coordination risks, which is the risk of an investment failing because of the absence of complementary investment by other players in the supply chain; (2) opportunism risks, which arise when a contracting party, with monopsonistic or monopolistic control over a complementary investment or service, removes, or threatens to remove, it from the supply chain after another party has made an investment that depends upon it; and (3) rent-seeking risks, where powerful government, political, criminal or other agents not party to a transaction see associated investments and/or revenues as an opportunity to expropriate, or threaten to expropriate, income or assets from the investor. Where these risks are high as compared with potential returns to investment, the investments needed for the development of the supply chain may be too risky to be worthwhile, and thus the chain may not develop even if it is otherwise potentially profitable.

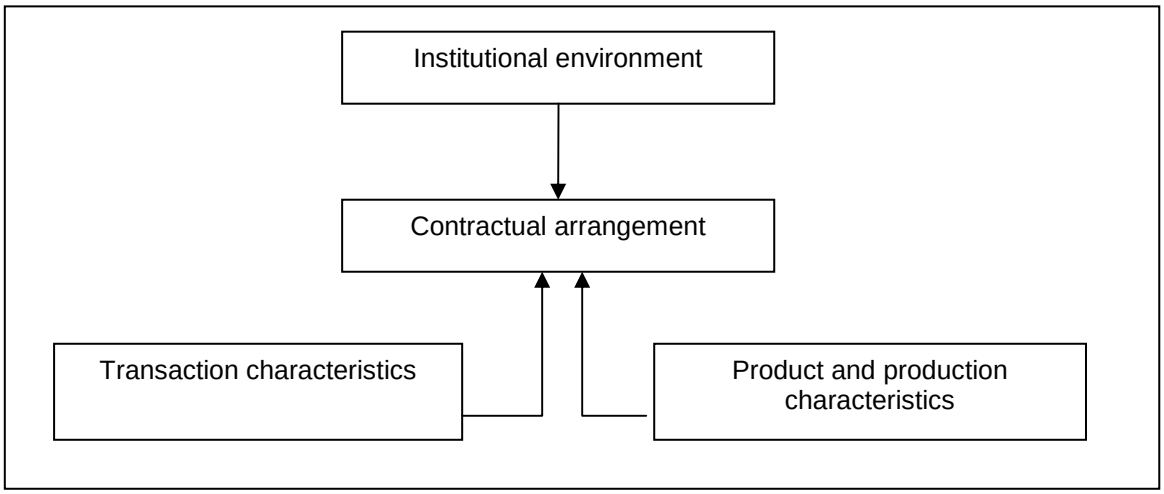
While Williamson (1985) emphasizes the characteristics of the transaction (including product and production characteristics), another approach in new institutional economics also emphasizes the impact of the institutional environment (North, 1990). The institutional environment, consisting of formal and informal norms and regulations, affects the availability of information, the level of trust among actual and potential trading partners, and the protection of property rights (such as through contract enforcement). Also the availability of credit and subsidies, and the physical condition of roads and telecommunication infrastructure can be considered as elements of the institutional environment.

For reducing transaction costs different governance structures exist, the choice of which depends on the characteristics of the transaction and on the institutional environment (i.e., the laws, norms, policies, judiciary, trust, etc). The transaction characteristics include the characteristics of the product and the production methods, which can vary substantially among agricultural products and therefore may be evaluated separately (Masten, 2000). Governance structures can be categorized on a continuum, ranging from spot markets as one extreme to hierarchy as the other extreme (Williamson, 1991). On a spot market trading between farmer and customer is anonymous and instantaneous, while under a hierarchy the market is basically eliminated and production takes place under direct control of the customer (as in a plantation system). A shift along the continuum from market towards hierarchy signifies a shift in decision rights from the farmer to the customer, reducing risks for the farmer, and strengthening coordination between farmer and customer activities. In between the extremes of market and hierarchy different so-called hybrid governance structures can be found (Menard, 2004). One type of hybrid governance structure is the contractual arrangement between agricultural producer and his/her customer. Such a contract can reduce

uncertainty and risk as well as improve coordination, thereby enhancing the efficiency of the supply chain.

