Development of a sustainability assessment framework for planning for sustainability for biofuel production at the policy, programme or project level

L. K. Haywood, B. de Wet, G. P. von Maltitz & A. C. Brent
Natural Resources and the Environment, CSIR, South Africa

Abstract

Biofuel development projects are proceeding at a pace that outstrips normal planning and feasibility evaluation. We present a theoretical framework for planning for sustainability for biofuel production at the policy, plan/programme or project (PPP) level. The objective of this framework is to foster and preserve the social ecological system in which the PPP is to occur so that the system remains dynamic, adaptive, resilient and durable through time. The overall approach to the framework is the understanding of the function and relationships within the social ecological system in which the proposed biofuel PPP is to occur. The system is analysed through stakeholder engagement and expert analysis. Sustainability is assessed through the development of sustainability principles and criteria with sustainability indicators to measure the progression. The framework has developed through a long history of impact assessment and strategic environmental assessment in the environmental sector.

Keywords: biofuel, sustainability assessment, planning, social ecological system, sustainability vision, principle, criteria and indicators.

1 Introduction

The world is facing looming energy shortages in the light of ever increasing energy demand and it is predicted that by 2025 the global demand for petroleum will have increased by 40-50% over current levels [1, 2]. This is extremely concerning considering that petroleum is the largest single source of energy consumed, exceeding coal, natural gas, nuclear, hydro and renewables [3]. The
rise in oil price, energy security and the realisations of the impact of global warming has sparked worldwide concern to rapidly address the replacement of petroleum with an alternative energy source. Biofuels, a renewable energy source derived from biomass, would appear to offer potential as an alternative energy supply as it is one of the few alternatives to fossil fuel derived liquid fuels. Despite the appeal of biofuels, a number of key concerns around the long-term sustainability of a biofuels industry have recently been raised, and it is now clear that careful, case-specific, assessment and planning needs to underpin any proposed biofuels initiative [4, 5].

The development of technologies to utilize biomass as a source of energy has advanced on many fronts to produce solid fuels (chips, pellets, briquette, logs), liquid fuels (methanol, ethanol, diesel), gaseous fuels (synthesis gas, biogas, hydrogen) and heat [6, 7]. Through modern technologies such as pyrolysis, gasification and anaerobic digestion countries such as the United States of America (USA) and the European Union (EU) are focusing on the use of biofuels as a replacement fuel to petroleum [6, 8, 9]. The advancement of bioenergy technologies has created a situation where the implementation of biofuel programmes, or specific biofuel development projects, is proceeding at a pace which outstrips that of normal planning and feasibility evaluation. It is not enough to have a renewable source of energy but this source must be sustainable in its supply thereby meeting the objectives of the Johannesburg Plan of Implementation and The Millennium Development Goals. Unless a number of measures are successfully put in place to ensure sustainable agricultural practices and sustainable biofuel conversion practices, particularly during the inception phase of any biofuel project, no matter the technological advancements, this industry may cause more ecological and social damage than the envisaged benefits.

Serious concerns have been raised about the sustainability of future biofuel development, both for a global environmental perspective as well as from local socio-economics perspective [10, 11]. Research on sustainable biofuel systems is a very young science so that few studies and empirical, field-derived data are available as yet. While reducing carbon emissions and security of energy supply are perceived positive benefits at a global level, developing nations and local communities are likely to consider job creation, income improvement, the local environment and regional development as more important considerations for engaging in biofuels [11]. These differing and potentially competing benefits may be regarded as aspects of assessing biofuel developments within a framework of sustainability, generally recognised as having three sets of criteria: economic viability, environmental performance and social acceptability [10].

Sustainability is not a measurable target or an accurate science. Sustainability and sustainable biofuel production is subjective depending on the desired outcomes of the end user. This paper sets out the basis of an approach for planning for sustainability for biofuel production at the policy, plan/programme or project (PPP) level. The objective of planning for sustainability at the onset is to foster and preserve the social ecological system in which the PPP is to occur so that it remains dynamic, adaptive, resilient and
therefore durable through time. This is different from the conventional approach to environmental assessment, which is used to provide information for decision-making, based on the level of potential environmental impacts that are considered acceptable, or which through mitigation can be managed. This research comprises a theoretical sustainability assessment framework to be used to guide and support planning and decision making for sustainable biofuel production.

