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The sustainability of biofuels¹ has been the focal point in the recent debate regarding its feasibility for displacing fossil fuels. The main reasons for using biofuels in large-scale include the potential reduction of greenhouse gas – GHG – emissions and the potential socio-economic benefits to rural population², including jobs creation, raising income and, in some cases, access to energy services³.

Recently, doubts have been raised about the rationale of producing and using biofuels. The most common questions raised at the international level have been regarding the effective contributions of biofuels in avoiding GHG emissions, the impacts due to land use change – LUC⁴, and on food supply. It's impossible to do an ultimate evaluation on this issue, but there are still a combination of serious concerns, lack of information and also defence of specific interests⁵.

However, two aspects should be taken into account. First, biofuels have been produced in

very heterogeneous conditions, with regard to raw materials (e.g., different results on GHG emissions, different productivities, required land, alternative uses etc.) and the production in itself (e.g., depending on soil and weather conditions and even producer's behaviour). Thus, any generalization would be risky, as good and bad examples can be easily found. Second, there is a great expectation due to the drivers indicated above.

Biofuels would be accepted as a sustainable energy option if the three following conditions are fulfilled:

- 1) their contribution to the reduction of GHG emissions needs to be significant, and the costs of avoided emissions should be relatively low;
- 2) local and regional environmental impacts should be significantly reduced⁶;
- 3) social segments directly involved with the production should get real benefits.

It is not reasonable to consider that the concerns regarding the sustainability of biofuels would be just transitory. Quite the opposite, it is clear that consumers' behaviour has been more and more impacted by environmental and socio issues, and this would not be different with energy. Brazil, as a country with large potential for biofuels production, and with comparative advantages and low production costs, would be in a much better position in the international market if the sustain-

¹ Taking into account their full life cycle.

² Other important reason is the enhancement of the energy security supply; for some analysts, this is in fact the main driving force for biofuels.

³ In less developed regions the production of biofuels could make possible, for instance, local production of electricity, water pumping, mechanization in the agriculture and the transport.

⁴ This question is further analyzed in more details. The impacts of land use change can be either direct or indirect, and can be on GHG emissions, on food supply or over biodiversity.

⁵ For instance, the oil and the food industries have reasons to be against large-scale production and consumption of biofuels, because the impacts on gasoline and diesel markets and on prices of the raw materials, respectively.

⁶ This means, the impacts where the production takes place or close to there.

ability of its production is widely recognized. Even more, if Brazil implement ambitious targets and improves the sustainability of its production, the country could further reinforce its leadership in the biofuels market.

This chapter is about sustainability of biofuels, in general. However, as the publication is about ethanol production in Brazil, specific aspects of this fuel, and about the Brazilian case, are also highlighted.

The follow section is about the different point of views on sustainability of biofuels. International and national initiatives aiming at assuring the sustainability of biofuels, including principles, criteria and policies, are also discussed. This follows by some thoughts about the knowledge available and the required actions.

VISIONS ABOUT SUSTAINABILITY OF BIOFUELS

The meaning of sustainability is wide and its definition is not simple; the term has been applied to almost all natural systems and human activities. There are different views regarding sustainability as the concept is normative⁷ and definitions are related to values, beliefs and choices. In particular, there is no consensus about the basic principles of sustainability of biofuels (RSB, 2008).

It's widely accepted that sustainability has three dimensions, i.e., any productive activity is sustainable if and only if it is (economically) feasible, socially desirable and environmentally correct⁸ (UNITED NATIONS, 2005). In respect to biofuels, the economic feasibility depends both on the competitiveness with fossil fuels (i.e., gasoline and diesel) and on the cost of avoided emissions. In other words, in mid – to long-run biofuels should be feasible when compared to traditional fuels, without subsidies, and the costs of avoided emissions (e.g., in \$/tCO₂) should be moderated regarding other mitigation options. Among all biofuels currently produced, only ethanol from sugarcane, mostly

produced in Brazil, is feasible with gasoline as long as oil prices are higher than 45 to 50 US\$/barrel⁹. As the balance of GHG emissions of the sugarcane ethanol is the best among all current biofuels, the costs of avoided emissions are also the lowest (IEA, 2004). This fact is internationally recognized and, as consequence, there is no doubt about the economic dimension of the sustainability of the Brazilian sugarcane ethanol. This is not the case of ethanol from corn and wheat, and even biodiesel.