In sum, the choice of the governance structure used for the transaction between farmer and his/her customer is influenced by at least three factors: the characteristics of the transaction (sush as uncertainty and asset specificity), the characteristics of the product and the production methods, and the institutional environment (see Figure 1). These factors determine the extent of transaction costs and risks, and thereby the choice of contractual arrangement that can reduce these costs and risks.

Figure 1. Different factors influencing the choice of contractual arrangement



Source: Modified from Dorward, 2001

3. Contract farming

As Figure 1 shows, the dependent variable of our model is the contractual arrangement, also known as contract farming model. Contract farming (CF) has been defined as an agreement between one or more farmer(s) and a contractor for the production and supply of agricultural products under forward agreements, frequently at predetermined prices (Eaton and Shepherd, 2001). CF has received increasing attention in the light of liberalization of agricultural markets and the need for stricter supply chain coordination (Kirsten and Sartorius, 2002; Da Silva, 2005). Contract farming can provide a number of benefits for smallholders (Key and Runsten, 1999; Eaton and Shepherd, 2001): access to output markets; access to inputs; access to technological assistance; lower market risk; lower innovation risks; and access to credit. Also for the processing and trading customer, contract farming may have a number of advantages, such as greater regularity of supplies; more homogeneous products; higher product quality; more flexibility and lower labor and fixed costs (when comparing with a plantation system).

Contracts in agriculture have three distinct functions (Hueth et al., 1999). First, they serve as a coordination device, allowing individual actors to make decisions (e.g. on investments) that are aligned with decisions of the partner(s). Second, contracts are used to provide incentives and penalties in order to motivate performance. Without proper incentives for each contract partner, no transaction will take place. Penalties may be needed to ‘encourage’ partners to comply with the agreement, particularly when market or physical conditions have changed in the time between contract signing and product delivery. Third, the contract clarifies the

allocation of financial risk. As economic actors have different risk attitudes, the risk neutral partner to a transaction usually takes most of the risk. As smallholder farmers are usually risk-averse (Rosenzweig and Binswanger, 1993), the contractor bears most of the financial risks. For example, farmers can mitigate the risk of income loss due to poor yield by signing an agreement with the contractor that specifies a portion of compensation independent of realized yields.

A typology of contracts

A classical typology of contracts in agriculture has been made by Mighell and Jones (1963), who distinguish between market-specification contracts, production-management contracts, and resource-providing contracts. These contracts differ in their main objectives, the extent of vertical coordination, and the transfer of risks, thus in their extent to reducing particular transaction costs (Minot, 1986). While the above typology has been used extensively, it has recently been criticized by Hueth et al. (2007) for being of little value for understanding contemporary agricultural contracts. Their main point of critique is that this distinction does not hold in practice. Most contracts combine elements of marketing (which is the interest of the farmer) and coordinating production with processing/marketing (which is the interest of the contractor). Also Swinnen and Maertens (2007) reject the typology of Mighell and Jones. They only distinguish between the marketing contract and the production management contract. They argue that the distinction between resource-providing and production management contract is small, as under both types vertical coordination is obtained by the provision of inputs and technical assistance. We follow the distinction made by Swinnen and Maertens (2007) in marketing contract and production-management contract.

A marketing contract is a pre-harvest agreement between producers and contractors on the conditions governing the sale of the crop/animal. The contractor reduces the producer's uncertainty of locating a market for the harvest, while the producer continues to bear most of the risk of his production activities. A marketing contract reduces the cost of gathering and exchanging information about demand, quality, timing and price, thus reducing uncertainty and the concomitant market risks.

The production-management contract gives more control to the contractor than the marketing contract, as the contractor will inspect production processes and specify input usage. Vertical coordination between producer and contractor is high, because producers agree to follow precise production methods and input regimes. The farmer has delegated a substantial part of his decision rights to the contractor, in return for the contractor taking on most of the risks. This type of contract is typically used when the quality of the output depends on the type and quality of inputs, when production and harvesting have to be closely coordinated with processing, and when inputs provision reduces production costs for the farmer and thereby purchasing costs for the contractor.

Contract farming models

Eaton and Shepherd (2001) distinguish between five contract farming models: the centralized model, the necleus estate model, the multipartite model, the informal model, and the intermediary model. Because of paper length restrictions we will only discuss the first three models, as the other two turned out to be of less importance for our study. These models differ in the type of contractor, the type of product, the intensity of vertical coordination between farmer and contractor, and the number of key stakeholders involved.

