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Sustainable and Integrated Bioenergy Assessment for Latin America, Caribbean and Africa (SIByl-LACAf): The path from feasibility to acceptability

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ABSTRACT

Uncertainties in evaluating bioenergy projects have lead policymakers to adopt a restrictive approach or even refuse to evaluate projects when the available information is limited or a clear perception of its benefits and impact is lacking. Indeed, despite its potential advantages, a bioenergy system poses several conceptual and operational challenges for academic as well as practical scrutiny because the inherent relationship and the intersection of areas related to energy production and agricultural activity requires a deeply integrated assessment. The aim of this paper is to review the available works in this field and propose an approach for supporting policymakers in the taking decision process of deploying sustainable bioenergy systems. The SIByl-LACAf framework provides a comprehensive framework for addressing the inherent complexity of the subject and its sustainability and acceptability as part of the evaluation process. With this approach, different and complementary evaluation methods are reviewed and set in a logical and sequential structure to draw a group of indicators used for assessing a given project with the help of a strengths, weaknesses, opportunities, and threats (SWOT) matrix. When acceptability is identified as an issue, a Public Consultation and Communication (PC & C) scheme can complement this process. The suggested application for Mozambique indicate that an acceptable outcome is possible even when considering the data requirements and constraints of developing countries. Thus, the potential of this integrated approach outweighs such limitations.

1. Introduction

Although sustainable bioenergy is recognized as an important energy alternative in global terms, crucial questions have emerged among countries regarding biofuel production. The introduction of fuel ethanol offers good possibilities for greater fuel diversification, lower prices, a cleaner environment, and better social benefits [1]. Based on several climate scenarios, bioenergy will grow to an average of 138 EJ by 2050, representing equivalent to 14% to more than 40% of the projected energy supply. To grow sufficient bioenergy crops for generating 100–200 EJ/year of bioenergy by 2050, about 50–200 million rainfed hectares are needed, corresponding to the use of

List of Acronyms and Abbreviations: ABM, Agent- Based Model; AGSIM, Econometric-Simulation Model of the Agricultural Economy Used for Biofuel Evaluation; ASEAN, Association of Southeast Asian Nations; BIOTSA, Bioenergy Technology Sustainability Assessment; BLUM, Brazilian Land Use Model; CGE, Computable General Equilibrium; C-LCA, Consequential Life Cycle Assessment; DEPS, GTAP-Dynamic Energy Policy Simulations; FAO, Food and Agriculture Organization of United Nations; GBEP, Global Bioenergy Partnership; GTAP, Global Trade Analysis Project; IA, Integrated Assessment; IC, Inherent Context; IDB, Inter-American Development Bank; IEA, International Energy Agency; ILUC, Indirect Land Use Change; I-O, Input-Output; IS, Innovation System; ISI, Institute for Scientific Information; ISO, International Organization for Standardization; LACAf, Latin America and Africa; LCA, Life Cycle Assessment; LCI, Life Cycle Inventories; LD, Landscape Design; MCA, Multi-Criteria Analysis; OLS, Ordinary Least Square; PC, Perceived Context; PC & C, Public Consultation and Communication; PE, Partial Equilibrium; PLUC, PCRaster Land Use Change; PROMETHEE, Preference Ranking Organization METHod for Enrichment Evaluations; RME, Rape Methyl Ester; SD, System Dynamics; SDSS, Spatial Decision Support Systems; SIByl, Sustainable and Integrated Bioenergy Assessment; S-LCA, Social Life Cycle Assessment; SNA, Social Network Analysis; STELLA, Structural Thinking and Experiential Learning Laboratory with Animation; SWOT, Strenghts, Weaknesses, Opportunities and Threats; UNCTAD, United Nations Conference on Trade and Development; WORLD, Watershed-scale Optimized and Rearranged Landscape Design; GHG, Greenhouse Gas; WoS, Web of Science; WTO, World Trade Organization

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0.4–1.5% of total global land. For an acceptable impact on the environment, the gross demand of land for modern bioenergy and other productive aims is estimated to be between 50 Mha and 200 Mha by 2050 [2]. In this case, the land availability for rainfed agriculture is estimated to be 1.4 Bha of prime and good land and an additional 1.5 Bha of spare and usable marginal land. About 960 Mha of this land is in developing countries in sub-Saharan Africa (450 Mha) and Latin America (360 Mha) although much of it is pasture/rangeland [3]. Thus, special attention must be paid to countries that are able to allocate available land to increase the bioenergy supply in local or international markets. However, each country has inherent peculiarity in terms of soil conditions, the climate for crop production, land availability, infrastructure, economic feasibility, and Available workforce in addition to the institutional framework for developing bioenergy systems, sometimes in scenarios of uncertainty or asymmetric information.