As for the social dimension of biofuel sustainability, what is desired is that their production could enhance life conditions of the workers and the people directly involved (e.g., RSB, 2008). The aspects considered most important are jobs creation, working conditions, the compliance with worker's rights and the avoidance of land tenure problems. In this case, it has been considered that the basic principle is the enforcement of the conventions of the International Labour Organization – ILO –, as well of Human Rights Convention.

A second aspect concerns the potential risk that biofuels production could negatively impact food supply due to the land competition and higher demand of agricultural products traditionally consumed as food or feed. These concerns is one of the main reasons for the development of technological routes known as second generation biofuels, based on cellulosic biomass; cellulosic biomass can be produced in low quality land and does not necessarily competes with land for food production. In 2007/2008, the growth of biofuels production was blamed for the raise of food prices. Despite the fact food prices have declined since 2009, and even with the continuous growth of biofuels production¹⁰, there remain still concerns with this issue.

⁹ Supposing that ethanol producing costs are between 590.00 and 660.00 R\$/m³, that the equivalence ratio is 1 litre of ethanol = 0.85 litre of gasoline, exchange ratio 1 US\$ = 2.20 R\$, and that the cost of the barrel of gasoline is 12% higher than the price of oil.

¹⁰ For instance, in March 2009 an official of International Energy Agency stated that one the challenges in the energy market is the potential competition for biomass, for biofuels and food production. See PFLÜGER, A. Potential Role of Biofuels in Future Markets. In: Biofuels Markets – Congress and Exhibition. Available at: <www.iea.org>.

⁷ Normative is a concept defined by social groups and that is related to values perception.

⁸ The so-called three pillars of sustainability.

The environmental dimension of sustainability is much wider as there are many aspects that could be taken into account. The most frequent concerns are not the potential impacts at the end-use stage, as it is recognized that disadvantages “vis-à-vis” fossil fuels will be few. For instance, in the case of ethanol the emissions of aldehydes could be higher than with the gasoline and the emissions of nitrous oxide could be higher with the use of biodiesel.

Conversely, there are more concerns regarding the impacts along the production chain of biofuels. The most frequent argument is that biofuels production could cause deforestation, directly or indirectly. In fact, the growth of biodiesel production from palm in Malaysia and Indonesia have caused deforestation in rain forests (direct impacts) (FRIENDS OF EARTH, 2005; WWF, 2002) and the same hypothesis has been presented regarding the indirect impacts of sugarcane expansion in Brazil, that has been correlated with deforestation in Cerrado and in Amazon forest.

With regard to biofuels production, two papers published in *Science* early 2008 have heated-up the debate on direct and indirect impacts of LUC. FARGIONE *et al.* (2008) analysed the direct impacts over GHG emissions due to the expansion of agricultural crops in biomes with significant carbon stock. As for Brazil, the authors have considered sugarcane cropping in areas previously occupied with woody Cerrado and soybeans production (for biodiesel) both in the Cerrado and in the Amazon Forest. They concluded that the GHG emissions due to land use change would cause significant impact, and that it would be necessary to produce biofuels during tens or even hundreds of years in order to balance the up-front emissions¹¹.

SEARCHINGER *et al.* (2008) addressed the same issue considering also the indirect effects of the expansion of corn production in US; the hypothesis is that due to larger ethanol production

from corn, the production of other agricultural goods (or even corn, for food or feed) would be displaced from US to other countries, potentially causing deforestation.

In the case of ethanol production from sugarcane in Brazil, the authors conclude that four years of ethanol consumption would be necessary to equal the up-front emissions due to LUC if sugarcane was to be planted in pasturelands, or 45 years in case the expansion of sugarcane would induce deforestation of the Amazon Forest¹².