The centralized model is the classical CF model where a processor or packer buys produce from a large number of (small) farmers. There is strict vertical coordination, which means that quality is tightly controlled and quantity is determined at the beginning of the growing season. Typically, products traded under this model require a high degree of processing, such as sugar cane, tea, coffee, milk, poultry, and vegetables for the canning industry. Given the importance of economies of scale in processing and thus the large quantities of uniform product required processors often prefer to source from large farmers.

The nucleus estate model is a variation of the centralized model where the contractor not only sources from independent farmers but also has its own production facilities. The central estate is usually used to guarantee throughput for the processing unit but is sometimes used only for research and breeding purposes. This model is mainly used for perennial crops, but there are examples of applications of this model in other crops.

Under the multipartite model, a joint venture between a statutory body and a private company enters into contracts with farmers. Also public or private providers of credit, extension services, and inputs may be part of the arrangement. When the joint venture has sufficient discretion to control its transactions with the farmers, vertical coordination will be intense. Given the involvement of a public partner in the joint venture, the farmer-contractor relationship may be affected by the political interests of this partner.

4. Jatropha for biofuel in Mozambique

Product and production characteristics

Jatropha is a large shrub originating from Central America but now grown in tropical areas throughout Asia and Africa. Although the cultivation of jatropha as a biofuel crop is new, it is not a new crop for Africa. Traditionally, jatropha is used by farmers as a fence to protect the fields from animals and for producting soap from its fruits (FACT, 2006).

Jatropha is a perennial crop which means that the crop has to be planted once and lives and produces for many years. After planting jatropha can reach maturity and full production in about 3-4 years (Jongschaap et al. 2007). The black seeds that the crop produces have an oil content of at least 30% (FACT, 2006). The seeds need to be collected when they reach maturity. As the seeds do not mature all at the same time, the fruits have to be harvested manually at regular intervals which makes this step labor intensive (Achten et al., 2008).

Jatropha is considered by many as a high potential biofuel crops, as it can grow on marginal soils, is drought tolerant, provides high oil yields, requires low labor inputs and is not very vulnerable to diseases. Jongschaap et al. (2007) have assessed these claims and concluded that some modesty about the benefits of jatropha is justified. They acknowledge that the crop can grow on marginal lands with a low level of inputs but they emphasize the positive relation between adding supplements and a better performing crop. While Technoserve (2006) predicts an oil yield of 1800 liters/ha per year, which is even better then rapeseed and sunflower, Jongschaap et al. (2007) comment that these figures are based on extrapolations of small plots without taking the growth reduction in such systems into account. While jatropha oil is highly suitable for the production of biodiesel, the oil quality depends on several factors like the size and number of seeds. The claim about the low vulnerability for diseases is not

supported by research. Jongschaap et al. (2007) argue that the plant can be vulnerable for a range of diseases. For Mozambique this vulnerability is confirmed by research on jatropha practice and experience in Manica province (Sitoe et al., 2008; Gagnaux and Santos, 2008).

At the crushing stage, the oil has to be pressed out of the seeds, either mechanically or chemically (Van Eijck and Romijn, 2008). As chemical extraction is only economically feasible with a minimum production of 50 ton biodiesel per day, mechanical extraction is the only option for small scale crushing. Small presses on village level can be a solution to the high transportation costs of jatropha seeds, while the seedcake can be used directly as fertilizer on jatropha fields. It is not yet clear whether centralized or decentralized (on a village level) is the most efficient option. Centralization of oil crushing leads to higher investment costs, higher transportation cost, and more concern over control over the presses.

After the pressing, the oil is ready to be processed in an oil refinery where the glycerin is extracted through a process of transesterification. The resulting biodiesel can then be blended with fossil diesel in fuels. The seed cake can be used for the production of biogas, fertilizer and briquettes. Because jatropha seeds are toxic, it is not possible to use the seedcake as animal feed.

