Assessing Bioenergy Sustainability through the use of the Global Bioenergy Partnership (GBEP) Sustainability Indicators for Bioenergy

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ABSTRACT

The Global Bioenergy Partnership (GBEP) is an international initiative that brings together public, private and civil society actors to cooperate on a voluntary basis in the areas of bioenergy for sustainable development, climate change mitigation, and food and energy security as per the mandate of the 2005 G8 Summit. FAO is a founding partner of GBEP and hosts its Secretariat since its establishment in 2006. In 2011, GBEP agreed on a set of 24 science-based, technically sound, voluntary and highly relevant indicators concerning the sustainability of all forms of bioenergy. The measurement of these indicators can inform policy-makers and other stakeholders in countries seeking to develop their bioenergy sector to help meet national goals of sustainable development. Measured over time, the indicators will show progress towards or away from a nationally defined sustainable development path.

To date the GBEP indicators have been applied in a number of countries to various extents including Japan, Germany, Indonesia, Colombia, the Netherlands, Ghana and Argentina, and several others have announced their intention to perform the assessment or are already carrying out the assessment including Kenya, Ethiopia, Viet Nam, Paraguay, the United States of America, Jamaica, Italy and Brazil.

In this paper the results of and lessons learned from the "Pilot testing of Global Bioenergy Partnership (GBEP) indicators for sustainable bioenergy in Colombia and Indonesia" will be shared.

Keywords: Bioenergy, Sustainable development, Colombia, Indonesia.

1. Introduction

The production and use of bioenergy is growing in many parts of the world as countries seek to diversify their energy sources in a manner that helps promote sustainable development. Modern bioenergy can provide multiple benefits, including promoting rural economic development, increasing household income, mitigating climate change, and providing access to modern energy services. On the other hand, bioenergy can also be associated with risks, such as biodiversity loss, deforestation, additional pressure on water resources, and increased demand for agricultural inputs, land, and commodities.

The Global Bioenergy Partnership (GBEP), an international initiative established in 2006 and of which FAO is a founding partner, has developed a science-based, technically sound, and highly relevant set of 24 indicators (Table 1) that can inform policy-makers and other stakeholders in countries seeking to develop their bioenergy sector to help meet national goals of sustainable development. Measured over time, the indicators will show progress towards or away from a nationally defined sustainable development path.

The indicators were intentionally crafted as a voluntary tool to report on the environmental, social and economic aspects of sustainable development. Each indicator was developed with three parts: a name, a short description, and a multi-page methodology sheet that provides in-depth information needed to evaluate the indicator.

Table 1: Indicator names.

GBEP INDICATORS		
Environmental	**Social**	**Economic**
1. Lifecycle GHG emissions	9. Allocation and tenure of land for new bioenergy production	17. Productivity
2. Soil quality	10. Price and supply of a national food basket	18. Net energy balance
3. Harvest levels of wood resources	11. Change in income	19. Gross value added
4. Emissions of non-GHG air pollutants, including air toxics	12. Jobs in the bioenergy sector	20. Change in consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	13. Change in unpaid time spent by women and children collecting biomass	21. Training and requalification of the workforce
6. Water quality	14. Bioenergy used to expand access to modern energy services	22. Energy diversity
7. Biological diversity in the landscape	15. Change in mortality and burden of disease attributable to indoor smoke	23. Infrastructure and logistics for distribution of bioenergy
8. Land use and land-use change related to bioenergy feedstock production	16. Incidence of occupational injury, illness and fatalities	24. Capacity and flexibility of use of bioenergy

In order to establish the feasibility of these indicators and enhance their practicality as a tool to support policy-making towards sustainable development of bioenergy, it was suggested to pilot test them, supporting countries with required technical and financial assistance.

As of July 2016, the GBEP indicators had been implemented in nine countries (i.e. Argentina, Colombia, Egypt, Germany, Ghana, Indonesia, Jamaica, Japan and Netherlands) and another dozen countries committed to implement or were in the process of implementing them.

