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Status quo and prospects of smallholders in the Brazilian sugarcane and ethanol sector: Lessons for development and poverty reduction

Fabian Scholtes

Abstract

Along with a growing global ethanol market, investment in the production of sugarcane is growing, targeting new production areas also in Africa. This study addresses the question of how production systems and related value-chains can be created and governed so that they include smallholders in a sustainable manner.

Brazil has historical experience with sugarcane and (large-scale) ethanol. The sector is highly concentrated. More recently, however, small ethanol distilleries have come up. The related production systems integrate small-scale sugarcane growing and alcohol processing in different ways. Therefore, this study asks: what caused concentration in Brazil, and how may it be circumvented elsewhere? And can positive pro-smallholder experiences be transferred from Brazil to other contexts?

Part 1 describes the Brazilian sugarcane and ethanol sector with regards to smallholders. Part 2 describes four different small-scale ethanol systems. These cases are analysed and considered as scenario options for policy advice in contexts outside Brazil.

The general conclusions of this study are as follows:

- Against statistical evidence, the target category of small, non-capital-intensive, poor landholders that produce cane for the sugar/ethanol industry is negligible in Brazil.
- The extreme concentration of the sector as observed in Brazil is not unavoidable. It is at least partly due to (past and current) economic practices and conditions that can in fact be subject to alternative policies.
- While accumulation in cooperatives has often been recommended, there are some doubts regarding feasibility in Brazil and more generally. Still, intelligent set-ups (as in case 2.3) make cooperatives an interesting option to pursue.
- Small-scale ethanol is indeed promising for remote energy supply and related value chains e.g. in rural Africa, especially for uses and markets other than transportation.
- Given the easy integration of cane and ethanol production via small-scale distilleries, cane-producing smallholders may profit from this in particular.
- There are several specificities to the Brazilian model cases, which will affect up-scaling and the transfer to other regional contexts.
- Regulation and several other policy measures are necessary to limit market concentration, and especially to empower small-scale sugarcane and ethanol production.

Keywords:
sugarcane, ethanol, Brazil, smallholders, small-scale biofuel, rural value chains

Introduction: background of the study

Rationale of the study: how to include smallholders in the growing sugarcane sector

The global ethanol market has recently been growing due to high oil prices and the increased demand for alternative transportation fuels. International private investment in the production of sugarcane (a highly efficient feedstock for ethanol production) is growing accordingly, targeting new production areas also in Africa.

In a perspective of development and poverty reduction, this raises the question of how production systems and related value-chains can be created and governed so that they include smallholders, as a care target group of development policies, in a sustainable manner. The hypothesis of the study is that there is a window of opportunity for policy advisory that would support governance and investment towards this inclusion.

Focus of the study: learning from the Brazilian sugarcane and ethanol sector

Brazil has a long historical experience with the production of sugarcane and sugarcane-based ethanol. Generally, the sector is highly capital-intensive and concentrated. The production of ethanol (50% of the industrial sugarcane use) is largely directed to the domestic (~3/4 of the production) as well as international transportation fuel sector. Small-scale sugarcane production does exist. However, it is mainly directed to non-industrial use, in particular to use as fodder.

One small-scale processing sector is the distillation of Cachaça (sugarcane spirit). More recently, this technology has been complemented in various places by small ethanol distilleries. These systems integrate small-scale sugarcane growing and alcohol processing in different ways, which are exemplified below.

Approach, structure and context of the study

Learning from the Brazilian case involves two perspectives. If the sugarcane and ethanol markets exclude smallholders, which processes have lead to this structure, and how may they be circumvented elsewhere? On the other hand, can pro-smallholder experiences be transferred from Brazil to other contexts where smallholder inclusion is vital and needed?

Part 1 analyses the Brazilian sugarcane and ethanol sector with regards to smallholders. Part 2 describes four small-scale ethanol production and processing systems. These cases are discussed with regards to their potential as models for policy advice. Part 3 draws policy conclusions and raises issues for further analysis.

The study is based on interviews and visits to the aforementioned pilot systems in Brazil. These visits were conducted in close cooperation with the International Energy Initiative (IEI) office at the State University of Campinas (Unicamp, state of São Paulo). In addition to this, the author has carried out extensive interviews with several Brazilian and international sugarcane experts.[1]

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[1] The author is grateful in particular for the support by Mr Leonardo Perdomo, research officer, and Prof. Gilberto Januzzi, at IEI. The author has lead interviews with sugarcane experts of the Campinas State University (Unicamp), the São Paulo Institute of Agroeconomics (IEA), the National Statistics Institute in Rio de Janeiro (IBGE), and Czarnikow Group, whose highly valuable insights are much appreciated. In addition, staff of the distillery producer Ouroverde Equipamentos in Ribeirão Preto, in the state of São Paulo (SP) has contributed important knowledge regarding technical and economic feasibility of mini-distilleries. Most important were insights offered by those running the small-scale ethanol projects of section 2, in particular the municipal administration of Angatuba in the state of Sao Paulo (SP), a anonymous sugarcane farmer near Ribeirão Preto, members of the biofuel engineering group at the Federal University of Viçosa, and two consultants of the Fazenda Jardim near Mateus Leme, in the state of Minas Gerais.

Based on a three-weeks field trip and data collection in August/September of 2008, the present study is to taken as complementary to literature-based analyses. Its purpose is to make available Brazilian expertise in small-scale

1. Smallholders in the Brazilian sugarcane sector: status quo and options

The main questions of this section are: Does the reported existence of sugarcane smallholders in Brazil show that, despite the sector's concentration, smallholders can compete with large-scale plantations in producing cane for sugar and alcohol industries? And if not (which will turn out to be the case), how do they persist without competitiveness? Based on this, section 2 will ask if small-scale ethanol is, or can be, an alternative, competitive economic niche for these smallholders.

Conclusions are (for details see section 1.1-1.3):

- The category of non-capital-intensive, poor, mainly cane-producing smallholders who produce for the sugar and ethanol industry is negligible in Brazil. Smallholders either do not produce cane for industry (but as fodder), or they mostly do not produce themselves (the industry produces on their land). Still, many smallholders do participate in the ethanol value-chain by renting land to the industry.
- There was no difference reported in terms of yields/ha between small and large cane producers. However, production costs differ from large plantations in particular due to harvesting mechanisation. The extreme concentration of the Brazilian sector is partly due to conditions (e.g. legal regulation) that can be subject to policy. Details of the Australian case show how concentration may be avoided.
- To achieve economies of scale with smallholders' cane produce, the accumulation in cooperatives has been recommended. There are several doubts, however, regarding the feasibility of cooperative models especially in Brazil. Cooperatives can be based on processing sugarcane towards ethanol. Small-scale ethanol production should target niche markets, but not the transportation sector.