Regarding the aspects mentioned above, the basic principles of sustainability are that the biomass production does not jeopardize sensible biomes and those that should be preserved (RSB, 2008), and that the biomass production does not occur in forest areas, wetlands, and regions with high biodiversity (EUROPEAN PARLIAMENT, 2008)¹³.

On the other hand, so far the main principle driving the sustainability of biofuels is the required reduction of GHG emissions considering fossil fuels displaced. Minimum amounts have been set considering the full life cycle of biofuels and fossil fuels. It is almost consensual that the GHG emissions on direct impacts of land use change should be taken into account but the same is not true regarding the indirect impacts¹⁴. For instance, in

¹¹ In the case of sugarcane cropping in the Cerrado region, 17 years would be necessary to balance the up-front emissions. In the case of biodiesel production from soybeans, 37 to 319 years would be necessary to balance the up-front GHG emissions (respectively, considering soybeans displacing Cerrado or Amazon forest).

¹² On indirect impacts, the hypothesis is that cattle herd would be displaced to the Amazon and this would be the immediate cause of deforestation. The deforestation would be indirectly caused by sugarcane expansion, as it would happen in pasturelands, even far from Amazon. It is true that most of the areas recently cleared in the Cerrado and in the Amazon region are immediately occupied by extensive cattle ranch and that sugarcane expansion has mostly occurred in pasturelands. However, there is no evidence of the indirect effects of sugarcane expansion as considered by SEARCHINGER *et al.* (2008). In fact, in recent years sugarcane expansion has occurred simultaneously to the intensification of cattle herd in Southeast Brazil. It has also been observed that cattle herd have entered in deforested areas of the Cerrado and the Amazon, due to enlargement of the activity and also due to the low land prices.

¹³ The Directives of European Commission, approved in December 2008 and published in May 2009, define areas in which biomass production should not occur – the so-called “no-go areas”.

¹⁴ In the case the Directives of the European Union, the GHG emissions due to indirect impacts of land use change won't

the case of the Directives of European Union¹⁵, the avoided GHG emissions of biofuels use in 2010 should be 35% regarding the life cycle of gasoline or diesel, and this level will be raised to 50% in 2017 (60% in the case of new production plants). In the early years indirect impacts of LUC won't be considered, but the society is pushing for a review in the short-term (i.e., indirect impacts of LUC could be considered in 2011).

The state of California, in US, has adopted a strategy based on a minimum level of reduction of GHG emissions (10%) in the transportation sector by 2020. This reduction should be proved by those who produce, import or commercialise fuels. Contrary to European Union, both direct and indirect impacts of land use change should be considered along the evaluation of GHG emissions in the biofuels life cycle.

The decision has been criticized because the hypothesis considered for evaluating the impacts of land use change in case of biofuels or the fact that the impacts of land use change have not been considered in case of oil products¹⁶. In the case of ethanol produced from sugarcane in Brazil, the direct emissions in the production chain were estimated as 27 gCO₂eq/MJ, while the emissions due to land use change were estimated as 46 gCO₂eq/MJ, totalling 73 gCO₂eq/MJ. Thus, without changes on the efficiency of the ethanol engines, the avoided emissions regarding gasoline life cycle (estimated as 96gCO₂eq/MJ, in case of California) would be low.

Other environmental aspects that have caused concern is that biofuels production could not negatively impact water resources, air quality and the soil. The associated criteria are that the use of

fertilizers and agro-toxics should be minimized, to no contamination of water bodies, minimization of residues production and proper disposition, and use of agriculture techniques that would avoid erosion etc.

INITIATIVES AIMING AT SUSTAINABILITY OF BIOFUELS

International initiatives

This section describes the sustainability principles and criteria currently considered abroad regarding biofuels. The cases highlight are considered to be the most relevant.

Directives of European Union

The sustainability criteria for biofuels at the European Union (EU) was set by the European Parliament in December 2008. The correspondent law was published early 2009. In respect to renewable energy sources, the Directive sets targets for the transport sector and sustainability criteria for biofuels. In the transport sector, the energy suppliers must reduce GHG emissions by 6% in the period 2011 to 2017¹⁷ and present reports about GHG emissions along the life cycle of all energy sources, starting in 2011.