With this paper, the results of the "Pilot testing of Global Bioenergy Partnership (GBEP) indicators for sustainable bioenergy in Colombia and Indonesia" will be shared.

The overall objective of the project was to pilot the GBEP sustainability indicators in Colombia and Indonesia, and build the capacity of these two countries to apply the indicators and use them to inform the sustainable development of their bioenergy sectors.

The project aimed to:

- assess and enhance the capacity of the two countries to measure the GBEP indicators and use them to inform bioenergy policy-making; and
- learn lessons about how to apply the indicators as a tool for sustainable development and how to enhance the practicality of the tool.

2. Results of the pilot testing

2.1. Main findings in Colombia

The testing of GBEP sustainability indicators in Colombia focused on ethanol from sugarcane and biodiesel from palm oil. The testing provided Colombia with an understanding of how to establish the means of a long-term, periodic monitoring of its domestic bioenergy sector based on the GBEP indicators. Such periodic monitoring would enhance the knowledge and understanding of this sector and more generally of the way in which the contribution of the agricultural and energy sectors to national sustainable development could be evaluated. Furthermore, the testing in Colombia provided a few lessons learnt about how to apply the indicators as a tool for sustainable development and how to enhance their practicality. These lessons learned, which were shared and discussed with neighbouring countries at regional level, as well as the trainings carried out during the project showed the importance of these activities in the measurement of the GBEP Indicators and in the facilitation of South-South cooperation.

2.1.1 Sustainability of bioenergy in Colombia

A number of environmental, social and economic issues associated with the sugarcane-based ethanol and palm oil-based biodiesel supply chains were identified during the testing of the GBEP indicators in Colombia.

On the environmental side, fertilizer and pesticide applications were identified as key sources of GHG emissions and water pollution along both supply chains. Few data could be found on this, due to the limited extent of ongoing monitoring and analysis of water quality in Colombia. Therefore, despite the limited interest in this issue expressed by Colombian stakeholders during the testing of the GBEP indicators, further data collection and analysis would be needed on the impacts of bioenergy feedstock production and processing on water quality. In parallel, good practices that reduce fertilizer and pesticide application while improving efficiency and profitability, such as Integrated Plant Nutrient Management and Integrated Pest Management, should be promoted. Wastewater is another source of GHG emissions and water pollution along the sugarcane-based ethanol and palm oil-based biodiesel supply chains. In this case, methane capture and use should be promoted, including through carbon offset programmes, as is already being done in the palm oil industry in Colombia.

In addition to water quality, issues related to water availability and use in bioenergy feedstock production were identified. In particular, water withdrawals for sugarcane production (including for ethanol) in the *Cauca* watershed might trigger medium-high water stress in dry years. Therefore, irrigation efficiency should be closely monitored and improved technologies and management practices promoted. Finally, with regard to soil quality, both the *Valle del Cauca* (the main sugarcane production area of Colombia) and the Northern region of the *Caribe*, where oil palm is cultivated, show high susceptibility to salinization.

On the social side, in addition to the aspects already discussed above, other issues were explored, for instance with regard to the quality of the jobs associated with biofuel feedstock production and processing. Overall, compared to the average agricultural worker, sugarcane and oil palm workers seem to benefit from a higher level of formalization of employment, better wages and benefits and better protection against occupational risks. Another interesting aspect relates to the business models and the level of smallholder inclusion along the biofuel supply chain. During the last decade, there was an important transformation in the palm oil supply chain in Colombia, with the emergence of the so-called *Alianzas Productivas Estratégicas.* The *Alianzas* are strategic business partnerships formed by small-scale producers, which organize themselves in order to improve their access to credit, strengthen their bargaining power with the mills, and ensure a secure market for their produce thanks to contracts with the latter. As of 2010, around 16 percent of the planted area of oil palm was under an *Alianza*, up from less than 1 percent in 1999. In addition to having contributed to the growth of the palm oil sector, these strategic business partnerships have been quite effective in strengthening the inclusion of smallholders in the palm oil supply chain and in increasing their profitability. The *Alianzas* should be further researched and analyzed and the potential for their future expansion in the palm oil supply chain and eventually in the sugarcane supply chain should be explored.