Institutional environment

There are currently many initiatives of commercial companies, state agencies and NGOs to start and support Jatropha production and processing projects. Several domestic and foreign companies have plans to set up large scale plantations, while most NGO's have planted small plots together with smallholders. Also the Mozambican government is active in the biofuel supply chain by setting up a task force to investigate and guide initiatives to produce jatropha for biofuel. This task force consisted of research institutes like IIAM and ICRAF but also NGO's like Technoserve (Technoserve 2006). A task force was needed because some jatropha initiatives headed for failure because companies and NGO's have started planting the crop without sufficient agronomic knowledge.

Based on our own research and a study by Benfica (2006) we assess the different elements of the institutional environment in Mozambique and the effect that these elements have on the incidence and size of transaction costs (Table 1).

Table 1. Elements of the Mozambique institutional environment and their effect on transaction cost

Institutional Environment	**Effect on transaction costs**
Low literacy and low education	Raises cost of adopting new technologies and new management practices; Raises cost of collective action Hard to set up complex contracts
Missing input / factor market	Non-availability or high cost of necessary inputs
Poor road and communication infrastructure	Raises cost of information exchange; High transportation costs
Weak property rights enforcement	Increases uncertainty with regard to reliance on contract and the use of collateral; High uncertainty about the paying back of loans
Weak local government	No provision of (technical) services to farmers
Not well developed market structures	High information cost; High procurement costs

Transaction characteristics

There is still very limited experience with Jatropha production. Neither large companies nor small producers have much experience with growing jatropha in Mozambique. In combination with little agronomic research on the crop, the lack of experience leads to high uncertainty about yields, pests and diseases, and best agricultural practices. Some (commercial) farmers have already had bad experiences with low quality starting material, poor nursery and planting practices (Technoserve, 2006). Due to failures in some large scale jatropha projects and the lack of agronomic knowledge on proper cultivation techniques, particularly on a larger scale than just a few hedgerows, there is broad skepticism about the success of many jatropha projects. Several of our interviewed partners indicated that Jatropha already has a bad image with small producers, which was also confirmed by student research in Manica province (Sitoe et al. 2008).

In a situation where smallholders are involved in the production of jatropha, the seeds have to be transported to a crusher and the resulting oil has to be transported to a refinery. The seeds can easily be stored and transported without loosing quality. However, as they are bulky, transportation over a large distance is not economic. For one liter of oil five kilogram's of seeds is needed.

Because jatropha oil is not edible, the only market outlet for the crop is biofuels. This makes farmers depending on the processing industry. Although crushing of the seeds can be done at village level (i.e. at a relatively small scale), transformation of the oil into biodiesel requires a larger refinery plant. As substantial economies of scale exist in this processing stage of the supply chain, only one or a few of such plants will exist in each of the jatropha production regions. This introduces a certain dependency of jatropha farmers on the processing firm, raising the opportunism risks for the farmer.

After planting there is no harvest in the first three to four years. This implies that farmers have to make investments in the jatropha crop (purchase the seeds and spend time on cultivation) without having any income from the crop until after 4 years. Most smallholders cannot afford to make such an investment.

There is a high chance of abuse of inputs and side selling of the crop. Smallholders may use the inputs for other crops, particularly for food crops. Side selling of the harvest may occur when at the time of harvesting another buyer offers a more favorable price than the buyer that has provided or financed the inputs.

There is high market uncertainty for the farmers as the price of jatropha oil is influenced by the price of fossil fuel, which is rather volatile. Another uncertainty results from the many projects of development NGOs. As these organizations generally have a limited time frame of support, market conditions may completely change when the NGOs shift to other projects and other sectors.

In sum, transactions between farmers and jatropha processors are characterized by high transaction costs and risks, due to the lack of knowledge and experience, the long time lag between planting and harvesting, and the lack of access to inputs and supporting services. Processors also face the risk of abuse of inputs and sideselling of the crop. Formal contractual arrangements may be hard to maintain due to weak property rights enforcement.

5. Contracting in the tobacco, cotton and cashew industries

When companies, state agencies and development NGOs develop new supply chains for jatropha for biodiesel in Mozambique they will most likely make use of experiences in supply chains for other crops and other markets. As the institutional environment for other cash crops is more or less the same as for jatropha chains, it is useful to make comparisons between contractual arrangements for the (potential) jatropha chain and the arrangements in the existing supply chains for cashew, cotton and tobacco.

