Socio-environmental impacts of sunflower production as feedstock for biodiesel in southern Minas Gerais, Brasil

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ABSTRACT

- The increase in global demand for renewable energy has encouraged, both directly and indirectly, the production of oilseeds, including sunflower, as feedstocks for biodiesel. In this scenario, Brazil stands out for its excellent agronomic and climatic conditions for growing these crops throughout its territory. However, there is still little information about the sustainability of the biodiesel production chain, depending on the source of raw materials and inputs, the rural context and the region where it is produced. Faced with these questions, this study aimed at evaluating the social and environmental impacts, both along the production chain of biodiesel obtained from sunflower, and at the rural establishment level, in the reference context of southern Minas Gerais state, Southeast Brazil.
- The methodology involved application of two impact assessment tools: a) the "Base System for Eco-certification of rural activities' (Eco-cert.Rural)" comprised of 24 criteria and 125 indicators for performance evaluation at the value-chain level (gathering 19 experts with knowledge of different links in the biodiesel chain within the studied area) and b) "System of Environmental Impact Assessment of Rural Activities" (APOIA-NovoRural), comprised of 62 sustainability indicators applied to the rural establishment scale (through a detailed field survey / interview involving a reference sunflower producer). The study was conducted in November 2009 and information from the interviews were inserted directly into the weighting matrices of the systems, automatically expressing the results in graphs for partial and final environmental impact index of the activity, that for the system APOIA-NovoRural varies between 0 and 1 (as the limit of sustainability, taking the value 0.7).
- According to the experts, the results of the insertion of sunflower for biodiesel production (in no-till system, following corn crop) promoted positive social and environmental impacts. The highlights were the criteria for producer training, income generation, food security and institutional relations. In the ecological dimension, not all indicators were favorable, mainly due to increased demand for inputs and sources of energy, while others had positive performance such as soil quality, biodiversity and environmental recovery. So to give this result in a rural area, the study APOIA-NovoRural system showed, in general results/trends similar to those obtained for the chain, with some significant discrepancies. Benefits were observed for management aspects (0.80, in a 0-1 utility scale) and economic values (0.82), which increased income and investment capacity on the farm. Still, social values changed little with the activity (0.71), which contradicts the opinion of chain experts. In terms of environmental performance indicators, the inclusion of sunflower has provided positive impacts on water quality (0.92), atmosphere (0.85) and for the production system, the experts disagreeing only for soil quality, which presented unsatisfactory result (0.68), denoting low fertility. This result was a point of alert for the farmer, who received recommendations for soil fertility correction before starting a new sunflower crop. This oilseed requires good nutrition and does not tolerate low pH. The experts who evaluated the biodiesel chain did not identify this. Thus, at the scale of the rural establishment, the insertion of an additional culture (late season) without a good management and technical support should impact negatively the soil quality, even though other environmental and economic positive aspects were observed.
- It is possible to conclude that the insertion of sunflower, stimulated by the biodiesel program, showed positive impacts for rural establishment, with a final performance index of 0.77. However, some aspects such as social benefits were not fully noted. This result points to the need of public actions for the effective implementation of the government guidelines in the Brazilian Program for Biodiesel Production and Use, which has social values as one of the pillars of sustainability.
- This kind of study subsidizes the elaboration of regional public policies that promote the sustainable development of the biodiesel production chain generated by sunflower oilseed.

Key words: Biofuel, impact assessment, sustainability indicators, APOIA-NovoRural

INTRODUCTION

The sunflower (*Helianthus annuus* L.) cropped area in Brazil is incipient (110 thousand hectares) when compared to the main world producers such as Russia, the European Union, Ukraine and Argentina, which sum up 19.9 million hectares. The Brazilian production represents only 0.4% of the world production, when compared with those countries, which represent 72% (FAO, 2008). However, there is an enormous potential for expansion if sunflower is planted in succession after soybean, which occupies an area of 21 million hectares (CONAB, 2011). The potential for area expansion is also driven by the Brazilian government demand for biofuel and demand for high oleic oil for human consumption.