Fuel suppliers should provide an adequate standard of independent auditing that must be verifiable, reliable and fraud-resistant.

The overall target was set at 20% share of renewable energy sources in energy consumption by 2020 in all Member States, and a 10% binding minimum target for biofuels in transport (energy basis). In the accountability process on avoided emissions, the contribution of biofuels produced from lignocellulosic materials will be weighted twice. The GHG saving regarding full life-cycle of fossil fuels must be at least 35% in 2010 and this target will be 60% in 2017 (50% will be the minimum for existing producing units at that year). As previously mentioned, the emissions due to direct impacts of land use change must be considered, but not those caused by indirect

be considered because the scientific knowledge is not solid enough to support such decision. Other argument is that indirect impacts of land use change cannot be attributed to the producers of biofuels.

¹⁵ Renewable Energy Directive, that includes a Fuel Quality Directive.

¹⁶ Brazilian producers of ethanol, represented by UNICA, have presented documents showing that the evaluation done by CARB – California Air Resources Board, had mistakes both regarding direct emissions and emissions due to land use change.

¹⁷ In respect to “emissões de combustíveis fósseis” in 2010.

impacts¹⁸. However, during 2010 the European Commission will propose procedures that could lead to take into account the indirect impacts as well (HODSON, 2009).

The UE Directive also focus on saving biodiversity and on the preservation of most sensible feedstock as biofuels produced in areas previously occupied by undisturbed forests, wetlands, area designated for nature protection could not be considered regarding the targets¹⁹. In addition, social aspects of biofuels production should be reported periodically (every two years) by each Member State²⁰; the references being the conventions of the International Labour Organization – ILO, but there are concerns regarding the legality vis-à-vis World Trade Organization – WTO procedures (DE DOMINICIS, 2009).

California State Government

The initiative of the state of California is known as Low Fuel Carbon Standard – LFCS and aims at reducing 10% of GHG emissions in 2020, regarding 1990. Besides the reduction of GHG emissions, the initiative also aims at reducing oil dependency, and at creating a market for clean-energy technologies in the transport sector. Emission standards have been proposed for fossil fuels (i.e., gasoline and diesel) and the energy that can displace them (CARB, 2009).

Considering the timetable for the period 2011 to 2020, more ambitious targets were defined for the last five years, and this is explained by the fact that more alternatives would be available by the end of the decade (e.g., hybrid vehicles, electric

vehicles, fuel cell vehicles, second-generation biofuels etc.). Thus, biofuels are only one the options considered for the reduction of GHG emissions. For the purpose of estimating emission reductions, the reference fuel in 2020 would be reformulated gasoline blended with 10% ethanol from corn (volume basis) and mineral diesel with low-sulphur content.

During the period 2011 to 2020, the agents responsible for the energy supply in the transport sector will report of results. If an agent has surpassed its targets, the commercialisation of credits will be possible.

Currently, the aim of the LFCS concerns reduction of GHG emissions. The Air Resources Board – ARB in California, has accepted a compromise that a wide set of sustainability criteria for biofuels will be proposed until 2013. Thus, other sustainability aspects will be considered. In a first moment, the environment assessment that will be conducted by ARB will take into account the impacts of LFCS over water resources and biologic resources, soils, and disposal of wastes etc. (CARB, 2009).

Renewable Transport Fuels Obligation

In United Kingdom, the Renewable Transport Fuel Obligation – RTFO – which came into force in April 2008, is a requirement on transport fuel suppliers to ensure that 5%, by 2010, of all-road vehicle fuels are from sustainable renewable sources (biofuels among them). It is predicted that RTFO will be implemented by a certification scheme controlled by the Renewable Fuels Agency – RFA. Fuel suppliers will be obliged to include the required percentage of biofuels (e.g., biodiesel and biogas, besides bioethanol) in their fuel mix or pay a penalty; certifications could be sold in the market. The focus point of RTFO is on reduction of GHG emissions²¹.