Cashew
Cashew has a long history in Mozambique. Smallholder farmer are the most important producers of cashew in Mozambique. In the harvest season small traders collect at the farms and sell to larger traders with sorting and storage facilities. These middle traders sell to export traders or sell to processors. Cashew is a low perishable crop; harvested nuts can be stored for a while. Prices are determined at the international market. Cashew poses several risks for farmers. First, it is a perennial crop which makes it difficult for farmers to switch to another crop. Second, only several years after planting the trees bear fruit and the farmer begins to earn some money. These risks are reduced by the involvement of INCAJU, a governmental organization, which supports farmers in their investment and provides them with seedlings, inputs and technical assistance. Contracting is not so common. Only 10 to 15 percent of the cashew is produced under (marketing) contract, some by small farmers but mostly by large commercial farmers, who have contracts with processors or exporting companies. When small farmers are engaged in contracting, they are organized in producer organizations. The contract farming model used in the cashey supply chain is the multipartite model, as the public agency INCAJU plays a dominant role in the supporting the cashew industry.

Tobacco
The cultivation of tobacco began in the late 1990s and increased due to the collapse of Zimbabwe's tobacco industry. The Mozambican tobacco sector works with a concession system where companies have the exclusive rights to purchase tobacco in a particular region. The sector works with a centralized contract farming model where the processing companies buy the largest part of the tobacco from small farmers. The price is determined every year in consultation between the Tobacco Board, which is a part of the ministry of agriculture, and the tobacco companies. Because tobacco requires strict procedures during the cultivation, production management contracts are common to ensure the quality of the crop. This type of contract enables strict coordination between farmers and processing company.

Cotton
The Mozambican cotton industry worked with a concession system until the government decided to liberalize the system in 1999. This free market resulted in heavy losses for the big cotton companies which made the government decide to re-introduce the concession system in 2002. The Mozambican cotton industry works with a centralized contracting model where the processing companies buy cotton from farmers. Companies provide production inputs and technical assistance, thus use production management contracts to tie the farmer to the company. The Cotton Institute, launched by the Mozambican government, is concerned with conflict resolution and setting a minimum price for the cotton.

6. Contract models for jatropha

Potential smallholder producers of jatropha seeds are faced with a number of transaction costs and risks. The sources of these costs and risks have been identified in section 4. The contract farming models identified in section 3 have a differential impact on the solutions to the transaction costs and risks. Three of the models turn out to be useful for the jatropha supply chain. Table 2 assesses the suitability of these three models in addressing particular challenges for jatropha production by smallholder farmers in Mozambique.

Table2. Assessment of contract farming models in reducing challenges for jatropha production by smallholders

Challenges for jatropha production	***Centralized model***	***Nucleus estate model***	***Multi-partite model***
Acquire experience with commercial production of jatropha	+	++	++
Provide access to inputs	+	+	++
Decrease of bad image of jatropha	-	++	+
Provide cash flows in the first years	+	+	++
Decrease market uncertainty	+	++	++
Decrease transport cost	-	+	-
Increase trust of small farmers	+	++	++
Avoiding abuse of inputs	+	+	++
Avoiding side selling	+	++	++

- means no effect; + means that the model can address the challenge; ++ means that the model is very appropriate in addressing the challenge

The centralized model is a classical contract farming model. A processor sources from a large number of small farmers. Coordination entails pre-harvest agreements on quality and quantity. In Mozambique, this model is used in cotton and tobacco. If this model would be used in the jatropha supply chain, the processor would buy the seeds from a large number of contracted producers. The processor invests in crushing and refinery facilities, which can guarantee an outlet for the jatropha seed producers. Because the processor does not have its own jatropha production facilities, it cannot provide farmers with technical assistance based on own experiences. Farmers have to find this expertise elsewhere, or just experiment themselves. Jatropha cultivation practice is largely unknown hence in this model the risks of crop failure seem to be mainly at the side of the farmer which may contribute to a bad image of jatropha.