With regard to the economic aspects, the Colombian biofuel sector can count on a high level of productivity in feedstock production, especially with regard to sugarcane, with an average annual yield among the highest in the world (i.e. 120 t/ha). From an energy balance perspective, Colombian sugarcane-based ethanol and palm oil-based biodiesel supply chains are rather efficient compared to the production of other first-generation liquid biofuels. This is true especially for sugarcane-based ethanol systems, which use the energy content of the biomass rather efficiently, through co-generation of electricity and steam from bagasse, in addition to the sugar and ethanol output.

While the gross value added generated by the biofuel industry in Colombia is relatively small compared to the GDP (e.g. 0.031 percent in the case of ethanol in 2010), the demand for goods and services associated with this industry was found to trigger multiple indirect and induced effects on the economy, including in terms of employment.
Furthermore, even though in 2009 ethanol and biodiesel accounted for only 1.05 percent and 0.7 percent respectively of the total primary energy supply (TPES) in Colombia, these biofuels substituted fossil fuels worth 103 million USD (ethanol) and 215 million USD (biodiesel) in 2012. However, the contribution of these biofuels to energy security was limited by their lack of diversity in terms of feedstock and geographic location, exposing their production to risks related to pest outbreaks and adverse weather conditions, especially in the case of sugarcane-based ethanol. Bagasse, which is a co-product of sugarcane processing used for cogeneration, contributed 3.49 percent to TPES in 2009. On other hand, in Colombia, where woodfuel was still accounting for 8.7 percent of TPES in 2009, modern bioenergy technologies have not played a significant role yet in displacing traditional uses of biomass and in providing access to modern energy services.

2.2. Main findings in Indonesia

The testing of GBEP sustainability indicators in Indonesia focused on palm oil-based biodiesel, reflecting the indications emerged during discussions with relevant stakeholders in Indonesia and the relevance of biodiesel within Indonesia’s modern bioenergy mix. The testing provided Indonesia with an understanding of how to establish the means for a long-term, periodic monitoring of its domestic bioenergy sector based on the GBEP indicators. Such periodic monitoring would enhance the knowledge and understanding of this sector and more generally of the way in which the contribution of the agricultural and energy sectors to national sustainable development could be evaluated. The testing in Indonesia also provided a series of lessons learnt about how to apply the indicators as a tool for sustainable development and how to enhance their practicality. These lessons learnt, which were shared and discussed with neighbouring countries at regional level, as well as the trainings carried out during the project showed the importance of these activities in the measurement of the GBEP Indicators and in the facilitation of South-South cooperation.

2.2.1 Sustainability of bioenergy in Indonesia

A number of environmental, social and economic issues associated with palm oil-based biodiesel supply chains were identified during the testing of the GBEP indicators in Indonesia. In Indonesia, the growing demand for palm oil, including as biofuel feedstock, has triggered a supply response, in the form of an expansion in the harvested area of oil palm. Thanks to this increase in production, there was no diversion of palm oil from the food market to the biofuel market, as confirmed also by the data available in national and international statistics. According to FAOSTAT, between 2008 and 2012, the supply of palm oil for food increased in Indonesia. However, the land-use changes associated with the oil palm expansion have given rise to a range of environmental, social and economic impacts.

In 2010, around 8.4 million hectares were planted with oil palm in Indonesia, of which 91.6 percent in the islands of Sumatra, Kalimantan and Papua. Between 1990 and 2010, about 6.35 million ha of land were converted to oil palm in these three islands.

According to the Life Cycle Analysis (LCA) of GHG emissions that was performed during the project, under indicator 1, this expansion led to the conversion of high carbon stock areas (e.g. forests, timber plantations, etc.), causing significant emissions of carbon dioxide. In addition, about 1.25 million ha of peatland were drained and converted to oil palm cultivation, resulting in high, continuous GHG emissions from peat decomposition. Overall, the results of the LCA confirmed that land-use change, especially from forests, is the most important contributor to total GHG emissions from the Indonesian palm oil industry.