RFA requires biofuel suppliers to submit annual, independently verified reports on both the net GHG savings and the sustainability of the biofu-

¹⁸ The decision was based on the fact that currently the scientific knowledge is not enough to support decisions regarding indirect impacts of land use change. One of the main concerns is that complains could be presented to the World Trade Organization – WTO.

¹⁹ According to the Directive, the commercialization and consumption of such biofuels is not forbidden, but they cannot be considered in the accountability that each Member State should present to prove that the targets have been reached.

²⁰ Member States will be responsible for the information presented. Each MS should be sure that all economic agents are supported by independent auditing systems.

²¹ In UK, the transport sector is responsible for 25% of total GHG emissions (DEPARTMENT OF TRANSPORTS, 2008a).

els they supply (DEPARTMENT OF TRANSPORT, 2008b). In the first stage, a report on carbon and sustainability is obligatory, but without consequences if poor performance is reported. By April 2010 it is predicted that biofuels will be rewarded according to the amount of carbon savings, and by April 2011 only biofuels that meet all sustainability standards will be rewarded.

Regarding GHG emissions, the methodology recommended is based on a well-to-wheel procedure including all significant sources of GHG. The required reduction of GHG emissions is 50% “vis-à-vis” the displaced fossil fuel. The recommendation will also include, when possible, the effects on overall GHG savings of previous land use change.

According to environmental and social principles, it is recommended that biomass production will not cause impacts such as those listed below (DEPARTMENT OF TRANSPORT, 2008b):

- destruction or damage of above or below ground carbon stocks;
- destruction to high diversity areas;
- soil degradation;
- contamination or depletion of water resources;
- lead to air pollution;
- adversely affect workers rights and working relationships;
- adversely affect existing land rights and community relationships.

It is worth mentioning that the UK Government recognises that some principles would be difficult to monitor at the fuel supplier level. Land use change arising as indirect result of biomass production and impact of biofuels on commodity prices is explicitly mentioned as an example (DEPARTMENT OF TRANSPORT, 2008a). Overall, the recommendation is that all principles should be monitored ex-post and the RFA report annually the potential effects to the Parliament.

Roundtable on Sustainable Biofuels

The Roundtable on Sustainable Biofuels is an initiative coordinated by the École Polytechnique Fédérale de Lausanne – EPFL, based in Lausanne,

Switzerland. In August 2008 launched the so-called “Version Zero” of Global Principles and Criteria for Sustainable Biofuels Production²², developed with participation of a considerable number of stakeholders of different countries. “Version Zero” was evaluated in a public consultation process and the so-called “Version One” should be released by mid 2010 (RSB, 2008).

Sustainability principles and criteria were proposed and discussed, but so far indicators have not been considered in details. Twelve relevant aspects should be considered in order to assure sustainable biofuels production in a broad sense. These aspects are the following (EPFL, 2008):

- All applicable laws of the country in which production of biofuels occur, as well as all international treaties relevant to biofuels’ production to which the producer country is a party, should be followed.
- For biofuels projects, all relevant stakeholders should be involved along the main steps of the decision process.
- Significant reduction of GHG emissions should be reached through biofuels use, also considering direct and indirect land use change.
- Biofuel production shall not cause violation of human rights or labour rights (include child and slave labour); working conditions should be decent.
- Biofuel production shall contribute to the social and economic development of local, rural and indigenous peoples and communities.
- Biofuel production shall not impact food security.
- Biofuel production shall avoid negative impacts on biodiversity, ecosystems, and areas of high conservation value.
- Biofuel production shall promote practices that seek to improve soil health and minimize degradation.
- Biofuel production shall optimise surface and groundwater resource use, including

²² Available at: <<http://EnergyCenter.epfl.ch/Biofuels>>.

minimizing contamination or depletion of these resources.

- The supply chain of biofuel production and use should not cause significant air pollution.
- Biofuels shall be produced in the most cost-effective way.
- Biofuel production shall not violate land rights.

