SUSTAINABILITY ASSESSMENT OF AN OIL PALM FARM THROUGH THE IMPLEMENTATION OF AN INTEGRATED INDICATORS SYSTEM

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Abstract

An integrated sustainability assessment of an oil palm farm has been carried out in the region of Belém (Pará State, Brazil) under the auspices of Embrapa's Network on Oleaginous Crops for Biofuels Project and the Program Parábiodiesel. The "System for Weighed Environmental Impact Assessment of New Rural Activities" (APOIA-NovoRural) applied in the study consists of 62 quantitative indicators integrated into five sustainability dimensions, as follows: (i) Landscape Ecology, (ii) Environmental Quality (atmosphere, water, and soil), (iii) Socio-cultural Values, (iv) Economic Values, and (v) Management and Administration. The methodological approach aimed at testing the applicability of the system as an environmental management procedure for oil palm production. Results of the assessment pointed out important contributions of oil palm plantation to the farm's sustainability, owing to several managerial, organizational and environmental management procedures observed. The approach here detailed can be a commending initiative for the oil palm production sector, aiming at promoting the environmental management and the sustainable insertion into agro-energy production chains.

Key words: *impact assessment, environmental management, biofuels*

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1. Introduction

The expectations with regard to biomass as a source of sustainable energy are high, but certain risks are attached to the large-scale use of biomass. Environmental conservation and social responsibility issues must be taken into account under the scenario of increasing demand of biomass for energy purposes. To fulfill this objective, it becomes necessary to select, adapt, transfer, and ultimately assess 'Sustainable Environmental Management Practices' (BARNTHOUSE et al., 1998). In order to bring a practical reach to this sustainable development goal, the use of ecological and social indicators of sustainability has been a method of choice (MONTEIRO & RODRIGUES, 2006). Ideally, the indicators are organized in Impact Assessment Systems that may span increasing levels of complexity and goal requirements for environmental management (PAYRAUDEAU et al., 2004; CALIMAN et al., 2006).

Important productive sectors have been organizing their commitment to a sustainable agro-energy future, such as the palm oil sector (RSPO, 2006a). In Brazil, the "Program of Incentives for Biodiesel Production in Pará State" (PARÁBIODIESEL, 2007) is an example of governmental policy instituted to coordinate agronomic, industrial, and technological research actions for consolidating the production chain of biofuels. Under this Program's technological research component and Embrapa's Agro-energy Network, an "Environmental management of oleaginous crops for biofuels" Delphi-type Workshop was recently organized (EMBRAPA, 2007), to report on the socio-environmental impacts of the current trend of increasing demand of palm oil for biofuels.

Building upon the results of this Workshop (RODRIGUES et al., 2007), the sustainability assessment of a selected oil palm farm was carried out, to check the adherence of the obtained socio-environmental impact assessment against the farmer reality, and to propose a procedure for promoting the farm's environmental management. The sustainability evaluation results were consolidated into an individual "Environmental Management Report" issued to the farmer, for his decision making regarding technology innovation adoption and productive activity best management practices for sustainable oil palm, under the specific local environmental settings and current indicators conditions.

2. Material and Methods

2.1. A case study on sustainable oil palm plantation management

The present study introduces the application of an integrated sustainability indicators system for oil palm production, under a somewhat atypical smallholder situation, in order to facilitate methodological testing. The sustainability assessment was carried out at the Ishihara Farm, considering its 1978 oil palm plantation time frame. All data refer to a March 5th, 2007 field survey / interview with Mr. Jorge Akio Ishihara, owner and responsible for the establishment management, and who agreed with the publication of the study results.

The establishment was selected by indication of the Association of Palm Oil Producers Dentauá Ltd., an affiliated member of the Parábiodiesel Project. The Ishihara Farm is located in the municipality of Santo Antônio do Tauá, in the Geographical Metropolitan Meso-region of Belém, Castanhal Micro-region (Pará State, Brazil), in the ecological domain of the Amazon Equatorial Rain Forest. At 54m altitude and geographical coordinates 01°06'13" S and 48°07'34" W, the 275 ha farm has oil palm in approximately 192 ha; and a diversified agricultural productive base, including black pepper (28 ha), açaí palm (28 ha), lemon (5 ha), papaya (5 ha), cupuaçu (2 ha), pineapple (2 ha), noni (5 ha), and woods (5 ha distributed among neem, teca, mahogany and Gliricidium). Only 2.5 ha correspond to native forests in the establishment, occupying the Permanent Preservation Areas shoring a small stream.