2 Theoretical background to planning for sustainability

2.1 Environmental assessment vs. sustainability assessment

Environmental Impact Assessment (EIA) has been firmly entrenched for the analysis of potential effects of developments on the environment. The technique and process of EIA have an established history of application spanning the past 40 years, having first been legislated in the USA in the National Environmental Policy Act of 1969. Although the use of EIA has brought environmental concerns into project level development planning, its success in promoting sustainability as an outcome of planning has been limited. The reasons for this limited success, is that EIA focuses primarily on identifying and evaluating the potential ecological, social and economic effects of proposed projects separately and in isolation from each other, and only thereafter are attempts made to integrate the implications of these effects, so that a more comprehensive picture of the impact of the proposed development can be obtained [12, 13]. In addition, EIA traditionally does not address the potential effects that may manifest over time, and is usually used to evaluate a proposal at a ‘snap shot’ in time meaning that the nature, extent and dimensions of the project must be constant for the analysis to take place, and so changes in the project over time constitute a ‘new project’, which must then be subjected to a new EIA [13, 14]. Finally, project level EIA is commonly focused only on the investigation of potential effects on the proposed project site and seldom broader and it is seldom that environmental impacts stay within a confined site boundary [14].

Strategic Environmental Assessment (SEA) attempts to address the limitations of EIA in that it is a tool designed to move environmental assessment in the development planning process [15]. SEA is intended to facilitate the consideration of environmental effects from a strategic perspective, so that broader considerations than only those applicable to individual projects are taken into account in planning. The strategic perspective changes both the nature and number of potential effects that may result from a particular development proposal, since many of the potential effects can be avoided by informed policy and development plan/programme formulation [15, 16]. Although SEA has made a substantive contribution to the incorporation of environmental concerns into development planning, the manner in which it is applied and the purpose that is defined for individual SEAs, also do not necessarily constitute planning for sustainability.
Sustainability Assessment is expressly to prepare and design a development policy, plan, programme or project with sustainability as the desired outcome, rather than merely to prevent or mitigate potential environmental impacts [17, 18]. The approach is inherently positive as well as prospective. It is about considering the relationships between social, ecological and economic factors. Gibson [19] advocates that sustainability assessment must be focused on these interrelationships and their character, resilience to change and adaptability. Since sustainability is an integrative concept, it is important to design sustainability assessment as an essentially integrative process that can act as a framework for better decision-making at all levels of development planning that may have lasting effects [19]. These relationships need to be characterised and explored at the earliest stages of a sustainability assessment process to inform the accurate formulation of appropriate sustainability criteria.

3 Fundamental methodological aspects of the planning for sustainability assessment framework

3.1 Stakeholder participation

The overall approach to this framework is the understanding of the function and relationships of the social ecological system in which the proposed biofuel PPP falls. Instead of taking a reductionist approach, in which various technical experts analyse aspects of the social ecological system and provide recommendations thereof, this framework works on the premise that wholeness of the system is best described by a wide variety of stakeholders. The explicit inclusion of those who have a stake in the planning scenario is now a development-planning orthodoxy. A holistic approach to sustainability defined as a participatory deconstruction and negotiation of what sustainability means to a group of people, along with the identification of indicators to assess such deconstructed vision of sustainability. Planning for sustainability is thus driven by broad based stakeholder participation coupled with evidence-based information throughout the entire planning process. The success of the planning process relies on drawing on the inputs of as many interested and affected parties as far possible to ensure that all the components of the social ecological system and the relationships between them are both identified and where necessary investigated. The participation is facilitated within a deliberative process which can include workshops, discussion groups, participatory rural appraisal or even the use of the rich picture technique. This process needs to be supplemented by evidence based data and information, and this might require the commissioning of specialist studies based on early scoping of important issues as well as the use of models and multi-criteria tools to aid stakeholders understand alternative scenarios. Without this comprehensive involvement, there is a high risk of excluding important considerations of the system in effectively planning for sustainability. Gibson [19] refers to this as a process that creates spaces for values and perceptions are considered alongside technical data; and identification
of modifications or alternatives to a proposal that would deliver more sustainable outcomes encouraged.

3.2 Sustainability goals and vision

Sustainability is based largely on the integration of social, economic and biophysical elements that exist within social ecological systems. The sustainability goals of any sustainability assessment must therefore address these elements as they are ultimately the drivers of change within a social ecological system. These sustainability goals form the starting point of the sustainability assessment as they provide the platform to stimulate the visioning process among the stakeholders. At a global scale there are commonly three broad sustainability goals for biofuel production. These include [4]

1. Rural development and food security;
2. Environmental change (including maintenance of ecosystem services and reducing future climate change; and

The most important step in sustainability assessment is to define a sustainability vision [17, 19] The vision is equivalent to a desired end state or sustainability scenario for the social ecological system in question, as defined by all interested and affected parties during the participation process. Elements of the above three sustainability goals (where appropriate) as well as any other local important sustainability goals should be infused within the end vision. In other words, the biofuel PPP vision becomes a locally accepted statement giving appropriate weighting to varying aspects of sustainability. If a common vision for biofuel development cannot be created amongst the stakeholders and there is no consensus on the vision, then this is where the sustainability assessment process stops. The PPP for biofuel development may thus not be appropriate for the specific area or regional/national context, and the desired state of sustainability will not be achieved.