In sum, smallholders are not competing with large companies. Brazil is not an example of including smallholders in the sugar industry or the ethanol boom. This said, there are potentially feasible options for small-scale ethanol value-chains (see section 2).

1.1 Do smallholders persist in the sugarcane/sugar/ethanol sector? If yes, how?

Information on if and how smallholders as a development target group persist in the sector is ambiguous: (a) 'Sugarcane smallholders' are defined in different ways, and not all are relevant to poverty reduction. (b) Statistics are unclear and biased, even regarding a defined category of smallholders: on most smallholdings, it is the industry that produces.

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ethanol – in particular recent experiences as embodied in the projects in section 2. As for related literature, Kohlhepp (2008) provides a useful, balanced background reading on the Brazilian sugarcane sector and the recent growth of the ethanol sector. Gerber (2008) offers a comprehensive review of the current state of the biofuel sector more generally. Smeets et al. (2008) inquire the overall sustainability of ethanol in the state of São Paulo, with a particular concern for certified production. As for Brazilian literature, Buainain 2007 provides an overview of Brazilian smallholder agriculture, which clearly shows the limited importance of sugarcane production (unless as fodder). Sidnei Gonçalves (2000) offers a critical analysis of the historical development of the Brazilian sugarcane sector and suggests the separation of planting and harvesting (as allegedly the case in Australia) for avoiding over-accumulation and over-concentration of the sector. The comprehensive small-scale ethanol experience of the Viçosa University group is summarised in a small handbook edited by Juarez De Sousa e Silva (2007). The master thesis by Roberta Nogueira, in which total production costs of ethanol are compared across large-scale producers (usinas) and smallholders, is not publicly available to date. The July 2007 edition of Globo Rural, a Brazilian magazine, presents the cases of several private small-scale ethanol producers who use their produces for their own car, and who are clearly not a main target group of development in the sense of poverty reduction.

a) Are there smallholders that would be a target group of poverty reduction?

Given the enormous properties of large-scale producers, a sugarcane farm with 100 ha in the state of São Paulo is considered a smallholder. This definition by relative size varies across states (producers in São Paulo are particularly large) and respondents. A usual threshold is 50 ha. Opposed to this, smallholders are also understood as family farming. As a legal term e.g. for credit lines, family farming is defined by property size (São Paulo: 30 ha), number of employees (<3) and gross annual sales. Smallholders in this sense are negligible in the sugarcane sector. Case 2.2 shows that a family-run sugarcane-for-industry farm needs far more property.

Development agencies may take a socio-economic rather than merely legal or relative focus: 'really small' landholders/family farmers are the target group since they are poor. This is not the case with 'relatively small landholders' who own 100 ha and even a processing unit worth R$ 6 million (case 2.2). Nor is this the case with a public servant's part-time production in the backyard. In Brazil, 50% of family farmers have less than 5 ha. In case these families live from farming only, they practice to a large extent subsistence farming (a typical development 'target group'), and they hardly produce sugarcane but crops that add higher value on their scarce land and labour.

Even if small family farmers do produce cane they do not do so for industry, and not exclusively, but as a complementary crop (as fodder). Cane-as-fodder is found for instance in Southern Brazil, where there are the highest numbers of smallholders with less than 50 ha producing cane (among other things). Cane-as-fodder is only 10% of all cane in São Paulo, and even less in other states. Exception to this is cane produced by, or directed to, small-scale cachaça producers, especially in the state of Minas Gerais, and cane producers connected with the large processing units (next section).

Regarding small cachaça producers, it is not clear if they would be a development agency's target group. Cachaça is not necessarily their main source of income. They tend to produce and sell clandestinely. One reason is that to be certified they would need to comply with demanding production standards. In 2001, there were 30,000 registered cachaça producers in Brazil, but the total number is probably much higher. Moreover, a cachaça-based livelihood is not a first-choice for policy recommendation.

b) Smallholders on whose land sugarcane is produced for (and by) the industry

Thus, the target category of 'really small', non-capital-intensive, poor, mainly cane-producing landholders that would be producing for the sugar and ethanol industry, and that would be competitive in this with plantations, is negligible in Brazil.

Statistically, however, smallholders do exist whose cane produce is directed to the sugar and ethanol industry, and who thus participate in this value-chain. These small producers supply to large processing units (usinas). There is a spatial limitation to this: only in a radius of ca. 30 km collecting cane is economically viable. Apart from transportation costs, cane also needs to be crushed within a time frame of ca. 48 h.

Within this radius, the land value rises and land is increasingly devoted to sugarcane production. Two resulting processes of property concentration are reported. Either the usina buys the land from smallholders and offers them a tenancy or the usina rents the land from smallholders in bilateral contracts and takes over the whole production process. The second renting system works in the majority of cases. For the smallholders, this means a reliable income. E.g., a 20 ha smallholder may plant vegetables on 8 ha and rent 12 ha for R$ 6,000/y to a usina. The usina produces 1.200 t/y of cane on this land, for which it would otherwise pay some R$ 30,000. Note that the smallholders' role is reduced to landholding. This implies a systematic dependence on contract compliance by the usina and on secured land tenure (which may be a bottleneck in other countries).

This renting system also implies that statistics are misleading. First, it was not possible to isolate data on how many smallholders supply to the sugar and alcohol sector, who and where they are, and how they produce. Moreover, the renting system leads to an overestimate of producers. Several experts hold that the vast majority of the statistical smallholders rent their land to the industry. These smallholders present themselves as producers because land rent is taxed significantly higher than productive income.

Thus, available agro-statistical data on supply quantities from smallholdings to the industry do not show smallholders' productivity or competitiveness.

In sum, it can be followed that there is de facto no competition, and presumably no competitiveness, of smallholders in industry-oriented cane production: either they do not produce for industry, or they do not produce themselves. Nevertheless, many smallholders, by land renting, do participate in the ethanol value-chain. In this specific sense, Brazil is not an example of competitive small-scale cane-for-industry production.