Other important consequences of land use change associated with oil palm expansion are habitat loss and impacts on biodiversity. As of 2010, 17 percent of Indonesian oil palm plantations were found in High Conservation Value areas.

Another important source of GHG emissions along the palm oil supply chain is the methane released by the anaerobic fermentation of palm oil mill effluent (POME). As of 2012, only around 5 percent of the over 600 Indonesian palm oil mills were equipped with methane capture systems. An analysis of the economic viability of these methane capture systems should be conducted and, if necessary, measures to promote their wider adoption might be considered.

In addition to land-use change and the associated effects in terms of GHG emissions and biodiversity, a number of other environmental issues were assessed and analyzed.

With regard to soil quality, in East Kalimantan, soil erosion affects oil palm production areas. Concerning soil organic carbon, data is scarce due to the lack of periodic monitoring.

Regarding water quality, it was found that large quantities of pollutants, mainly nitrate and phosphate, are discharged into the bodies of water near the oil palm plantations. As a result, in several areas pollutant concentrations in rivers often exceed the thresholds set by law, particularly around smallholders plantations on peat soils. Further and more refined investigations of pollutant loadings in the internal waters in Indonesia due to biodiesel feedstock production are needed, including mathematical modelling of material transport. With regard to non-GHG airborne pollutants, the low level of mechanization in oil palm cultivation results in relatively low emissions of such pollutants. Concerning tailpipe emissions, tests have demonstrated that biodiesel can significantly reduce the emission of most non-GHG pollutants when compared to fossil-based diesel, showing the potential environmental and health benefits of a shift from traditional fuels to biofuels, especially in densely populated urban areas.

With regard to social sustainability, in addition to the food security implications mentioned earlier on, other issues were explored as well, for instance with regard to the income effects and the number and quality of jobs associated with biofuel feedstock production and processing. As explained above, the increased in the demand for palm oil for biodiesel in Indonesia has triggered a supply response, leading to a significant expansion in the planted area (and subsequently harvested area) of oil palm. This has resulted in a considerable increase in the number of people employed in palm oil production. Regarding the quality of the jobs created in this sector, compared to the average agricultural worker oil palm workers seem to benefit from a higher level of formalization of employment, better wages and benefits, and better protection against occupational risks. The increase in the demand for palm oil for biodiesel production has also provided additional income-generating opportunities for agricultural producers, including smallholders, who accounted for around 35 percent of total palm oil production in Indonesia in 2012.

With regard to land tenure, a few cases of land conflicts were reported in literature, including in the context of oil palm plantations, with lack of adequate legal recognition of customary rights to land identified as one of the main causes.
Last, but not least, concerning energy access, it was found that to date modern bioenergy has not played a significant role in providing access to modern energy services and in displacing traditional uses of biomass, which still accounted for over 18 percent of the Total Primary Energy Supply (TPES) in 2012.

With regard to the economic sustainability aspects, the Indonesian biofuel sector appears to be cost-competitive. However, yields have been stagnant for many years, whereas higher yields have been obtained in experimental trials thanks to the research and development of improved varieties and management regimes.
While the gross value added generated by the biofuel industry in Indonesia is relatively small compared to the GDP (e.g. 0.026 percent in 2012), the demand for goods and services associated with this industry has been reported to trigger multiple indirect and induced effects on the economy, including in terms of employment.
From an energy balance perspective, the Indonesian palm oil-based biodiesel supply chain is rather efficient compared to the production of other first-generation liquid biofuels. However, there appears to be room for further improvement in the feedstock production phase of the supply chain (particularly in the case of independent smallholders), as well as for the refinery component of the processing phase.
Furthermore, even though in 2012 biodiesel accounted for only 0.19 percent of the total primary energy supply (TPES) in Indonesia, this modern bioenergy led to around 282 million USD of estimated savings from avoided oil imports and generated 657 million USD of export revenues.