Global Bioenergy Partnership

The Global Bioenergy Partnership – GBEP – was created in 2006, following a decision taken during the meeting of G8 + 5²³ in 2005 with the purpose of fostering biomass and biofuels consumption mainly in developing countries. During the meeting of the G8 + 5 group in 2008 it was decided to enhance GBEP's action and it was asked the development of bench marks and indicators relative to the best practices of production and consumption of biofuels (GBEP, 2009).

The action plan of GBEP in short-term includes the following actions (GBEP, 2009):

- The promotion of sustainable bioenergy, including the support to the implementation of projects. This working group is led by United Kingdom and aims at the development of criteria and indicators, as well as examples, of best practices on biofuels sustainability. The group also aims at evaluating impacts of biofuels on food supply, taking into account specific aspects of each production process and of each producer country.
- The harmonization of methodologies of evaluation of GHG emissions considering the production of biofuels and solid biomass. This working group is headed by United States and final results will be presented in early 2010.

- The promotion of bioenergy, including the dissemination of information.

In its preliminary version, the sustainability criteria defined by GBEP's working group were classified in four categories: environmental, social, economic, and related to the security of supply. The most important environmental aspects are related to GHG emissions, to the capacity of production of land and ecosystems, to land use change (including indirect impacts), air quality, availability and quality of water resources, and to biological diversity.

The relevant social aspects include security of food supply, access to land, access to water resources and to natural resources, working conditions, rural and social development, access to energy services, human health and security.

Finally, the relevant economic aspects include the availability and the efficient use of resources (e.g., soil, water, capital, working force, energy etc.), the economic development, the economic feasibility and the access to capital and to technological capacity (GBEP, 2009).

Cramer Report

In 2006/2007 the so-called Cramer Commission²⁴ set the Dutch sustainability principles defined by the project group "Sustainable Production of Biomass" (CRAMER *et al.*, 2007). In the final report, principles, criteria and indicators were defined for the main issues concerned to the environmental and social sustainability of biomass production (including biofuels).

Six areas of concern were highlighted by the Cramer Commission. The principles concerned to these priorities are listed below:

- GHG emissions – the use of biofuels should imply reductions of GHG emissions. The comparison should be done regarding the average use of fossil fuels, considering the life cycle of fossil and biofuels (i.e., well-to-wheel basis) and in case of biofuels reduction should be at least 30%. Carbon

²³ The eight most important countries from an economic point of view (USA, Germany, Japan, United Kingdom, France, Canada, Italy and Russia); and the five most important developing countries also from an economic point of view (China, India, Brazil, Mexico and South Africa).

²⁴ Headed by Jacqueline Cramer, Ministry of Environment of The Netherlands.

emissions due to land use change²⁵ should also be taken into account.

- Impacts over food supply – the production of biomass for energy must not endanger the food supply and other local biomass applications. The analysis should be developed considering possible changes of land use in the region of biomass production.
- Biodiversity – Biomass production must not affect protected or vulnerable biodiversity. The basic criteria are that violation of national laws and regulations are unacceptable.
- Local environmental effects – Principles include (a) soil and soil quality, that must be retained or even improved, (b) ground and surface water supply, that must not be depleted, and water quality, that must be at least maintained, and (c) air quality, that must not be depleted. The basic criteria are that national laws and regulations should be enforced.
- Local economic effects – The production of biomass must contribute towards local prosperity.
- Social well-being – The production of biomass must contribute towards the social well-being of the employees and the local population.

National Initiatives

The text to follow presents some initiatives at national level that aim at enhancing biofuels sustainability at their production and use.

Agro-ecologic Zoning (at national level)

Embrapa is the Brazilian Research Centre for Agriculture, linked to the Ministry of Agriculture

(MAPA), and assumed the coordination of the Agro-ecologic zoning for sugarcane at national level. The Zoning has been developed by a multidisciplinary group of state institutes/universities, government organizations and private consultants. The results of the Zoning should be used as guidelines for licensing and credits concession with public funds. Among the targets are the minimization of risks due to the expansion of sugarcane in sensible areas and also avoidance of pressures on food supply.