2.2. Integrated sustainability indicators system

The "System for Weighed Environmental Assessment of New Rural Activities" (APOIA-NovoRural - RODRIGUES & CAMPANHOLA, 2003; RODRIGUES & MOREIRA-VIÑAS, 2007) has being proposed as an adequate method for promoting the environmental management of rural establishments, as well as for checking their conformity with defined eco-certification objectives (MONTEIRO & RODRIGUES, 2006). The APOIA-NovoRural System consists of a set of 62 indicators weighing matrices, formulated toward the systemic assessment of a rural activity at the rural establishment scale, 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. The sustainability assessment is performed by quantitatively and analytically assessing the effects of the rural activity on each and every indicator constructed for these five dimensions, and automatically calculating the impact indices, according to appropriate weighing factors (Figure 1). The impact indices are expressed as utility values (0-1, with the baseline sustainability conformity level defined at 0.7 - BISSET, 1987) in graphs for each indicator, the aggregated dimensions and a final sustainability index.

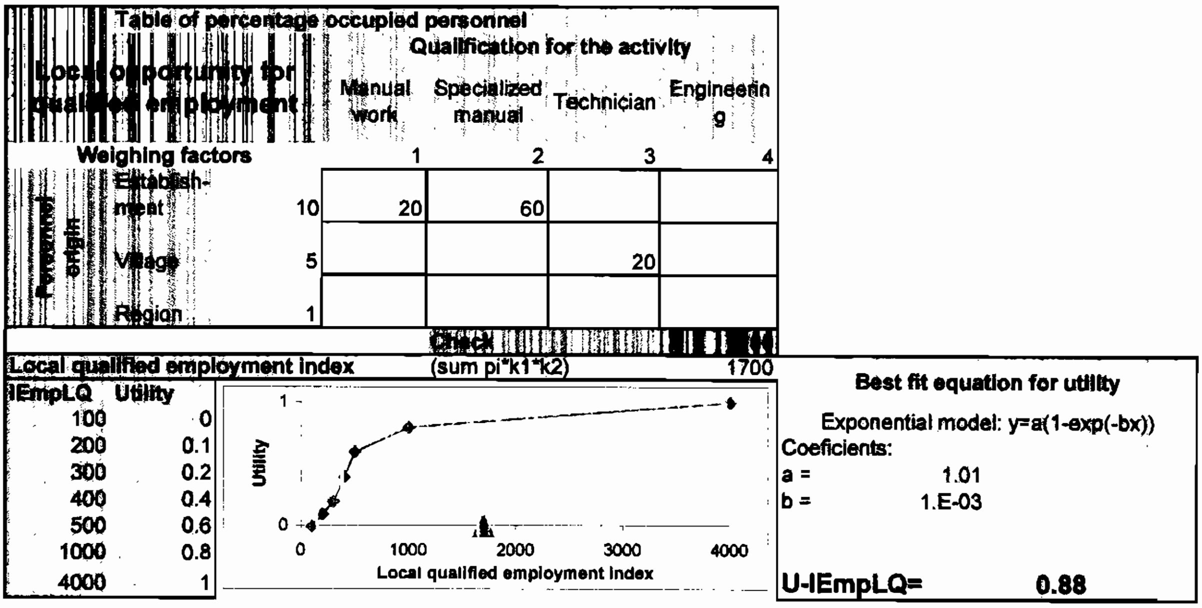


Figure 1. Typical weighing matrix of the "System for Weighed Environmental Impact Assessment of New Rural Activities" (APOIA-NovoRural), showing the 'Local opportunity for qualified employment' indicator.

The utility functions built in the system express the environmental performance of the rural activity for each particular indicator, and were derived by probability and sensibility tests, case by case, for each indicator (GIRARDIN et al., 1999). In the probability test, the indicator scale limits (maximum and minimum) and the baseline conformity value (0.7) are modeled, according with the numerical solution of the indicator variable (in the Figure 1 example, percent occupied personnel, according with origin and qualification). In the sensibility test the indicator direction (whether positive or negative) and the meaning of the changes brought onto the indicator by the rural activity are modeled, according with the quantitative performance relationship defined in the sustainability baseline. These tests allow the construction of a correspondence table from impact indices to indicator utility values (in the Figure 1 example, IEmpLQ = Σ pi*k1*k2 = 1700), which are then presented graphically in the weighing matrices. This correspondence relationship is, then, algebraically effected by a best fit equation, resulting in the expression of the utility value sustainability index (U-IEmpLQ, in the given example = 0.88; Figure 1).