1.2 Reasons for the concentration of the sugarcane/sugar/ethanol sector

Sugarcane is a commodity with no qualitative differentiation except for its sucrose content. Mechanisation of production is possible if land inclination is low. If mechanisation is not possible, manual harvest, while physically extremely demanding, does not require highly qualified labour. Sugarcane therefore offers substantial economies of scale.

The related tendency of mono-cultivation, accumulation and concentration of production and processing units has been interpreted as 'natural'. With free competition and economies of scale, concentration displaces small producers from the market (including the land-renting model). In the state of Paraiba, the number of smallholders has declined by 80% to 400 in the period of 1987-2002. Except are those close enough to a usina so that the usina, if it needs additional supply, buys their feedstock despite higher prices. Given the ambiguity of statistical information, it was not possible to isolate this group.

However, to conclude from this that smallholders are not competitive with large companies would be a truism. Moreover, in India and Australia, concentration did not place like it did in Brazil. The question rather is: Under which conditions does such concentration occur, and are these conditions governable? Among the conditions are the following:

- In Brazil, climate allows for growing sugarcane throughout the year, which facilitates accumulation. In other countries, climate may restrict accumulation temporarily, but probably only until biotechnology provides compatible varieties.
- Limits to mechanisation of harvesting, especially unfavourable topography, impede extreme concentration. Restricting sales in a non-mechanisable area to locally produced cane may allow for regional persistence of smallholders. For Brazil, this should be considered for areas in the Northeast from which large companies are currently withdrawing. If this can be organised successfully is an open question.
- Highly sophisticated genetic engineering (cane varieties) and technological improvements in harvesting, industrial processing and end use technologies strongly have contributed to the concentration. While organisations like EPAGRI (the public Agricultural Research and Extension Company of the state of Santa Catarina) do provide sophisticated cane seedlings for free, to date mainly the large companies have profited from technological development. Appropriate adaptations of technological development to support small producers in increasing their productivity and gains are lacking. The access of smallholders to advanced cultivation technology can be addressed on the policy level (see section 2.6).
- Concentration is also explained with the association of harvesting/processing capital and land in single companies. Much of the production land is owned by processing companies (100% in the state of Goiás, 75% in São Paulo). Concentrations in production and processing facilitate each other. In Australia, the two capitals are kept separate: by law, the processing industry must not produce feedstock, and harvesting is to a considerable extent organised in a system of outsourcing.
- In the Australian case smaller harvesting machines are available, providing mechanisation advantages also to small producers. In this system, even producers with only 150-160 ha seem to be competitive. The Australian case was recommended several times for further research.
- It has been suggested that a patrimonial mind-set, which values the management of one's own land, impedes an outsourcing-based system like in Australia that would lead to less concentration. If other mindsets in other contexts could facilitate maintaining small-scale production is, however, a problematic issue.

- Finally, dominance of large producers is seen as a result of market failure: these producers do not bear ecological and social costs of monoculture and capitalisation. A comprehensive comparison of the full cost structures of small and large production/processing systems is currently done at the Federal University of Viçosa. According to it, the cost difference per litre of ethanol of R$ 0.25 (large-scale usina) vs. 0.65-0.75 (mini-distillery) are largely due to ecological and social costs not being internalised into the usina's cost structure.

As for smallholders participating in the ethanol value-chain by selling ethanol, there is a legal impediment. Ethanol retailing is regulated by the National Petrol Agency (ANP). An ANP decree from 2000 restricts retailing to petrol stations. These stations can buy fuel from authorised distributors only. This centralising system is justified with concerns of guaranteeing quality. It implies that ethanol produced by small enterprises cannot be sold directly, but only to often-distant distributors. This causes additional transportation costs and circumscribes small producers' competitiveness. A legislation proposal that stipulates direct retail to consumers and petrol stations by small producers is in process.

1.3 Prospects of the sector with regards to smallholders

a) Expansion of the consolidated sector expected to perpetuate concentration

A new agro-economic census, based on data of 2006, still awaits final publishing. In June 2009, only preliminary results were available online. According to the census' coordination office of the Federal Statistics Agency (IBGE), the concentration in cane-production and particularly in the processing industry has even increased since the last census (1996). The ethanol boom, including an increased export orientation, will reinforce the importance of economies of scale.

The system of land-renting by smallholders is hardly controllable. Law enforcement is a general challenge in Brazil. The land-renting system has started including even assentamentos. These are formerly unused land units, expropriated under land reform law and given to landless families. They are intended to allow for subsistence and food production. Their use for industrial cane undermines this intention. Moreover, it is expected that new generations of smallholders will even sell their land to the industry.

Mechanisation is still being intensified. In 2014, all land in São Paulo with up to an inclination of 2% (i.e. 80% of arable land of the state) will be harvested with machines. According to a 2008 report of Globo Rural television, harvest costs/ha are 650 R$ with machines and 1.100 R$ with manual labour. The pre-harvest burning of cane fields for manual harvesting, though still being practiced in some 80 % of the cane fields, is increasingly being out-phased. This is partly for reasons of the workers' and public health (air pollution), partly because it wastes bagasse used by usinas to produce and sell electricity – currently, usinas install more efficient boilers, since it is not anymore only about getting rid of the bagasse. Finally, labour unions exert pressure to end the slavery-like manual harvest. A drawback of this is the loss of income for smallholders who come from the Northeast as seasonal workers. In SP, the unemployment of these workers is expected to start in 4 years and would affect >140,000 individuals.

Due to relief-induced limits to mechanisation, large producers of the Northeast (states of Paraíba and Pernambuco) have started moving to Paraná in the South. To what extent this translates into opportunities for labour-intensive small-scale cane production is currently analysed at Unicamp.

b) Cooperatives: a suitable and effective means to achieve economies of scale?

According to most respondents, the best way to include smallholders into sugarcane production (other than the land-renting system) would be via cooperatives that accumulate sufficient produce to cross the efficiency threshold of processing units.

At the same time, respondents are pessimistic about the realisation of cooperatives. Only a sophisticated government program could provide for sustainable incentive structures (beyond reduced income tax, as it exists in Brazil) and governance of cooperatives. Note, however, that the biodiesel program in the Northeast, which was to support family farmers, failed primarily because farmers were

unable to deliver scheduled feedstock quantities. This may be different with the traditional feedstock sugarcane.