With regard to the logistics of the biodiesel supply chain, distribution to the easternmost provinces of the archipelago, namely Papua and Maluku, may be difficult due to the lack of efficient infrastructures and this is considered the main cause that has prevented the country from fulfilling the B10 mandate in 2012. Distribution hurdles are also found in the two main producing islands, i.e. Sumatra and Kalimantan. The latter, in particular, suffers from limited availability of processing facilities and poor internal distribution routes (e.g. dirt roads and shallow ports). For this reason, large quantities of feedstock need to be transported in relatively small batches from Kalimantan to Sumatra. In order to meet higher biofuel mandates, these logistical issues are expected to be thoroughly assessed and managed.

3. Conclusions and recommendations

During the pilot testing of the GBEP indicators, both in Colombia and Indonesia, only partial analyses could be conducted due to the limited data available. Filling these data gaps will be essential in order to enable an effective monitoring of the GBEP indicators in the future and thus assess over time the sustainability of bioenergy production and use in the two Countries. Data gaps were particularly significant for the social sustainability indicators. In order to fill these gaps, surveys should be carried out. In addition, as already mentioned above, as the bioenergy sector continues to expand and higher biofuel mandates are considered, it is essential to monitor land-use changes associated with bioenergy feedstock expansion, given the important implications that land-use changes can have for a range of environmental, social and economic sustainability issues. Remote sensing, field visits and stakeholder consultation are complementary tools that should be used in order to study and analyze the land-use changes associated with bioenergy feedstock expansion.

Furthermore, as anticipated above, the pilot testing in Colombia was focused on sugarcane-based ethanol and palm oil-based biodiesel and, to a certain extent, cogeneration from bagasse, while the pilot testing in Indonesia was focused on palm oil-based biodiesel. This reflected the indications emerged during discussions with relevant stakeholders in the two countries. However, as different bioenergy technologies start being deployed in both countries, the impacts associated with these technologies should be assessed as well. In Colombia, in particular, wood fuel still accounts for an important share of total primary energy supply (TPES) and rural households rely heavily on fuel wood and charcoal for heating and cooking. Traditional uses of biomass are inefficient and lead to a number of detrimental environmental and health effects. Therefore, the potential for displacing these traditional uses of biomass with modern bioenergy technologies and for providing access to modern energy services through them should be explored and promoted, and the resulting environmental, social and economic effects should be assessed.

Regarding the long-term measurement of GBEP indicators in Colombia and Indonesia it is recommended to involve all relevant stakeholders in the process, ranging from relevant government departments/ministries (e.g. those dealing with agriculture, energy, environment, rural development, food security, infrastructure, etc.) to producer associations, universities and NGOs. Stakeholder engagement and ownership of the process is key in order to get access to the necessary data and information, receive inputs and feedback, discuss and interpret the results, and ultimately inform policy discussions and decisions.

In addition to this, a network of focal points within each relevant organization could be considered in the future as a means to strengthen institutional coordination and stakeholder engagement for regular national activities related to bioenergy.

With reference to the objective to enhance the practicality of the GBEP indicators, during the testing in Colombia and Indonesia it was realized that more clarity and guidance from GBEP would be needed regarding both methodological and practical issues related to the implementation of certain indicator methodologies. An implementation guide would be needed in order to complement the GBEP report on the sustainability indicators.

On this matter, further guidance would be necessary, in particular, on the complex and crucial issue of the attribution of impacts to bioenergy production and use. For each indicator a range of suitable approaches should be identified and illustrated in detail providing specific examples, and the pros and cons of using one approach versus another should be discussed.

Furthermore, in order to significantly reduce the time, skills and cost required to measure the GBEP indicators, an Excel and/or web-based application should be developed. This would allow users to easily enter all data required for the 24 indicators into one single data entry sheet and to get a set of results for each indicator based on the related methodologies. In addition to the aforementioned benefits, this process would also simplify considerably the data collection process, and it would allow to easily save and share the results and to re-run the tool over time with up-to-date information.

Last, but not least, given the global nature of the GBEP indicators, the report containing the methodology sheets should be translated into other official languages of the UN beside English, e.g. French and Spanish. This would greatly facilitate the dissemination and implementation of the indicators in developing countries around the world.

REFERENCES

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