The sunflower crop has shown advantages for biofuel use such as: high oil content (40%), also allowing cold extraction (Gazzoni, 2005), low production costs and a high positive energy balance (unit of energy produced as biodiesel/unit of energy used for crop production) when compared with other oil crops (Ungaro, 2006), particularly when it is used as a secondary crop, after soybean (Lazzarotto et al., 2005). These facts may allow reduction on the demand for fossil fuels, optimization of the use of fertilizers, water, land and other inputs, therefore producing environmental benefits and maintenance of the productive capacity of soils .

Considering the fact that the economic and environmental benefits (except for fossil fuel use in reducing greenhouse gases emissions) of sunflower for biofuel production are quite the same as those for food production, there is a current debate regarding its destiny. Some authors advocate that such a high quality and noble oil, with a high content of low polyunsaturated fatty acids, the presence of vitamin E, β-caroten and phospholipids must be used for human consumption rather than for biodiesel production. Moreover there is an increased demand in South America for sunflower genotypes with high oleic oil for frying purposes. The use of vegetable oils for biodiesel production has been proposed as a renewable alternative to fossil fuels, while much controversy is still in place regarding possible negative impacts on natural resources conservation, as well as on social factors such as income generation and distribution, farmer training and technology adoption, food security among many other issues. These concurrent and potentially conflicting objectives may be better understood through environmental impact assessments, as proposed in the present study.

Numerous environmental impact assessment tools have been made available in the scientific literature, for the most varied scopes of analysis and working scales. Among the methodological alternatives consolidated for application at the agricultural production chain scale, a 'Base system for eco-certification of rural activities' (*Eco-cert.Rural*; Rodrigues et al., 2006) has been used for studies in the agroenergy sector, allowing the analysis of criteria associated with socio-environmental impacts of implemented productive activities (Rodrigues et al., 2007).

On the other hand, sustainability indicator systems have been proposed for application at the rural establishment scale, specifically addressing environmental management decision-making. Among these methods, a 'System for weighted environmental impact assessment of rural activities' (*APOIA-NovoRural*; Rodrigues & Campanhola, 2003) has been applied toward the environmental management of oleaginous crops, under biofuel production contexts, in several regions of Brazil (Rodrigues et al, 2009; Rodrigues et al, 2010).

Building upon these methodological propositions and as continuation to previous studies, the present paper aimed at evaluating the social and environmental impacts, both within the production chain of biodiesel obtained from sunflower, as at the rural establishment scale, both inserted in the southern region of Minas Gerais state, Southeast Brazil.

MATERIALS AND METHODS

The study was conducted in November 2009 and comprised an extensive literature review and application of the two afore-mentioned environmental impact assessment tools, one directed toward the local production chain scale, and the other directed toward the rural establishment scale, as follows:

a) a 'Base system for eco-certification of rural activities' (*Eco-cert.Rural*), comprising 24 socio-environmental criteria and 125 indicators, assessed with basis on the input of experts knowledgeable on the diverse segments of the biodiesel chain in the region of the study. The data were obtained in a Delphi-type workshop, involving 19 institutional representatives who expressed their knowledge about the expected and observed impacts of the increasing demands on sunflower crop for biofuel production;

b) a 'System for weighted environmental impact assessment of rural activities' (*APOIA-NovoRural*), comprising 62 indicators formulated toward the systemic assessment of rural activities, according to five sustainability dimensions: i) Landscape ecology, ii) Environmental quality (atmosphere, water and soil), iii) Socio-cultural values, iv) Economic values and v) Management and administration. Data were