Moreover, a cultural argument was made quite often: in Brazil in particular, opportunism and individualism would eventually frustrate any corporativism and lead to non-compliance of cooperative obligations and free-riding. The exception would be the southern states where smallholders are well-organised for historical reasons. Note that sugarcane 'smallholders' in Paraná often have some 70 ha. Several respondents suggested that, based on more collectivist cultures or religious leadership, cooperatives may function better in Africa. However, evidence collected also by ZEF challenges this view.

As for cane-for-ethanol, cooperative accumulation relates to two versions: accumulating feedstock vs. accumulating processed liquid, especially pre-alcohol. Pre-alcohol includes residuals from cachaça distillation with 35% or low-level alcohol with 80%, both of which would then be processed in small, though centralised distillery. Examples of accumulation at early processing stages (i.e. collecting cane juice) were not found. Cooperatives are usually understood as associations of farms, rather than a farm run by several farmers. Details are discussed below in the context of small-scale models. Beyond the cooperative option, the option of individual mini-distilleries is considered.

It needs to be considered to what extent a shift to sugarcane production for industry implies a fundamental restructuring of family farming. For instance, labour use would be concentrated on cane production/harvest during several months of year, circumscribing the labour resources available for other cropping activities.

In terms of production efficiency, small distilleries are reported to now come close to large usinas. Opinions differ, however, on whether this also holds for very small units, and if it is an option that smallholders have individual distilleries. Opinions also differ on if the necessary human capital, i.e. technical knowledge for small-scale processing is given. Finally, instead of mechanic sucrose extraction, chemical extraction ("diffusion") has been mentioned to be potentially more viable for small producers in that it demands less investment. However, others doubt that this rather sophisticated system is, or can be, adopted on a small scale. Follow-up research on this is necessary.

c) Different uses of ethanol: niche markets for small-scale production

Given the structure and regulation of the Brazilian market, the inclusion of smallholders and/or small ethanol producers has been seen in niche uses and markets rather than in transportation fuel. Selling small-scale ethanol for transportation would require a legal reform. Even then, and even if internalisation of ecological and social costs of large-scale production took place, it is open if small ethanol production would be competitive with large distilleries. The cost model of case 2.3 allows for some optimism.

One niche would be household devices like ethanol-fuelled cooking stoves, lamps, fridges, etc. A second main niche would be electrification in remote areas. Note that both niches have been considered to be options especially for other countries. In Brazil electrification is steadily advancing under the government program 'light for all'. As for cooking, a comprehensive LPG (liquid gas) distribution network is already established. Moreover, cultural barriers have been seen against the substitution of liquid gas by ethanol. Section 2.6 considers these alternative uses as options for other countries than Brazil.

2. Small-scale ethanol production: pilot projects as potential scenarios

In contradiction to available data, in Brazil industry-oriented sugarcane is hardly produced by smallholders. This section asks therefore if small-scale ethanol is a promising economic niche for (these) smallholders, or under which conditions it can become such niche.

In the following, four small-scale ethanol production sites are described. They are viewed as developmental pilot projects and analysed as potential scenarios or models of how an ethanol-based value-chain could be set up.

Conclusions of this section are as follows:

- Small-scale ethanol is indeed promising for remote energy supply and related value chains e.g. in rural Africa, especially for uses and markets other than transportation.
- Given the easy integration of cane and ethanol production via small-scale distilleries, cane-producing smallholders may profit from this in particular.
- There are several specificities to the Brazilian model cases, which will affect and partly limit up-scaling and the transfer to context.
- Small-scale ethanol will not be sufficient to keep smallholders as sugarcane producers in the sugarcane-for-industry/sector when this becomes subject to concentration. Regulation and other policy measures are necessary to avoid market concentration and to empower small-scale sugarcane and ethanol production. Some of these measures are demanding, though not impossible.

The technical process of small-scale ethanol production is as follows. The harvested biomass is milled, yielding some 600 l/t of juice. If used for alcohol production, the juice is diluted to have an adequate sugar-to-water mass ratio (Brix) that allows for fermentation (usually from ca. 21 down to 15). This liquid is fermented to wine (10-36 h).

When the Brix level has reached zero, this wine is distilled: the alcohol (10-12 %) is separated from the water and rectified up to 95%. Steam from a boiler, which is often fuelled with bagasse, provides process heat. In the case of a combined cachaça/ethanol distillery, the first and last 10-15% of the distillate can be used as pre-alcohol (35%) and distilled further, either to low-level alcohol (80%) or up to ethanol (95%). Vinasse remains as residual. On average, one hectare yields 90 t of cane per harvest, or about 6,000 l ethanol (at 70 l/t).

2.1 Angatuba: multipurpose value-chain created and sustained by a public body

The municipality of Angatuba (with 20,000 inhabitants, in the state of São Paulo) runs a small sugarcane processing unit that produces ethanol, which is used as fuel for the municipal car fleet, and rapadura, a nutritious sweet produced from concentrated cane juice that is distributed as snack in primary schools.

Prefect J. Lisbôa presented the project as an endeavour to 'bring the economy back to the people'. The project is run publicly, and to considerable extent by him personally. He extensively highlighted social contributions of the project (employment, healthy school snacks). His vision is every smallholding has its own distillery.

Six smallholders of the municipality grow high-quality cane along with other crops, on 3 ha each, during 10 months of the year. Three cutters of a nearby large distillery harvest the cane manually. Since

harvesting is without burning, they make some 5 t/day. The project employs one person for transporting the feedstock to the processing unit. The municipality buys the cane from the growers at market price, with a loose guarantee (no contract), and supports plantation and growing.

Four people run the processing unit, during 7 h/day. The 5 t/day of cane are milled with grid electricity. The bagasse is used for heating the boiler, together with wood from municipal street-cleaning. Some 500 l of juice/hour result from milling. Juice is partly diluted and fermented to cane wine, or concentrated for rapadura sweet. Output quantities are currently being verified, since numbers that were stated are contradictory. If all cane were used for ethanol, some 3,500 l/day should result, but the distillery is smaller. Vinasse (liquid distillation residual) is used as fertilizer on the nearby orange plantation.

Production of rapadura sweet (left margin) and
mini-distillery for ethanol (background) in Angatuba

Concrete information on the cost structure was not accessible. This concerns labour costs/income generation (cutters, distillery staff), operating costs (mill electricity), and avoided costs of the municipal fleet, of the rapadura production, and of production inputs to related activities (fertilizer for orange plantation). Moreover, regarding the cane-producing smallholders, it is not clear whose land they farm, how complementary cane-growing is with other crops, what their added income is from the project.