Information required for filling out the APOIA-NovoRural weighing matrices in the present study were obtained in a field survey (aided by GPS, maps and satellite images) and data on the managerial and administrative history of the rural establishment provided by the farmer / manager, according with a structured questionnaire. Other indicators, related with water and soil quality, were obtained in field and laboratory analysis. Some water quality indicators (O_2, pH, Conductivity, Turbidity) were measured in the field with a Multi-parameter Horiba (U-10) probe. Nitrate was analyzed with a Merck RQFlex field colorimeter. Fecal coliform levels were estimated with Tecnobac (AlphaTecnoquímica) culture strips. Water samples were brought to Embrapa Environment laboratory for phosphate and chlorophyll determination with a HACH spectrophotometer. Soil samples were sent to Embrapa Oriental Amazon laboratory for routine macro-nutrients determinations.

For further details on the methodology, the full set of indicators, and access to the operational system, please refer to RODRIGUES & MOREIRA-VIÑAS (2007).

3. Results

The APOIA-NovoRural System shows the assessment results in a synthesis graph for the sustainability dimensions, and an aggregate index for the establishment, according with the spatial and temporal context defined locally (Figure 2). For the case of Ishihara Farm this Sustainability Index reached 0.70, right in agreement with the conformity baseline defined in the method. Among the sustainability dimensions considered, quite favorable mean indicators results were obtained at Ishihara Farm for Water Quality (0.85) and Economic Values (0.78). With mean indicators values very close to the conformity baseline were Landscape Ecology (0.67) and Socio-cultural Values (0.68). On the other hand, mean indicators results for the dimensions Soil Quality (0.51) and Management & Administration (0.61) were below the conformity baseline defined in the APOIA-NovoRural System.