The following aspects have been considered in order to define adequate areas: a) soil and weather adequacy; b) topography²⁶; c) water availability and water requirements²⁷; d) that sugarcane cannot be planted in areas with sensible ecosystems²⁸; and e) areas where other crops have been produced.

The study was finished in mid 2008 but it was released only about one year after due to political disagreements as some areas currently with sugarcane production were considered inadequate. The results of the Agro-Ecologic Zoning show that 65 Mha are considered suitable for sugarcane cropping of which 37 Mha are currently pasturelands. About 30% of the total area is considered of very large potential for sugarcane production. The most suitable areas are concentrated in the regions where the bulk of the production already occurs (e.g., São Paulo, Paraná, Minas, Mato Grosso Sul and Goiás).

Certification by INMETRO

INMETRO is the National Institute of Metrology, Standardization and Industrial Quality that belongs to the Ministry of Development, Industry and Foreign Trade²⁹. In 2007/2008 the Institute decided to conduct the so-called Brazilian Program of Biofuels Certification. According to its premises,

²⁵ Both considering above ground carbon sinks (vegetation) and underground carbon sinks (soil). In addition, as principles, (1) the installation of new biomass production units must not take place in areas in which the loss of above ground carbon storage cannot be recovered within a period of ten years of biomass production, and (2) the installation of new biomass production units must not take place in areas with a great risk of significant carbon losses from the soil, such as certain grasslands, peat areas, mangroves and wet areas.

²⁶ Maximum declivity 12% is due to the consideration of current technology for mechanization. It is possible to take into account 18% as the maximum, which would enlarge the area. However, the required technology is not yet available.

²⁷ A minimum level of irrigation has been considered (e.g., the so-called salvation irrigation).

²⁸ For instance, Amazon and Pantanal were fully excluded as adequate areas.

²⁹ More information is available at: <www.inmetro.gov.br>.

certification would not be compulsory and the criteria should be in-line with strategies aiming at foster biofuels exports and at reduction of trade non-technical barriers. A first version of the proposal was submitted to public consultation in mid 2008 and a final decision by the Brazilian government was expected during the first semester of 2009, but it has not happened yet at the time of writing.

INMETRO has a similar program aiming at certifying forest management (CERFLOR), which is internationally recognised; INMETRO evaluates that this experience is a good start-point for the program with focus on biofuels. Ethanol certification was defined as the main priority. According to the proposal, an ethanol producer could only start the certification process if the following conditions are fulfilled (INMETRO, 2008):

- Sugarcane production should be in accordance with the Agro-Ecologic Zoning.
- All environmental licences are required.
- Evidences of water recycling are required.
- Electricity should be generated on-site, from sugarcane residual biomass.
- Evidences of trash deposition over the soil are required.

Agro-ecologic Zoning in São Paulo

The Agro-ecologic Zoning in São Paulo has been effective since October 2008. The information provided by this study has been considered by the Environment Secretary along the licensing process of new mills. The zoning was defined taken into account the following aspects: a) soil and weather constraints; b) topography; c) water availability at the surface and risks to water shields; d) the existence of protected areas; e) areas that should be preserved considering conservation of biodiversity; and f) air quality.

The cultivated land in São Paulo was estimated in 2006 as 7.9 Mha, being at that time 4.3 Mha were already cultivated with sugarcane.

Agro-environmental Protocol (State of São Paulo)

The Agro-environmental Protocol was established in the state of São Paulo in 2008, signed by

the state Government and the sugarcane sector. In São Paulo, 151 out of almost 190 ethanol mills have adhered the Protocol; the number of sugarcane suppliers that have adhered to the Protocol is estimated as 13,000 (LUCON, 2008). The Protocol is a voluntary scheme aimed at promoting best practices beyond business-as-usual. One the future target is issuing a Certificate of Conformity. Ten directives were defined as guidelines, as presented bellow (SÃO PAULO, 2008a):

- Anticipation of the due-date for phasing-out of sugarcane burning previous to harvest in areas with declivity lower than 12% (from 2021 to 2014)³⁰.
- Anticipation of the due-date for phasing-out of sugarcane burning previous to harvest in areas with declivity higher than 12% (from 2031 to 2017).
- In areas of sugarcane expansion burning should not be a practice.
- All by-products of sugarcane cannot be burned without a control system.
- Protection of the riparian forest of sugarcane planted areas³¹.
- Recovery of natural vegetation in order to protect water springs of sugarcane farms.
- Implementation of a technical plan of soil conservation, including erosion control and contention of water runoffs.
- Implementation of a technical plan aiming water resources conservation, including reuse action and a water quality program.
- Adoption of good practices for agrochemicals packaging waste.
- Adoption of good practices aiming at minimizing air pollution and optimise recycle of solid wastes.