The system depends on electricity grid connection. This may be a bottleneck for decentralised island solutions (see section 2.6). Finally, the project relies on the personal idealism and leadership of the prefect. It has not been possible to find out if the project self-sufficient in market terms or if it depends on cross-subsidising with municipal means.

2.2 A private farm with individual distillery for cachaça + ethanol

The sugarcane farm roughly near Ribeirão Preto remains anonymous here to protect the owner as informant. The farm is privately run and has its own processing unit. By comparison, this distillery is still small, even though according to the interview it processes 5,000 to 6,000 l of alcohol per day (see picture on next page). The total investment for the milling and distillation facility was specified as 6 m R$.

The acreage used for sugarcane was said to be 100 ha, from a total of 140 ha. This would yield some 10,000 t per harvest, of which 9,000 are actually processed, yielding some 5.400 m³ of juice. If all juice were used for ethanol, it would yield 675 m³/harvest, or about 3.800 l/day (with the plant being run 6 months/year). Since also cachaça is produced, with a higher yield per l of juice, this would correspond to

the indicated 5,000l of alcohol/day. However, the owner says he uses only 30% of the juice for alcohol (20% for cachaça, 10% for ethanol) and the rest for sugar, and that he even sells sugarcane. This would mean his property is even larger (or less alcohol is actually processed).

5,000 l/day cachaça and ethanol distillery, Ribeirão Preto

Ethanol production costs were estimated R$ 0.60/l by the owner. Recent doubling of fertilizer prices contributed to this. The distillery fabricant who built the processing unit estimated them at R$ < 0.40. Usinas produce at R$ 0.25. The retail price for ethanol had fallen (by that time to 1.30 R$/l). Outside the state of São Paulo, prices are higher due to different tax rates and costs of transportation from the production sites. Small production may be more competitive in these states (de Sousa 2007: 50). The owner sells clandestinely, at a retail price of R$ 0.95 (R$ 0.85 for cachaça). The ethanol profit margin between R$ 0.35-0.55/l does not match the conservative general estimates of the owner. However, the owner has reasons to maintain a low profile towards investigators and might have given information accordingly; similarly, the distillery fabricant has reasons to highlight the efficiency of his equipment and might underestimate the production costs.

This case shows the economic situation of small/medium private farms in comparison to large usinas. This farm was beyond the legal size definition of family farming. Still, it seems to have to rely on direct, clandestine retailing. The owner considered expansion of his enterprise a problem. Partly this is because industrial credit lines, as opposed to agricultural credits, are not available to small producers (i.e. less than 10,000 l of ethanol/day). In sum, the case casts doubt on the option of small-scale/family farming ethanol production for the transportation market, even at this size (> 100 hectares).

2.3 Viçosa: private cachaça + ethanol distilleries linked via a milk cooperative

The concept of small-scale alcohol production near Viçosa (state of Minas Gerais) is to use the logistical and processing infrastructure of an existing milk cooperative. In terms of logistics, this means that the milk road tanker that passes at the different remote smallholdings would also collect the low-level alcohol. This reduces the transaction costs substantially and facilitates the accumulation of produce. In terms of processing infrastructure, this means that the heating part of the milk pasteurisation machine, which is used only during a couple of hours per day, also serves for the rectification of pre-alcohol (35%) or low-level alcohol (80%) into ethanol (95%).

Moreover, this central production unit also constitutes the distributive centre from which, in this particular setting, the members of the cooperative can directly get ethanol in barter exchange for the pre-alcohol they provide – maybe at a lower price than at the petrol station, which is an additional income generation for the cooperated farmers.

At the Federal University at Viçosa (UFV), a research group is investigating the technical and economic feasibility of mini-scale ethanol production. The group also fabricates small processing units. A

hypothetical cost model for a 1,000l/day distillery with 25 ha of cane shows a hypothetical cost structure and investment calculus (see De Sousa, Ed., 2007, pp. 65 ff. Numbers are approximated, monetary values are given in R$.)

Framework and production data:

- Planned production: 200,000 l of 80% alcohol (for rectification in central distillery) in a harvesting period of 200 days (= 1,000l/day)
- Required feedstock/acreage: 2.857t/period (=15 t/day), or ca. 25 ha + buffer area.
- Assumptions: yield of 1st harvest = 140 t/ha, declining to 80t/ha in 6th year
- Plantation system: 18 ha planted in year 0, then 1 ha planted in addition in each harvesting year 1-6. In year 6, 24 ha are used, of which 18 ha (planted in year 0) need renovation.

Non-recurring costs of initial investment:

Item	P/unit	Units	Value
Facility shed	15,000	1	15,000
Mechanical mill	20,000	1	20,000
Distillation unit (complete)	15,000	1	15,000
Fermentation barrels	1,8000	4	7,200
Storing barrels	1,000	3	3,000
Seedlings	100/t	270 t	27,000
Total			87,200

Recurring costs (total sum, over 5 years, i.e. initial year 0 and 4 subsequent farming years; varies in total per year according to acreage used):

Item	P (/unit)	Units	Value
Labour (ploughing, harrowing, furrowing, liming)	50	* X ha	9,240
Labour (planting, fertilising, harvesting, transportation)	20	* X ha	96,800
Land rent	300/ha	25	7,500
Fertiliser, pesticides etc.	Var./ha	* X ha	108,725
Administration	600/month	12 m/y	36,000
Technician	20/h	20h/y	40,000
Accountancy	7.20/ha	* X ha	2,100
Total			300,365

Cash flow scheme over 1+7 years, with an assumed retail price of R$ 0.68/l:

Year	Sales volume (l)	Sales value	Costs	Flow	Flow, discounted	Accumulated Flow	Acc. flow, discounted
0			168,324	-168,324	-168,324	-168,324	-168,324
1	201,600	137,088	59,857	77,231	67,157	-91,093	-101,167
2	209,600	142,528	63,068	79,460	60,083	-11,633	-41,084
3	204,800	139,264	63,527	75,737	49,798	64,104	8,715
4	204,000	138,720	66,945	71,775	41,038	135,879	49,752
5	200,800	136,544	69,072	67,472	33,545	203,351	83,298
6	200,400	139,264	83,353	55,911	24,172	259,261	107,469
7	198,400	134,912	59,261	75,651	28,440	334,912	135,909
Total	1,419,600	968,320	633,408	334,912	135,909		

This flow implies a net present value of 135,909 R$ and an amortisation time of 3 years.