The nucleus estate model is a variation of the centralized model. Besides sourcing products from smallholders the firm also has its own production facilities, in order to guarantee sufficient throughput for the processing unit. This model is often used for perennial crops like oil palm. For the jatropha supply chain this model means that seeds for processing come from both own plantation and from neighboring small producers. The plantation can guarantee a constant throughput for the processing unit and can be used for doing research on the crop and for the production of seedlings for the small producers. The investments by the firm in a plantation, a crushing facility and a refinery show to farmers that there will be a constant demand for their jatropha seeds. On the basis of its own cultivation experiences the firm can help farmers with technical assistance. As the farmers live near the processing plant and thus face low transportation costs, side selling is less attractive for them.

The multi-partite model implies collaboration between the state, a private firm, and farmers. In Mozambique this model is used in the cashew sector. For jatropha this models means that

the processing firm has contracts with farmers for delivery of the seeds, while a state agency provides technical support and inputs. In addition, this agency can provide market information and help farmers bargain over a contract. This model seems particularly attractive when a new supply has to be set up, as the public agency takes care of some of the risks such as access to inputs, providing technical support, access to credit, access to a guaranteed market, but also sharing experiences with jatropha cultivation.

For jatropha, the nucleus estate model and the multipartite model are the most favorable as they reduce most of the farmers' risks. Suitable cultivation practices for jatropha are still under study. In the nucleus estate model farmers can rely on the experiences acquired by the firm and the reduction of the uncertainty about whether there is a market for the harvested seeds. In the multipartite model there may be a task for the government to protect the farmers by setting minimum prices. Provision of technical assistance and production inputs to farmers could be provided by a public agency.

7. Conclusions

As a result of the increasing demand for biofuels new supply chains develop that link farmers to the bioenergy market, both in developing and developed countries. Particularly for smallholder farmers in developing countries jatropha is considered an interesting crop, as it can grow on marginal soils and it needs low external inputs. However, jatropha supply chains may not easily develop as jatropha production and processing involves substantial transaction costs and risks, both for farmers and processing companies. Jatropha only generates harvestable seeds after three to four years, which requires investments from the side of the farmer which he often cannor afford. In addition, the need for processing makes the farmer dependent on the existing processing facilities. When farmers do not get any guarantee that processing facilities will be available at limited distance (due to high transportation costs) they may not plant jatropha. Moreover, as jatropha is not edible, it competes with food crops. For buyers of jatropha there is the dilemma that they need to invest in processing facilities while they do not have the guarantee of (sufficient) supply of seeds.

In Mozambique the government and NGOs are supporting jatropha production. However, there is limited experience with jatropha as a bioenergy crop. Some development projects failed because of bad quality of starting material and/or because of the non-existence of the processing facilities. This has led to skepticism about the feasibility of jatropha production.

Contract farming could reduce at least part of the transaction costs and transaction risks. Under a nucleus estate model, a state-owned or private company establishes a jatropha production and processing unit and purchases additional jatropha seeds from small farmers. As the company has its on jatropha fields it generates knowledge on jatropha cultivation, also useful for smallholder farmer. The nucleus estate model may also reduce the financial and market risks for the smallholders. Also suitable is the multipartite model, where farmers and processors enter into a delivery contract but a governmental agency is supporting farmers with information, inputs, technical assistance and potentially also credit. This agency could be funded directly by all firms in the industry or indirectly through taxes. By coordinating pre- and post-harvest activities with the actual jatropha cultivation and by providing (temporary) support to smallholder producers, this governmental agency may reduce the transaction costs and risks sufficiently to get jatropha production and processing started.

References

Achten, W.M.J., L. Verchot, et al. (2008). "Jatropha bio-diesel production and use." *Biomass and Bioenergy* 32(12): 1063-1084.

Benfica, R.M.S. (2006). *An analysis of income poverty effects in cash cropping economies in rural Mozambique: Blending econometric and economy-wide models*. Dissertation, Michigan State University. Department of Agricultural Economics.

Da Silva, C.A.B. (2005). *The growing role of contract farming in agri-food systems development: drivers, theory and practice*. Rome, FAO, Ag. M'ment, Marketing and Finance Service: 30.

Dorward, A., J. Kydd, C. Poulton Eds. (1998). *Smallholder Cash Crop Production under Market Liberalisation. A New Institutional Economics Perspective*. Wallingford, CAB International.

Dorward, A. (2001). "The effects of transaction costs, power and risk on contractual arrangements: A conceptual framework for quantitative analysis." *Journal of Agricultural Econ* 52(2): 59-74.