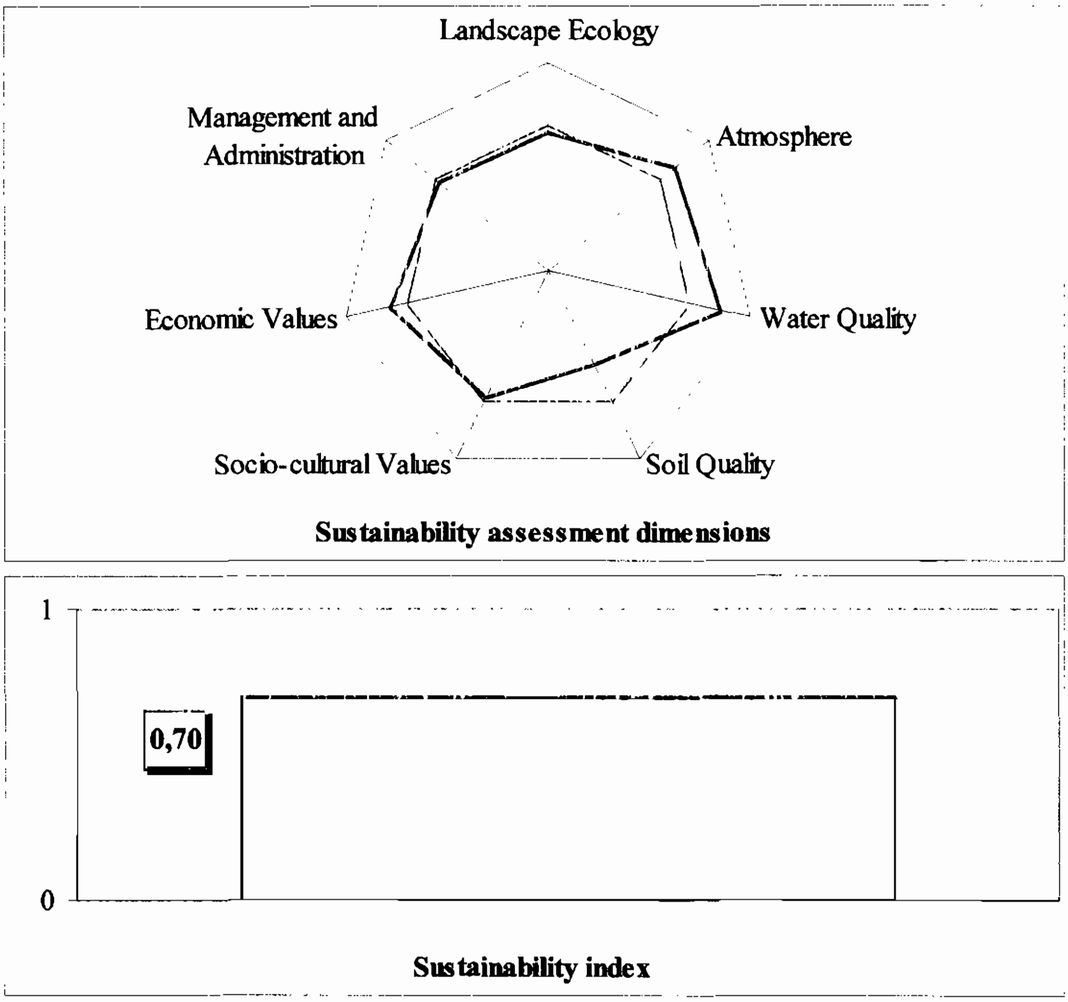


Figure 2. Sustainability assessment for Ishihara Oil Palm Farm, in Santo Antônio do Tauá (PA, Brazil), according with the APOIA-NovoRural System assessment dimensions. March 2007.

The Landscape Ecology dimension (Figure 3) presented the indicators concerned with Natural habitats conservation (0.89), Productive areas management (0.97), and Confined activities/animal husbandry management (0.79) as extremely favorable conditions for the farm's sustainability. The area destined to agricultural production at Ishihara Farm adds to approximately 262 ha, fully taken by perennial crops, mostly oil palm (70%), which is less intensive in terms of inputs and natural resources, comparatively to the other cultures. Natural habitats make up only 3 ha, comprising a paludal forest in pristine condition, and a tract of recovering secondary rain forest, both very important for conforming the legally mandated Permanent Preservation Area indicator (index = 0.82). On the other hand, the mandated Legal Preserve is nonexistent (indicator = 0.0), a passive from the time of implantation of oil palm in the establishment, when the treelike trait of the culture was amenable for Legal Preserve denomination.

The large number of different crops grown at Ishihara Farm results in a relatively high Productive diversity indicator (0.67, Shannon-Wiener index = 0.48), a positive factor for the farmer's economic security, against eventual market instabilities. Even though below the baseline level defined in the assessment system, the Landscape diversity indicator was also satisfactory (0.59), owing to the perennial aspect of the crops, which contributed moderately for the conformation of Fauna corridors (0.68), and favored the protection of Endangered species (index = 0.80). The Endemic diseases vectors indicator (index = 0.58) registered the problem brought about by the exotic African giant snail (*Achatina fulica*) that has caused damage to fruit trees and black pepper crops in the establishment. Control measures were prescribed to the farmer (http://www.parasitologia.org.br/topico.php?codigo=36; access April 18th, 2007). The oil palm plantation influenced negatively the Fire hazard indicator (0.55), due to the piling up of flammable organic material remaining from harvest operations and brought back from the industry and left under the trees. As in the eventuality of fire the main culture itself would be affected, causing severe losses, the effect on the sustainability index is quite important. This practice, on the other hand, contributes with the organic matter balance in soils, as shown later on in the text.