A farm near Viçosa uses this group's equipment. During 3 m/year, ca. 3 ha of cane are grown and harvested. As in cases 2.1 and 2.4, harvesting is manual and without burning, and a substantial amount of biomass remains on the field (ca. 25 %, picture below). This is an example of a production system that combines cachaça and ethanol. For cachaça the tip has to be removed. This adds further biomass remaining on the field.

Some 2 tons of cane or 1,200 l of juice are processed per day, resulting in 15,000 l high quality cachaça per year, which is sold for 6 R$/l on-farm (12 R$/0,75l bottled). The first and last 10-15 % liquid of the distillation process, which are not feasible for cachaça production, are processed to ethanol (3.700 l/year), which is used for the farm's car.

Sugarcane field near Viçosa: biomass remaining from harvest serves as fertilising mulch

The remaining bagasse is used for heating the boiler. As fertilizer, the vinasse is used. This system again is not an island solution. It depends on the electricity grid for the mill and process water pump (3,000 l/day). The total cost of the overall investment was indicated at 180,000 R$. While in this case it is only the cachaça distillation residual that is used for alcohol production, other customers of the university's research group have (only) bought the distillation tower and directly produce low-level alcohol or ethanol.

2.4 Fazenda Jardim: low-technology integrated cattle + ethanol farm

The Fazenda Jardim distillery is a pilot project founded by a pioneer of Brazilian small-scale ethanol production. It is set up as a most simple technology. Cachaça and ethanol production is integrated with livestock farming. The whole system only occupies 20 of 300 ha, of which some 6 ha are pasture, and 10 ha a reserve of natural vegetation.

On 2 ha, sugarcane with low impact on soil ecology is grown, yielding 100t/ha. The portfolio includes precocious and delayed harvest varieties, so that harvesting is extended over a longer period. Harvesting is usually done manually and without burning, cutting 3-4 t/day (ca. 4h/day) over a period of ca. 200 days/year. Daily cutting amounts are limited since cutting has to be coordinated with other activities of the family-run farm. A time schedule that exemplifies the integration of sugarcane and ethanol into this family farming system, including labour amounts will be provided by technical consultants of the project.

Fertilising of the cane field is done with the distillation residual (vinasse), of which up to 150 m³ are applied per ha (if not given to life-stock, especially in the dry season). The residual is also enriched with liquid manure and bagasse (unless used as fodder, for which it is left with 30% of moisture). This fertiliser also raises the cane's Brix level.

The sugarcane is milled with an electric mill, though not completely, since the tips are processed as tasty finger food (400 kg/ha) and sold. For a grid-independent solution, the mill could also be a manual one (with a metal or would axis pulled by an ox).

Fermentation of the juice is done not with artificial ferment, but with a rice/corn mixture. In this system, the combination of cachaça and ethanol (rather than raw alcohol from cachaça residuals, case 2.3) means that for cachaça the lower part of the wine is taken for distillation, and for ethanol the upper part is taken.

Processing heat for distillation is gained by burning eucalyptus fuel-wood planted in a mini-monoculture field of 1 ha (with 20,000 trees/ha/year), harvested stepwise in a folding technique, throughout the whole period. 3 kg of fuel-wood are necessary to produce 1 l of ethanol. The eucalyptus field is fertilised with wine residual.

2.5 Other small-scale ethanol systems

The number of mini-distilleries for ethanol has recently grown considerably in Brazil, even though there were no policy measures to support this. It would be helpful to know how these work in comparison with cases 2.1-2.4. Unfortunately it is futile to try localising them for instance by tracking them back to equipment-providing companies: most mini- distilleries are employed by small cachaça producers in the state of Minas Gerais, who use production residuals and who are often not registered. Beyond cases 2.1-4 the author is aware of three more activities/projects. With these and the cases presented above, the spectrum of different small ethanol models seems to be roughly covered:

- Similarly to case 2.1, the 1,200 km² large municipality of Mariana (state of Minas Gerais) plans to cover its fuel demand of 1800 l/day with ethanol from a small central distillery. Different from 2.1, the municipality only facilitates the set-up of a cooperative, to empower the small producers to become organised entrepreneurs. Similar to 2.3/2.4, the smallholders' cane production is linked with dairy cattle farming. An income generation for 1,200 cooperated producers is envisioned. According to the project consultant, the feasibility threshold lies at only 200 ha of cane, or 100 smallholders and 980,000 l/year. This is 50% more than the municipal fleet's demand, which would be a base demand. The rest is to be sold as cooking fuel to consumers, or – for a lower price, but as guaranteed sale – to an official distributor.
- In the state of Rio Grande do Sul, the Biofuel Cooperative Cooperbio plans to set up a processing unit for 60,000 l/day of ethanol, with an investment planned at 15-20 million R$. 10 mini-distilleries are being installed on smallholdings with cane production, to provide low-level alcohol for rectification in the central unit. To date, the cane is used as fodder. The ethanol can be sold in the Petrobrás framework on the market. In the targeted area, the next usina is

300 km away, so that the usual ethanol price is high (2.00 R$/l). The locally rectified alcohol can be sold, at least to the members of the cooperative, much cheaper than this.

- In the state of Rio Grande do Sul, an energetically self-sufficient system is run with a very small distillery of 50 l/h, where the sugarcane mill is fuelled with ethanol. This is an attractive option for decentralised energy development and promises important insights for isolated systems.

2.6 Analysis and policy implications: Prospects of small-scale sugarcane/ethanol

The cases show that, given some conditions, smallholders are indeed able to produce sugarcane and ethanol, for domestic use or beyond. The required technology is available, and ethanol production can be integrated into a small family farming production system.

Three issues are crucial: (a) Can these experiences be generalised beyond pilot projects? (b) What are related prospects of small-scale sugarcane and ethanol, especially in terms of energy development? (c) Which value-chains are possible with such systems?

a) Up-scaling and transfer to other countries: general issues

The presented systems are pilot projects (except 2.2). Up-scaling the number of systems will constitute a challenge: for small-scale family farming, shifting production towards (more) sugarcane implies a substantial transformation, even under favourable economic conditions. Moreover, the visited cases rely on public support, individual idealism and leadership, or clandestine retail. As economic systems, they are not free-standing. This limits up-scaling further. Regulation of small-scale sugarcane and ethanol markets cannot suppose that all systems will work like the presented cases. It rather requires additional incentive structures etc. that support farmers in taking up production by themselves. The conclusion of this study suggests how the economic viability of different small-scale systems may be inquired by means of scenario-building.