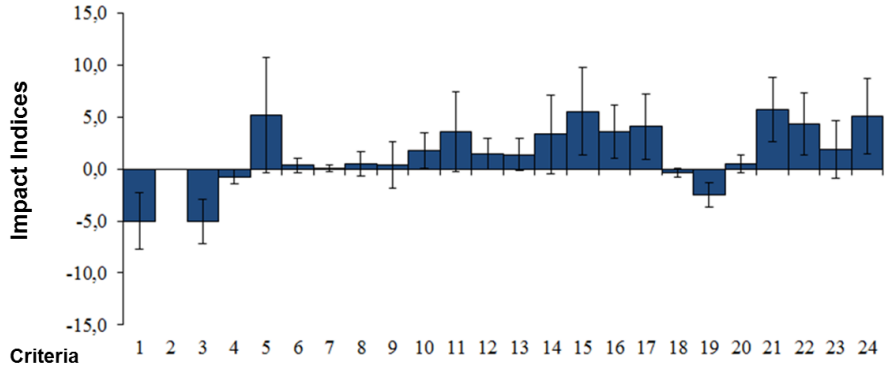
obtained in a detailed interview and instrumental field and laboratory analyses, in a reference sunflower farm. The method entails multi-attribute analysis of the effects of the rural activities, with automatic calculation of sustainability indices expressed in utility values (0 to 1.0 scale, sustainability conformity level standardized at 0.7), according to appropriate weighting factors and best fit conversion models (Rodrigues et al., 2010).

At the end of the study Environmental Management Reports were formulated and sent to the reference farmer and all participating experts. These reports emphasized positive and negative impacts, as well as technology adoption and alternative management practices, contributing toward local sustainable development. For methodological details, please refer to Rodrigues et al., 2007; 2010.

RESULTS & DISCUSSION

The assessment of impacts in the sunflower production chain for biodiesel, as expressed by the 19 experts participating in the *Eco-cert.Rural* Delphi workshop, indicated that the National Program for Biodiesel Production has favored the expansion of the crop, both directly and indirectly. The indirect influence is related with the strong displacement of soybean oil for biodiesel production, opening a market share for sunflower as edible oil. The direct effect is related with firsthand acquisition of sunflower oil by the biodiesel mills.

With respect to the impact assessment proper, the experts pointed out that the ecological performance (first eight indicators in Figure 1) has shown some negative indices for sunflower production, even if considering no-till management. These negative impacts were essentially related to use of inputs, resources (criteria 1), energy (criteria 3) and atmosphere (criteria 4); due to an increased dependency on external production means under the incremented demand in the biodiesel chain context. Specifically, increased use of mechanization, herbicides, fungicides and diesel for spraying operations were pointed out, although subjected to a high level of divergence among experts, as shown by the large standard deviation observed for the criterion (Figure 1).



1. Use of Agricultural Inputs and Resources	2. Use of Veterinarian Inputs and Raw Material
3. Use of Energy	4. Atmosphere
5. Soil Quality	6. Water Quality
7. Biodiversity	8. Environmental Restoration
9. Product Quality	10. Production Ethics
11. Training	12. Opportunity and Qualification for Local Empoyment
13. Job Generation and Engagement	14. Employment Quality
15. Net Income Generation	16. Income Sources Diversity
17. Land Value	18. Personal and Environmental Health
19. Occupational Safety & Health	20. Food Safety & Security
21. Farmer Capability and Dedication	22. Trade Arrangements
23. Waste Disposal	24. Institutional Relationship

FIGURE 1. Mean values and standard deviations for the socio-environmental criteria evaluated with the *Eco-cert.Rural* indicators system, as expressed by 19 experts on sunflower production for biodiesel in the Três Pontas region (MG, Brazil).

The remaining ecological performance criteria have shown positive or unaltered indices, with soil quality being highly improved, as a result of the no-till production system (Figure 1). Small improvements have been observed also in the environmental restoration criteria, as influenced by integration of sunflower production into local productive arrangements for biodiesel, which calls for compliance with legal nature protection legislation, as proposed by the participating experts.

The Socio-environmental performance criteria were mostly positive (Figure 1), except the indicators on personal and environmental health (criterion 18) and occupation safety & health (criterion 19) as a direct consequence of the increase in pesticide use. Reference was given to the increase in income generation (criterion 15), dedication and training of farmers (criterion 21) and institutional relationship (criterion 24), due to the inclusion of a new agricultural activity that requires integration with the market (biodiesel mills). These indicators explain also the positive influence observed in the farmer capability and dedication, and the trade arrangements criteria, as submitted to the improved conditions offered by the local organization of the biodiesel production chain.