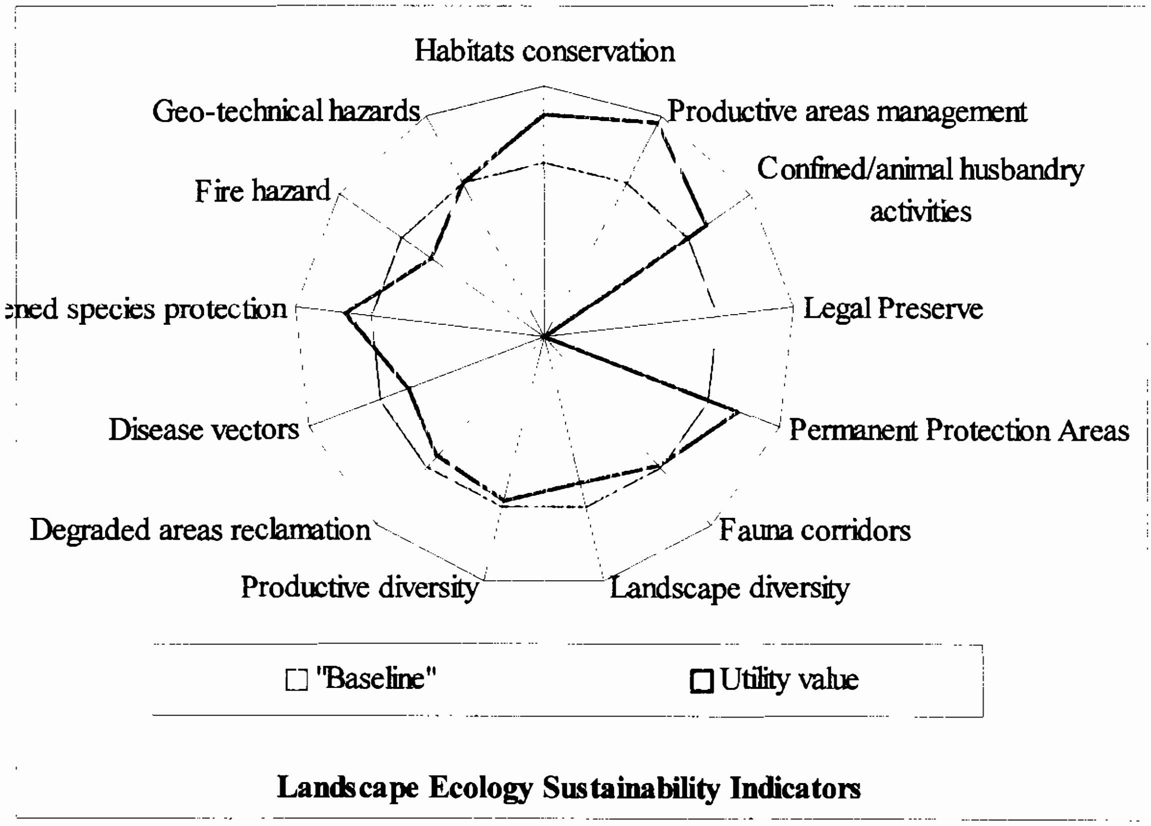


Figure 3. Sustainability indices for the Landscape Ecology indicators, Ishihara Oil Palm Farm, Santo Antônio do Tauá (PA, Brazil), according with the APOIA-NovoRural System. March 2007.

The Environmental Quality dimension resulted well above the baseline conformity level for the indicators of Atmosphere (mean = 0.79) and Water Quality (0.85), whereas the Soil Quality resulted well below that level (mean = 0.51). The Atmosphere indicators pointed out the absence of particulates and smoke emissions (for no burning is allowed in management, index = 0.89), foul odors (1.0) and reduced period and low intensity of noise generation (0.92). Neither were there important sources of sulfur (0.70) or nitrogen oxides

(0.70). On the other hand, the intermittent traffic of tractors for harvesting and management imposes some emission of carbon oxides (0.65) and hydrocarbons (0.65) at the local scale.

The Water Quality showed positive indices for most indicators, pointing out the favorable influence of the perennial crops, especially oil palm, for water conservation. Surface waters analyzed showed adequate levels and excellent improvement in oxygen saturation (index = 0.97, up 82%), adequate pH (index = 0.89), nitrate (0.80, under 2.0 mg/L), total solids (index = 1.0), chlorophyll (1.0), conductivity (0.95), visual pollution (1.0), and potential pesticide impacts (1.0). Even though showing adequate conductivity (0.95), groundwater (sampled in the farm's well) showed elevated levels of nitrate (up to 8.0 mg/L, index = 0.21), calling for periodic monitoring. This contamination, however, is most likely linked to domestic effluents, not to agricultural practices.