Finally, beyond very good conditions for growing sugarcane, Brazil also has a long tradition of processing cane to alcohol (cachaça). The sector relies on wide-spread technical knowledge and a distillation culture that may not easily be achieved elsewhere. The vast majority of privately produced small-scale ethanol in Brazil is attached to cachaça production, which is not necessary a policy option for other contexts. The importance of the cane and ethanol tradition should not be overestimated, but neither must it be neglected. The history of development practice contains numerous examples of technologies not being taken up for reasons of incompatibility with local culture. While pilot projects may successfully be set up in a different context, the take-up by a broader population is a challenge that can only be solved by local innovation that invents locally compatible systems by adapting the available technological elements (see also b.ii and Buainain 2007). Therefore, a key conditions for up-scaling is whether ethanol systems and value-chains based there-upon are able to be 'dismantled' and reassembled according to local needs, existing practices, mindsets etc. and to keep functionality at the same time.

b) Empowering small-scale sugarcane/ethanol production, avoiding concentration

(i) Empowering small-scale sugarcane production

A core issue is reducing smallholders' overall cane production costs. Regulation should make technological progress available to smallholders on a general scale, as related to seedlings, harvesting mechanisation etc. Beyond regulation of private knowledge (patents), public provision of new knowledge and technology is an option (see 2.4). Incentives for small-scale technology innovation are plausible. E.g. harvesting labour is a dominating cost factor. Above an acreage threshold, small harvesting machines – possibly compatible with land inclinations that do not allow for large machines – should be profitable.

Complete specialisation of family farming production towards sugarcane is not recommended, as it risks loosing the resort to subsistence production. Integrated systems e.g. with cattle, like in the cases above, are more plausible. If this integrated approach conflicts with a minimum acreage devoted to sugarcane is

an open question. It needs consideration if land concentration can be avoided by measures as reported from Australia, i.e. separating feedstock growing and harvesting, so that the recursive accumulation of owning large harvesting machines and ever-larger properties is avoided.

Incentives that lead to hidden concentration need attention, too. An example is the tax preference for production income over land rent. This may support small producers, and it could be fostered by size discrimination, preferring production income or even subsidising produce from smallholdings over large farms. However, if limited enforcement and monitoring lead to the undeclared renting to large producers like in Brazil, concentration follows, and the pro-smallholders effect merely depends on the renting contracts.

(ii) Empowering small-scale ethanol production

There are different options of making use of new ethanol distillation and use technologies:

- If policy is in particular about the inclusion of (sugarcane) smallholders, it needs to include the measures of the former subsection, e.g. to lower overall production costs.
- If policy is about energy development and income generation more generally, and if there is large-scale sugarcane at lower costs, smallholdings can buy feedstock and use mini-distilleries for their domestic energy supply. This may be preferable to shifting production to sugarcane, especially in the context of family farming.

In Brazil, small-scale ethanol technology is advanced. Producers of small cachaça distilleries (alambiques) can easily take up equipment production. Some mini-distillery business has already developed. To include equipment production into small ethanol value chains in other countries, local innovation is required, backed by entrepreneurial and technical training. This may be supported with external technology transfer, but since the hardware is rather simple, innovation will probably relate to locally specific implementations of this hardware. Regulation may reserve this market for small entrepreneurs, to prevent it from being taken over by large companies producing the giant usina equipments.

Legal facilitation of small-scale ethanol production may include for instance less demanding hygiene requirements for official registration as compared to cachaça. Apart from that, production regulation mainly concerns ethanol quality (see below).

It is not clear how small energy-autonomous ethanol processing systems can be, and if they are feasible for individual households. In the cases above, grid-dependence mainly stems from electric mills. Burning bagasse can provide heat. To date, cogeneration of electricity from bagasse needs some scale and is restricted to large units. Using the system's ethanol output for a generator is technically feasible. However, it has been estimated that up to 50% of the produced alcohol would be used. For very small and remote units, animal power (an ox pulling a mill wheel) is a feasible alternative.

c) Value-chains based on small-scale ethanol: local and related to energy development

Current growth of global biofuel markets seems to suggest new opportunities for smallholders. Some results do suggest a potential competitiveness of smallholders or small ethanol producers. But related to these results are drawbacks, for instance: The efficiency of small distillation comes increasingly close to large distilleries – however, feedstock is a main cost item, in which mechanised production (so far done by usinas and middle-scale farmers like in case 2.2) would remain cheaper. In theory, it is possible to reduce the cost advantage of usinas by policies of internalising social costs – however, this is demanding in terms of social cost accountancy, legislation and especially enforcement. It seems little realistic that in terms of overall production costs smallholders will become competitive for the global sugar or ethanol-for-transportation market.

It seems more plausible that small-scale production and value-chains be sought in different markets. New/improved value-chain gains are then interlinked with local energy development and subsequent

demand. Different markets can be (i) a differently regulated national/regional ethanol market, or (ii) a different product market.

(i) Differently regulated (national/regional) transportation fuel markets

The Brazilian small ethanol cases rely on the use of ethanol for transportation. Brazilian users have flex-fuel cars for home consumption; the related demand justifies individual ethanol systems. Outside Brazil, this is not the case, so that other uses are more plausible. However, despite long-term arguments for shifting biofuel use away from transportation, global market processes may lead to an increased availability of ethanol cars. In this case, pro-smallholder regulations for regional ethanol markets would apply.

Based on the Brazilian experience, an alternative regulation implies accessible marketing chains that do not exclude small producers e.g. by long distances to retail places (as with the Brazilian distributors system). One challenge is quality guarantee, so that uncertainty about the quality of small-scale ethanol does not impede this ethanol entering the market. This is mainly about alcohol concentration; technically control is easy. The problem is the enforcement of equal, regular application, e.g. by remote fuel stations.

(ii) Different fuel markets: small-scale ethanol for local and regional energy demand

In countries other than Brazil, basic energy is often lacking. Related uses/markets of ethanol as fuel include: household devices (cooking, fridges, lamps etc.); small processing units for agricultural produce; and decentralised, maybe individual electricity generation. These uses can lift local living standards and productivity immediately and substantially.