3.3 Sustainability principles, criteria and indicators

Assessing whether a proposed biofuel development will be sustainable or not, requires that sustainability principles, criteria and indicator be defined. A sustainability principle is a broad based statement for achieving the sustainability vision. Sustainability criteria are management objectives that are set in order to achieve the broad principles as set out in principles. Sustainability criteria essentially indicate how the sustainability principles can be achieved. All the sustainability criteria that have been set must be satisfied to ensure that the sustainability principles and thereby the sustainability goal will be achieved in the implementation of the proposed PPP for biofuels development. In essence the criteria represent the minimum acceptable condition that is agreeable to all stakeholders, and as such any proposal that cannot meet the criteria should be rejected. Sustainability indicators provide a measure of the criteria. Practical, meaningful and measurable indicators should be identified for each of the criteria, so that it is possible to measure whether individual sustainability criteria
have been met or not. Indicators may be qualitative or quantitative in response to
the specific criterion. Great care needs to be taken to ensure that indicators do
not unintentionally bias the interpretation of the criteria or prevent innovative
and novel means to ensure that the criteria is met. Table 1 provides a theoretical
example of sustainability principles, criteria and indicators for an associated
sustainability goal.

Table 1: Example of the application of the sustainability goal and the
development of sustainability principles, criteria and indicators.

<table>
<thead>
<tr>
<th>Sustainability Principles</th>
<th>Sustainability criteria</th>
<th>Sustainability indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>The biofuel program has a net positive impact on the livelihoods of rural dwellers in the project area</td>
<td>Household food security does not decline as a result of the biofuels project</td>
<td>No household should have reduced household food security as a direct consequence of the project</td>
</tr>
<tr>
<td></td>
<td>There is no reduction in overall food provision from the entire region</td>
<td>No high potential agricultural land is used for biofuel production</td>
</tr>
<tr>
<td></td>
<td>Biofuel projects shall not violate existing formal or informal land rights</td>
<td>Compliance with Land Reform Act</td>
</tr>
<tr>
<td></td>
<td>Biofuel production shall not violate human rights or labour rights, and shall ensure decent work and the well-being of workers.</td>
<td>Workers will enjoy freedom of association, the right to organise, and the right to collectively bargain</td>
</tr>
<tr>
<td></td>
<td>There is no local extinction of species</td>
<td>No conservation areas or areas of high biodiversity importance are used for biofuel plantations</td>
</tr>
<tr>
<td>Key Ecosystem services are maintained</td>
<td>Downstream uses continue to maintain good quality water</td>
<td>Stream flow does not change substantially as a consequence of the project</td>
</tr>
<tr>
<td></td>
<td>The project results in net greenhouse gas emission reductions</td>
<td>No pesticide of nutrient pollution enters streams</td>
</tr>
<tr>
<td></td>
<td>Only feedstock with proven positive GHG benefits are used</td>
<td>There is no deforestation of existing forests</td>
</tr>
</tbody>
</table>

The principles, criteria and indicators are context specific, taking into account local social, economic and ecological conditions and the relationships between them, as well as the unique group of stakeholders. Setting a sustainability vision and determining principles and criteria for the achievement of sustainability at
the start of a sustainability assessment process, provides robustness to the analytical process required for decision making later in the process.

3.4 Mapping of the receiving environment

Mapping the social ecological system entails describing and characterising in detail, the baseline status quo of the specific social ecological system within which the PPP for biofuel development is proposed. The outcome of this task should be a comprehensive description of the receiving social ecological system or context in which the biofuels PPP is to be implemented and all internal and external influences on it. At the level of a proposed biofuels development policy, the social ecological system could be the interacting natural and social components of an entire country. The analysis should be expected to be conducted in a more abstract sense. In the case of a plan or programme, the social ecological system could be limited to a specific catchment, or geographic region, or to the social ecological systems in a range of different non-contiguous geographical regions / locations, or a specific vegetation or ecological zone. At the level of a biofuels development project, the social ecological system will likely be primarily bounded by the immediate environment in which the project would be situated. The analysis should be expected to be less abstract and based more on direct empiricism.

The information will provide baseline values and trends against which to assess the sustainability performance of the PPP for biofuel development.

3.5 Opportunities, constraints and trade-offs

The purpose of the sustainability assessment analysis is to identify characteristics of the social ecological system or context that provide opportunities for achieving a sustainability vision for the PPP for biofuel development, and characteristics that would constrain achieving the sustainability vision. The analysis should be conducted in a process of deliberation with all stakeholders. Where possible the opportunities and constraints should be captured and illustrated visually and in combination to assist in determining the potential for the implementation of the PPP for biofuels development i.e. whether the vision is realistic and achievable.