The Soil Quality indicators represent the comparison between oil palm areas and orchards/woods soils, areas to be converted into oil palm when plantations eventually expand in the establishment. The less intensive management and smaller input demand observed in the oil palm areas, which nearly excludes hydro-soluble fertilizers in favor of organic matter amendments, has brought strong decreases in soil fertility levels. Despite the slightly higher soil organic matter (index = 0.77), drastic decreases in phosphate (0.09), potassium (0.46), and magnesium (0.55) were associated with high potential acidity (0.50), resulting in very low sum of bases (0.12), and bases saturation (0.20). Important reduction on sheet erosion can be attributed to current oil palm plantation management practices (index = 0.75, Figure 4).

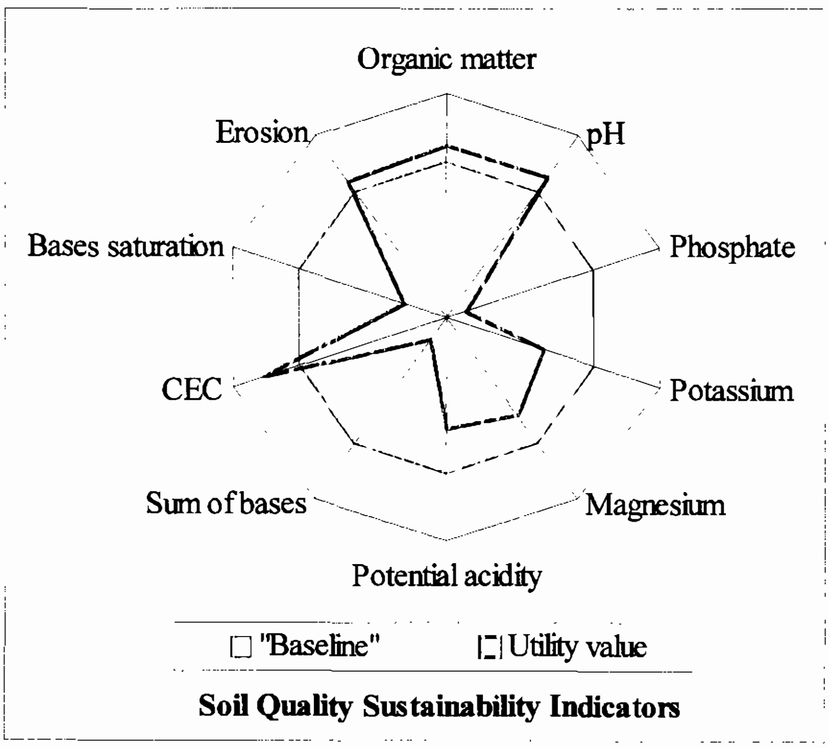
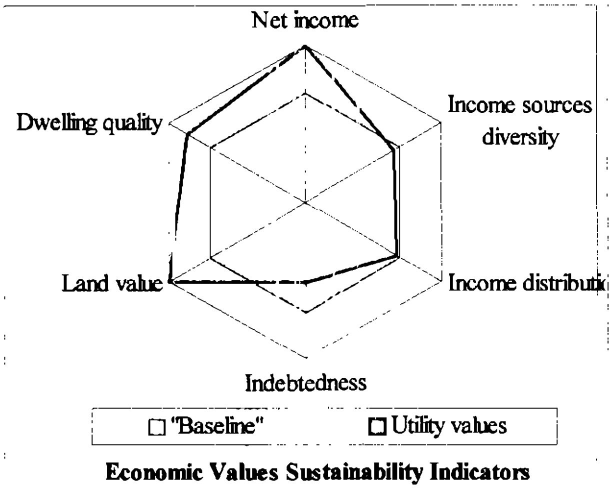
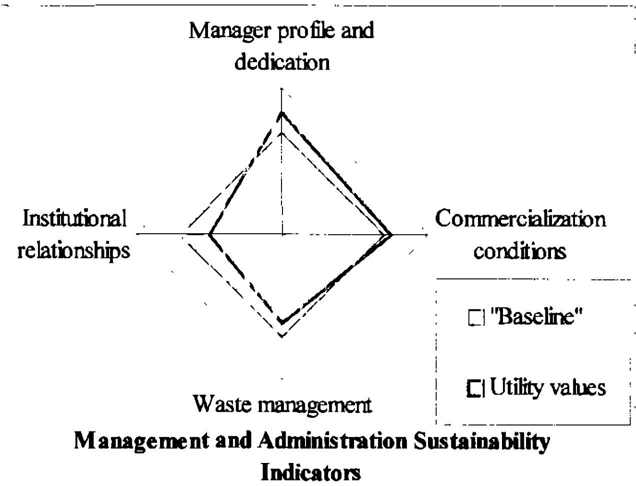


Figure 4. Sustainability indices for the Soil Quality indicators, Ishihara Oil Palm Farm, Santo Antônio do Tauá (PA, Brazil), according with the APOIA-NovoRural System. March 2007.