Ethanol-for-cooking is a research object of IEI. A suggestion is to focus on peri-urban areas in countries like Mozambique, where cane and ethanol can be produced for urban household demand. Given ongoing use of traditional wood stoves in urban settings, with detrimental health effects and fuel supply problems, ethanol can meet an important need. This may even be a more promising market – and thus income source for peri-urban population – than rural areas where fuel-wood, despite growing scarcity, is free.

About ethanol-for-electrification, views are mixed. In an economic perspective, ethanol is a relatively sophisticated and expensive energy carrier. It would become viable only under quite specific circumstances, i.e. when alternatives are not economically feasible. However, this may indeed be the case in remote areas. Moreover, electricity generation from ethanol is said to be more energetically efficient than burning it in car engines.

The adaptation or use of diesel-fuelled generators for ethanol is easy. Small ethanol-fuelled gas turbines for electricity generation are being developed. Bagasse-fired steam turbines are not yet commercially available in small scale. In Brazil, a main reason for low small-scale innovation may be a legal threshold for surplus energy retail at 3 MW (t.b.c.). Relatively cheap grid energy is another de-incentive for investment and innovation.

(iii) Different fuel allocation systems: cooperatives

An alternative to market-based value-chains is to create cooperated systems, in which internal barter or collective use (including for transportation, if vehicles are available) allocate and value the produce. An example is case 2.1. On top of a base demand e.g. by the municipal car fleet, exceeding ethanol can be sold on the market by the cooperative, with lower transaction costs (see appendix 1). However, the organisational set-up of cooperatives is demanding. Given experiences to date, set-ups and regulations still need investigation. In particular, they require context-specific adaptation.

3. General conclusion regarding small-scale ethanol and outlook

Under the qualifications outlined above, small-scale ethanol is promising for remote energy supply and related value chains e.g. in rural Africa, especially for uses and markets other than transportation. Given the easy integration of cane and ethanol production via small-scale distilleries, cane-producing smallholders may in particular profit from this.

The study has pointed to problems of up-scaling and transfer of the models to other context. There are challenges to policy and regulation that would also apply to Brazil. Among them are: pro-smallholder innovation; support markets or other allocation settings for small-scale ethanol and related goods (equipment, feedstock) without compromising competition; maintain marketing chains open for small-scale ethanol while, at the same time, allow for reliable quality monitoring to avoid mistrust.

Small-scale ethanol value chains will not be sufficient to keep smallholders as cane producers in the sugarcane-for-industry/sector when this sector becomes subject to concentration. The inclusion of smallholders requires a demanding market regulation to counteract concentration and scale-effects. Small-scale ethanol for other markets, however, may provide smallholders with income opportunities from sugarcane even before entering, or after leaving, the large sugarcane-for-industry/transportation market.

One main result of section 1 is that several causes of concentration in the Brazilian sugarcane and ethanol sector are, in a broad sense, policy-related and/or can be subjected to alternative policies. Regarding ethanol, the legal limitation of ethanol retailing to petrol stations supplied by authorised distributors structurally impedes market access to small producers. Regarding sugarcane, causes of concentration like mechanisation, limited access of smallholders to technological improvements or failure to internalise social and ecological costs into the large producer's cost function can be subject to regulations that offer equal opportunity to small producers.

Hence, while in Brazil concentration may have reached an almost irreversible state, this does not imply that adequate policies could not avoid concentration elsewhere. In that sense, it would be inadequate to follow from the Brazilian case that smallholders are necessarily unable to compete with large farmers, despite the economies of scale. It very much depends on the policy setting. This may seem trivial at first reading. However, sceptics regarding small-scale sugarcane and ethanol too often neglected this.

In section 2.6, policy options have been suggested. As for further research, the Australian case promises insights into how market governance can support smallholders. While these smallholdings are considerably larger (150-200 ha) than the target group assumed in this study (which would rather have up to 5 ha), the general mechanisms can be taken into account for policy advice regarding this sector. Another case to look at is India, where concentration is reported to be low as well.

For extrapolating Brazilian experience with small-scale sugarcane and ethanol to other contexts, context-specific scenarios that are based on the Brazilian cases presented above, but which vary those parameters in which the Brazilian case is specific, should be useful. Based on such scenarios, conclusions are possible regarding how ethanol becomes an – economically viable – policy option for rural energy development and income generation. Examples for scenarios are:

- An individual household/farm system without any cachaça production involved;
- A cooperative ethanol production, with local retail not impeded by regulation;
- A system in which few smallholders produce ethanol with mini-distilleries and sell it in the village, as fuel for low-consumption household and processing devices;
- A system in which communal electricity (isolated mini-grid) is produced with ethanol or bagasse from local sugarcane, involving a guaranteed demand for cane.

This study has brought up many technical details. As for further expertise on ethanol for rural (energy) development, the socio-economic side should be emphasised. Information on how these systems function in a socio-economic context is scarce. This information is particularly important for the aforementioned scenarios.

References

Buainain, António Márcio (2006) Agroecologia e Desenvolvimento Sustentável. Questões para debate. Instituto Interamericano de Cooperação para Agricultura, Brasília/Brasil.

Buainain, António Márcio (Ed.) (2007) Agricultura Familiar e inovacao tecnológica no Brasil: caraterísticas, desafios e obstáculos. Editora da Unicamp, Campinas/Brasil.

Gerber, Nicolas (2008) "Bioenergy and Rural Development in Developing Countries: A Review of Existing Studies". ZEF discussion paper on development policy 122.

Sousa e Silva, Juarez de (2007) Produção de Álcool Combustível na Fazenda e em Sistema Cooperativo. Universidade Federal de Viçosa, Brasil.

Kohlhepp, G. (2008) "Ethanol-Boom in Brasilien". In: Tópicos 3/2008, pp. 8-11.

Sidnei Gonçalves, José (2000) Agricultura Brasileira: Desafios ao fortalecimento de um setor fundamental. Série discussão Apta 1, São Paulo/Brasil.

Smeets, Edward/Junginger, Martin/Faaij, André/Walter, Arnaldo/Dolzan, Paulo/Turkenburg, Wim (2008) "The sustainability of Brazilian ethanol – an Assessment of the possibilities of certified production". In: Biomass and Bioenergy 32/2008, pp. 781-813.

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