It is inevitable that for social and economic gain there will be a trade-off with biophysical or ecological elements. Given the complex nature of biofuel tradeoffs, the need arises for an evidence based understanding of likely tradeoffs as well as appropriate tools for assisting stakeholder in understanding the consequences of likely tradeoffs.

When planning for sustainability and in sustainability assessments the one essential rule is that trade-off decisions must not compromise the fundamental objective of net sustainability. As the sustainability framework is participatory based all trade-offs and compromises identified must be openly discussed and explicitly justified and the most desirable option chosen. In this regard, the following generalise rules must be applied [19]:
• No trade-off or compromises will be permitted unless approved by all relevant stakeholders; or
• Only undertakings that are likely to provide neutral or positive overall effects for each core sustainability requirement can be acceptable; or
• No significant adverse effects in any core category can be justified by compensations of other kinds, or in other places.

As far as possible tradeoffs should already have been considered at the point of developing the criteria, and the agreed criteria should be set up in such a way as to accommodate tradeoffs, whilst drawing a clear limit as to what adverse impacts are non-negotiable.

4 Planning for sustainability framework

The sustainability assessment framework comprises of four tasks. The tasks are as follows:

I. Planning for sustainability for proposed biofuel PPP (Preparation for Sustainability Assessment)
II. Sustainability Assessment for proposed biofuel PPP.
III. Re-design or modification of proposed PPP to improve sustainability performance
IV. Project appraisal (if required, e.g. EIA mandated by legislation)

Figure 1 diagrammatical represents the planning for sustainability framework.

In the case of a new PPP where no development planning has yet been undertaken then only Task I should be completed (followed by Task IV for any project). This task will ensure that the biofuel PPP is planned at the very onset with sustainability as its main goal. The outcome will be a set of principle, criteria and indicator that can be used through the PPP life span to ensure that sustainability is applied. For any PPP for which there currently are development plans (i.e. there are current infrastructure) in place then Tasks I to III must be completed as a minimum, in sequence, for the process of planning for sustainability to be effective. Task I forms the foundation for assessments or further work in subsequent tasks (II – IV) and must always precede any assessment forming part of those. Any assessment conducted without this foundation, will not deliver a biofuel PPP with sustainability as its focus, but merely PPP in which the prevention, tradeoff and mitigation of potential environmental (social, economic and ecological) impacts might have been identified and addressed.

All planning, assessment and analysis conducted within the processes outlined in the framework, should focus on the entire biofuels production value chain i.e. the complete life cycle. This applies to all types of biofuels development proposals – policies, plans / programmes and projects. Only in the case of specific biofuels development projects, which only address specific portions of the value chain, might it be permissible to evaluate only the relevant portion of the value chain, for example feedstock production only to delivery at a refinery, or the industrial process of biofuel production in isolation from...
TASK I: Preparation for Sustainability Assessment

STEP 1
Define the purpose of the PPP

STEP 2
Formulation of a vision

Environmental boundary of the PPP

Input
Mapping of receiving environment

Input
Identification of opportunities and constraints

Input
Negotiation of trade off and off sets

SUSTAINABILITY VISION

STEP 3
Develop sustainability principles
Develop sustainability criteria
Develop sustainability indicators

TASK II: Sustainability Assessment

Evaluate the PPP

TASK III: Improve design for sustainability performance

Improve/update the design of the PPP

TASK IV: Project Appraisal

Environmental Impact Assessment or other project specific assessments

Figure 1: Planning for Sustainability Framework.
feedstock supply. The intention behind the Planning for Sustainability Framework is to ensure that the focus of any particular analysis of proposed biofuel development is as comprehensive as possible, and that proponents should strive to conduct tiered or nested analysis of policies, to plans/programmes, and then ultimately to projects.

5 Conclusion

The undertaking of a sustainability assessment would be initiated mainly by some form of legislation promoting sustainable development principles, environmental management best practice and natural resource protection. Another driver initiating the use of this framework is that of international biofuel sales. Due to the potential negative elements of biofuel production such as loss of biodiversity, changing land use patterns, social economic impacts and greenhouse gas emissions, sustainable biofuel production is becoming a key concern and is being considered as a requirement for market access. Setting standards and establishing certification systems is currently being promoted, however, a process that promotes a vigorous planning for sustainability for the life span of the biofuel PPP could help strength trade agreements.

Sustainability assessment is an emerging science. The current principles have developed through a long history of impact assessment and strategic environmental assessment in the environmental sector. The framework presented will improve and mature over time as its application is tested on actually planned biofuel production PPP’s. It is likely that over time new and innovative methods and tools will be developed to assist the process. The CSIR is current involved in a European Union funded project known as Re-impact, which has started to test the planning for sustainability framework methodologies in India [20]. The CSIR is also looking to opportunities to test this in South Africa.

References