The mean indicators result for the Socio-cultural Values dimension at the Ishihara Farm (0.68, Figure 5) was very close to the baseline sustainability level of the APOIA-NovoRural System. The establishment houses the manager and eight family members, one temporary and 16 permanent workers. Regarding the Access to education indicator, only the manager receives regular short training courses (offered by Dentauá Ltd.), with no other contribution accountable to the oil palm activity (index = 0.70). The typically modest Consumption standards of the region, especially referring to the employees, result in a lower than the baseline index for this indicator (0.64), compared with a relatively good availability of Public services (0.69). The activity shows no influential changes on the Access to sports and leisure (0.70) or the Cultural/historic patrimony (0.70) indicators. The occupational safety and health indicator (0.77) pointed out good working conditions, even though the Local opportunity for qualified employment (0.62) shows essentially manual, low specialization, field labor opportunities only. Most importantly, due to the virtual absence of fringe working benefits, and the uncertain contractual regime of the temporary worker, the quality of employment indicator was lower than the baseline sustainability level (0.61).





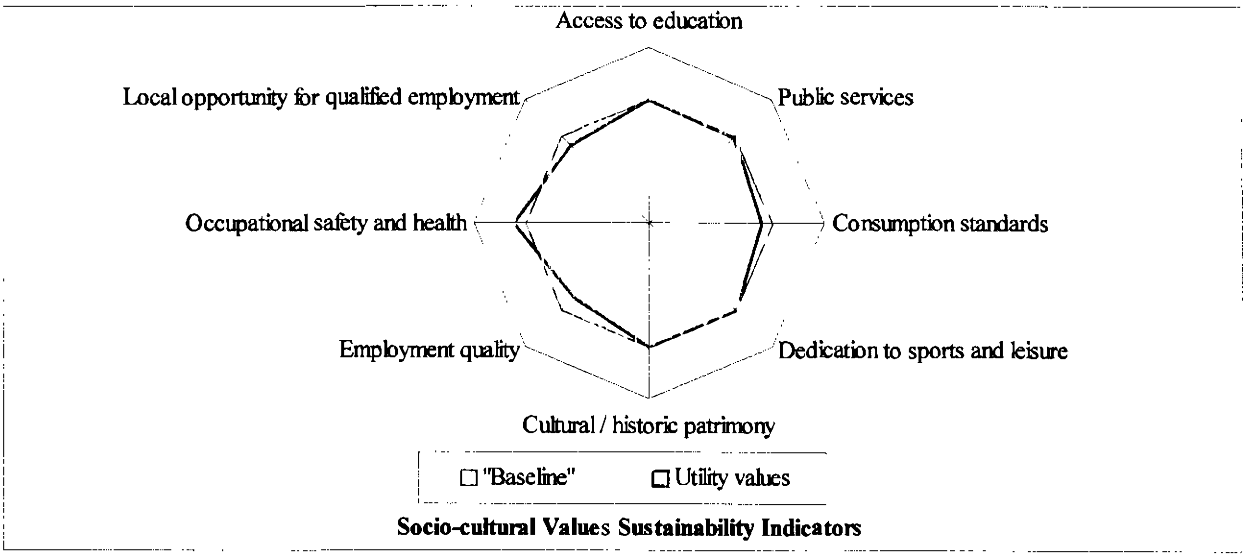


Figure 5. Sustainability index for the Socio-cultural Values, Economic Values and Management and Administration dimensions of the Ishihara Oil Palm Farm, Santo Antônio do Tauá (PA, Brazil), according with the APOIA-NovoRural System. March 2007.

The Economic Values dimension (0.78, Figure 5) showed important indicators with indices well above the baseline sustainability level. Net income improved security, stability and amount (index = 1.0) resulted from the oil palm activity. Reasonably diversified agricultural Income sources (0.65) are associated with a fair pattern of Income distribution (0.67, 1-3 net income / total wages relationship). On the other hand, an increased Level of indebtedness (index = 0.50) is associated with very important Land value improvement (1.0) and good Dwelling conditions (0.86).