In order to check these results at the rural establishment scale, the APOIA-NovoRural system showed general results/trends similar to those obtained for the chain of sunflower to biodiesel production, with some significant discrepancies (Figure 2). Benefits were observed for management aspects (index = 0.80) and economic values (0.82), which increased the income levels and investment capacity on the farm. Still, social values changed little with the activity (0.71), which contradicts the opinion of chain experts. In terms to environmental performance indicators, the inclusion of sunflower has provided positive impacts on water quality (0.92), atmosphere (0.85) and for the production system, the experts disagreeing only for soil quality, which presented unsatisfactory result (0.68), mainly due to fertility aspects. This result was a point of alert for the farmer, who needs to work the soil fertility before starting the production of sunflower to support the high nutrition that this oilseed requires (it does not tolerate low pH). The experts who evaluated the biodiesel chain did not identify this point. Thus in the scale of the establishment, the insertion of an additional culture (late season) without a good management and technical support should impact negatively the soil quality, even though other environmental and economic positive aspects have been observed.

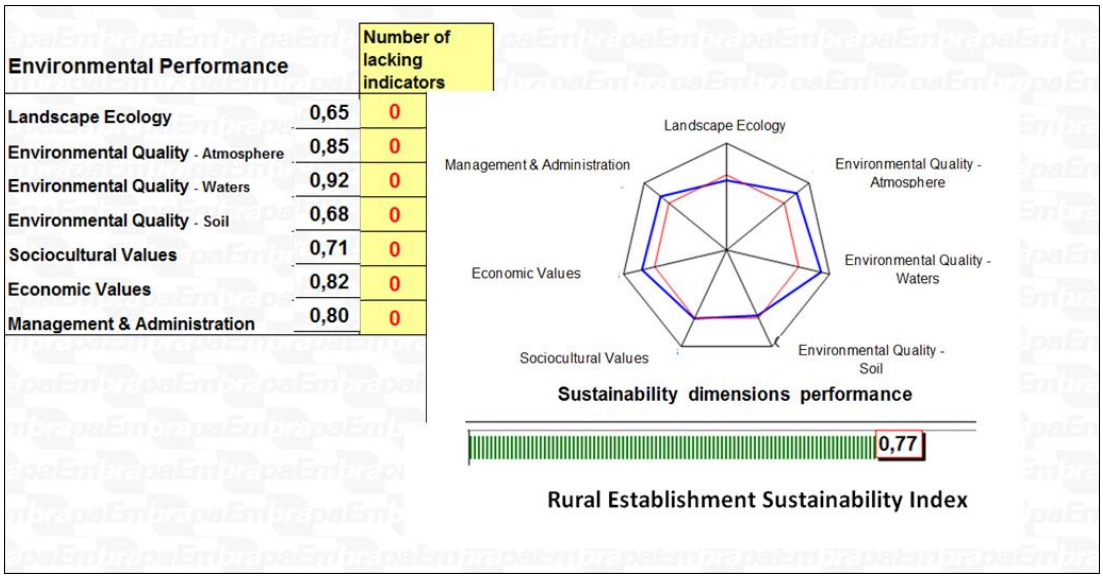


FIGURE 2. Sustainability index in the reference sunflower-producing farm studied in Três Pontas (MG, Brazil), according to the assessment dimensions of the APOIA-NovoRural indicators system.

Similar results were obtained for canola production (Ramos et al., 2011) grown in no-till and rotation system in the southern region in Brazil. So it is possible to infer that oilseeds such as sunflower and canola, which are grown in a complementary way to other crops, did not compete with food production, which would be the main growth in the critical area of energy crops in Brazil.

CONCLUSION

Biodiesel production based on sunflower in the Três Pontas region, Minas Gerais state, Brazil, has shown to bring mostly positive impacts for the environment and for the livelihood of people involved in the production chain. On the other hand, increased oil demand under the biodiesel production context has imposed intensive use of inputs, resources and energy, causing the criteria related to ecological performance to be less favorable. Sunflower production has brought important contributions for the sustainability of the reference farm studied.

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