³⁰ It is defined by law that the due date for phasing-out of sugarcane burning before harvest is 2021 in areas with declivity lower than 12% and 2031 as the due date for areas with declivity higher than 12%. Through a voluntary agreement, the intention is to anticipate such due dates.

³¹ The existing law already defines protection of riparian forest as an obligation, but there are areas in state of São Paulo where the enforcement is weak.

CONSIDERATIONS REGARDING THE CURRENT STAGE AND THE NEAR-TERM

The previous text gives an overview of a reasonable number of initiatives and also makes clear the different point of views regarding the subject. Sustainability, in general, and sustainability of biofuels, in particular, is a relatively new theme and disagreements regarding its importance, priority aspects, and how to use the results in a constructive way are natural.

On the other hand, it has been observed that in past few years the resistance of some social sectors has declined. In fact, it is impossible to overlook the importance of sustainability and not to be part of the debate as it is the main driving force of biofuels and also due to the significance of the priority aspects.

Obviously the real target of the whole process should be the improvement of the production systems and better results of biofuels production and consumption. However, as there are many different interests and the state-of-art of knowledge is not that advanced, it has been possible to distort information and to define rules with particular purposes.

A very important aspect is that this process could not resume in a single certification process, satisfying those who are not exactly concerned with real social, economic and environmental benefits. It would be disastrous to have a certification process with all known distortions of those of existing certification processes.

The development of biofuels should allow the inclusion of the most marginalized social sectors that have had few job opportunities, few opportunities for improving life, and for having access to energy services. The sustainability of biofuels production chain is essential but cannot be an excuse for setting trade barriers for less developed countries. In this sense, it is necessary to assure technology transfer, building capacity, financial support and less constrains on trade in order to make biofuels a real option.

But it is also necessary to have in mind that biofuels are not a panacea for solving energy sup-

ply and GHG emissions problems. Firstly because it is not possible to conceive a sustainable scenario, in long-term, based on the current transport system. Secondly, because as an alternative to reduce GHG emissions, there are other most cost-effective options with the required technology already available (e.g., the improvement of end-use efficiencies).

On the other hand, it is important to recognise that many of problems imputed to biofuels have been historically observed in the agriculture e.g., soil degradation, large-scale use of fertilizers and agro-toxics, changes on carbon stocks and land tenure problems. The production of biofuels is and will be marginal with regard to agriculture and thus cannot be blamed for the main problem. In fact, biofuels production could help to modernize agricultural practices and disseminating best techniques.

It is worth to mention that the controversy surrounding sustainability of biofuels is also motivated by lack of understanding, expeculative behaviour and incorrect generalisation of few results. Sustainability is clearly a multidisciplinary issue and is very close to people's day-by-day, and this has both positive and negative aspects; the debate can be wide and democratic, but also moved by interest and based on non-accurate information. Clearly, there is a lot to be done by basic science, technology and dissemination of knowledge. An adequate data basis is required for each region, and models should be developed or adjusted to each specific case.

Brazil has long tradition on ethanol production, a huge potential for biofuels production and adequate conditions – including human and materials resources – for contributing with scientific and technology development. It is clear that Brazil has a very important role because is one of the few developing countries that can influence the biofuels debate and set positive bench marks on sustainability. The country is able to cooperate on disseminating biofuels production to other developing countries, as it has the technology, qualified people and reasonable investment capacity. Brazil is currently able to produce biofuels in large-scale, and at low costs and fulfilling the most relevant sustainability principles.

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