The Management & Administration dimension (mean result = 0.67, Figure 5) showed very positive indicators, contrasting with important opportunities for improvement in the sustainability performance of Ishihara Farm, without need for heavy investments. Among the indicators denoting valuable management advantages brought about by the oil palm production activity stand those related with the farmer Profile and dedication (0.83), including local residence, exclusive dedication, specialized training for the activity, family involvement, and formal accountancy system utilization. The only missing component for the indicator was the application of a formal planning system, which may become imperatively valuable for tracking the dynamics presently being imposed onto the agro-energy business. The Commercialization conditions indicator resulted above the baseline level of the APOIA-NovoRural System (0.75), failing to comply only with some components less related with oil palm management, such as Linkage to services/activities and Association to local producers.

Even without regular public service for wastes removal, disposal of domestic residues is adequately performed, exception to sanitary sewage treatment, that may be impairing groundwater quality with nitrates. Solid domestic residues are selectively handled, with organic matter being incorporated to soil as amendment. Finally, the Institutional relationship indicator (index = 0,50) denotes availability of Formal technical assistance and Association/Cooperation, both offered by Dentauá Ltd., and also Access to legal consultation, while no Nominal technological affiliation or Continuous training can be referred to.

The sustainability assessment of the Ishihara oil palm farm pointed out important contributions of the main agricultural activity (oil palm plantation) for the socio-environmental performance of the establishment. The Sustainability Index obtained (0.70), which stresses the conformity with the baseline proposed in the APOIA-NovoRural System, figures as a target for continuous improvement and a tool for the farmer's decision making regarding the adoption of technological innovations, managerial practices, and infra-structural and processes investments for improving the establishment's performance.

4. Discussion

The APOIA-NovoRural System has been shown to be a comprehensive environmental management tool, amenable to expedite field application by trained technicians, and adequate for distribution and use at low cost, generating objective reports in printed format of easy interpretation. The System facilitates the detection of critical impacts for management practices and technology uses corrections, as well as the quantification of favorable impacts, which may contribute towards sustainable resources exploitation and natural habitats conservation.

The set of indicators combine, at the rural establishment scale, issues related with ecological integrity, economic vitality and socio-cultural equity measures for local sustainable development, all explicit objectives of the palm oil productive sector, expressed in the "Roundtable for Sustainable Palm Oil" Certification Systems (RSPO, 2007), which include smallholder producers, such as the one involved in the present exercise (RSPO, 2006b).

There are three main certification system types commonly accepted, especially when agricultural practices are concerned, namely the 'track and trace' system, the 'mass balance' system and the 'negotiable certificates' (book and claim) system (CRAMER, 2007). Given its global reach, involvement of different farmers typology and institutional arrangements, and complexity of Principles, Criteria, and Indicators being proposed by the sector (RSPO, 2007), a certification system of choice for the particular demands of palm oil production should prioritize the stepwise process of constructing a sustainable development agenda, involving and motivating farmers and enterprises for technology and best practices adoption; as well as the participatory organization of an appraisal methodology. The present study proposes a procedure applicable towards motivating farmers to begin and organize their environmental management practices and related documentation, for eventual certification according with the sector's guidelines.

Following this goal, the so-called 'book and claim' certification system, of which the APOIA-NovoRural is one example, should be preferable especially for the agricultural link of the palm oil production chain, due to several attributes: (i) it is usually faster and easier to introduce; (ii) primary producers (farmers / foresters) profit directly from the assessments; (iii) field operations are not hampered in their daily activities by the data collection procedures; and (iv) additional implementation of mass balance or track and trace systems may be called upon when necessary or appropriate (CRAMER, 2007).

Even though not immediately addressing certification objectives, the sustainability assessment procedure carried out in the present study is a contribution towards the organization of a farms' environmental management practices, and of the associated information and documentation, in a straightforward, systemic and reproducible fashion. Additionally, the procedure can serve as an objective field verification process of the efficacy of an implemented certification program to effect environmental quality improvements, a commending initiative for the palm oil sector, for sustainable insertion into the agro-energy production chain.

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