Eaton, C. and A.W. Shepherd (2001). *Contract farming; partnerships for growth*. FAO Agricultural Services Bulletin. Rome, FAO.

FACT (2006). "Jatropha Handbook." Retrieved 12 November 2008 from www.fact-fuels.org/media_en/jatropha_handbook_march_2006

Gagnaux P. and L. Santos (2008). Entomofauna associada à cultura da Jatrofa (*Jatropha curcas L.*) em Moçambique, Faculdade de Agronomia e Engenharia Florestal, 30 de Outubro de 2008

Hueth, B., E. Ligon, S. Wolf, and S. Wu (1999). "Incentive instruments in fruit and vegetable contracts: input control, monitoring, measuring, and price risk." *Review of agricultural economics* **21**(2): 374-389.

Hueth, B., E. Ligon, and C. Dimitri (2007). "Agricultural Contracts: Data and Research Needs." *American Journal of Agricultural Economics* 89(5): 1276-1281.

Jongschaap, R.E.E., W.J. Corré, P.S. Bindraban, and W.A. Brandenburg (2007) *Claims and facts on Jatropha curcas L. : global Jatropha curcas evaluation. breeding and propagation programme*. Wageningen: Plant Research International (Report 158).

Key, N. and D. Runsten (1999). "Contract Farming, Smallholders, and Rural Development in Latin America: The Organization of Agroprocessing Firms and the Scale of Outgrower Production." *World Development* 27(2): 381-401.

Kirsten, J. and K. Sartorius (2002). "Linking agribusiness and small-scale farmers in developing countries: is there a new role for contract farming?" *Develop. Southern Africa* 19(4): 503-529.

Masten, S. E. (2000) "Transaction-cost economics and the organization of agricultural transactions," in: M.R. Baye (ed). *Industrial Organization*, Amsterdam, etc., JAI / Elsevier, pp. 173-195.

Ménard, C. (2004). "The economics of hybrid organizations." *JITE* 160(1): 1-32.

Mighell, R.L. and L.A. Jones (1963). *Vertical Coordination in Agriculture*. Washington, DC, US Department of Agriculture, Economic Research Service, Farm Economics Division.

Minot, N.W. (1986). *Contract Farming and its effects on small farmers in less developed countries*. MSU International Development Papers. East Lansing, MI, Michigan State University, Department of Agricultural Economics.

North, D.C. (1990). *Institutions, institutional change and economic performance*. Cambridge, UK, and New York, Cambridge University Press.

Poulton, C., A. Dorward, and J. Kydd (2005). *The Future of Small Farms: New Directions for Services, Institutions and Intermediation*. The Future of Small Farms, Proceedings of an IFPRI Research Workshop; Wye, UK, June 26-29, 2005.

Poulton, C., J. Kydd, and A. Dorward (2006). "Overcoming market constraints on pro-poor agricultural growth in sub-Saharan Africa." *Development Policy Review* 24(3): 243-277.

Rosenzweig, M.R. and H.P. Binswanger (1993). "Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments." *The Economic Journal* 103(416): 56-78.

Sitoe, A. (2008). Valiação da produção da Jatropha curca L. na provincial de Manica. Universidade Eduardo Mondlande, Faculdade de Agronomia e Engenharia florestal, curso de mestrado em desenvolvimento agrário, simulação de projectos, Mestrandos do ano lectivo 2008/09, Setembro 2008

Swinnen, J.F.M. and M. Maertens (2007). "Globalization, privatization, and vertical coordination in food value chains in developing and transition countries." *Ag. Economics* 37(s1): 89-102.

Technoserve (2006). *Jatropha Plan*. Maputo, Mozambique.

Van Eijck, J. and H. Romijn (2008). "Prospects for Jatropha biofuels in Tanzania: An analysis with Strategic Niche Management." *Energy Policy* 36(1): 311-325.

Williamson, O.E. (1985). *The Economic Institutions of Capitalism. Firms, Markets, Relational Contracting*. New York, Free Press.

Williamson, O.E. (1991). "Comparative Economic Organization: The Analysis of Discrete Structural Alternatives." *Administrative Science Quarterly* 36(June): 269-296.