Under such conditions, after an initial positive evaluation, proposals of bioenergy systems may eventually not be acceptable according to the local community perspective or because of other particular aspects. This risk has led policymakers to adopt a restrictive approach or even refuse to evaluate bioenergy projects when the available information is apparently limited or lacks a clear explanation of its benefits and impact.

Despite its potential advantages, however, a bioenergy system poses several conceptual and operational challenges for academic as well as practical scrutiny because the inherent relationship and the overlap of areas and aspects related to agricultural activity and energy production requires a deeply integrated evaluation. Some assessment methods of agricultural and bioenergy systems are currently available. However, considering their environmental, technological, economic, social, and institutional aspects, such methods usually emphasize particular dimensions and do not allow this integration, which is essential for understanding and evaluating the system's sustainability.

The aim of this paper is review the current experience in assessing bioenergy systems and propose a pathway to support policymakers in the taking process of deploying new sustainable bioenergy systems or evaluating existing ones, particularly for developing countries. Considering the usual constraints in the data and information required, a set of evaluation methods is compiled in a logical and sequential structure to draw a set of indicators used for assessing a given project. These indicators are evaluated in a strengths, weaknesses, opportunities, and threats (SWOT) matrix in order to obtain a set of options for evaluating bioenergy projects. If acceptability is an issue, this process can be complemented by a Public Consultation and Communication (PC & C) scheme. This particular approach, the Sustainable and Integrated Bioenergy Assessment for Latin America and Africa (SIByl-LACAf[1]) approach, constitutes a comprehensive framework for addressing the inherent complexity of the subject, and the sustainability and acceptability as part of the evaluation process of bioenergy systems and projects.

This paper is structured in four sections including the introduction. The next section introduces the SIByl-LACAf framework, which includes the essentials of the selected method and the steps in following such an approach. Section 3 gives the suggested steps for a hypothetical application of the SIByl-LACAf framework to Mozambique, and Section 4 presents the main remarks and final considerations.

2. The SIByl-LACAf framework

The literature offers a relatively limited number of methods and analyses related to important aspects of agriculture, particularly bioenergy and biomass and their co-related aspects as environmental, technological, economic, social, and institutional impacts. This lack of information highlights the need to understand sustainability from an integrated perspective. Howells et al. [5] discussed the lack of this type of treatment in recent literature relative to bioenergy, water, land, and climate change. Moreover, they stressed the need for systematic national-level integrated assessment, which differs from traditional practices.

The literature identifies Integrated Assessment (IA) as a reflective and iterative participatory process that links knowledge (science) and action (policy) regarding complex global change issues such as bioenergy production and climate change [6]. Dale et al. [7] reported that significantly fewer studies used IA for bioenergy system approaches than those using isolated approaches for qualitative analysis of indicators used for understanding the socioeconomic factors in such a system. If IA could provide more information than the isolated approach to the scientific field, it will be necessary to understand how this approach can be implemented to significantly improve the analysis for policymakers while supporting the choices among different alternatives [8].

Dowlatabadi et al. [9] and Rotmans et al. [10] defined IA as an interdisciplinary process of combining, interpreting, and communicating knowledge from scientific subjects to evaluate the problem from a synoptic perspective. Moreover, they reported that this process should have added value compared with single disciplinary assessment, and it should provide useful information in the taking process. Leimbach et al. [11] used IA as a common tool for assessing strategies, considering the complex relations among environmental, social, and economic factors.

The present study uses IA to integrate different perspectives of analysis to address this inherent complexity and the inter-relationships discussed by Leimbach et al. [11]. In addition, we determine that technological and institutional aspects must be evaluated. Thus, following Rotmans et al. [10] and Dowlatabadi et al. [9], we propose a more integrated approach in which the data and information, models and methods, and the taking process are part of a full network of relationships [12].

In a network approach, areas and sub-areas are related, which lowers the efforts and costs compared with the necessary time and expense needed for understanding isolated components. For example, to understand the sustainability of a local process, it is more important to understand the connections among environmental, economic, and social aspects than to examine each part individually. The available information or data can contribute to understanding these aspects simultaneously, and the final result will show stronger connections with shared information among these areas.

In this scenario, the implementation process of a sustainable bioenergy system in a specific country involves numerous direct and indirect factors that can result in complexity. The problem begins by defining why, where, and how such a process is implemented. Once the scope of the study is defined, the process of data and information collection is important because they indicate the complexity of the analysis. This step is linked with the chosen framework of analysis: addressing the inherent complexity of information in an integrated approach. The results of the models and methods applied to answer the questions formulated in the objectives, which must be summarized to identify key indicators that accomplish both the investigator taking desision criteria and external sustainable guidance from international agencies such as Global Bioenergy Partnership (GBEP) and Inter-American Development Bank (IDB) Scorecard. Finally, stakeholders such specific agents or make a decision, and the problem is identified.

To explore this process, Fig. 1 summarizes the SIByl-LACAf approach into seven steps: i) definition of objectives, ii) recognizing the complexity of data, iii) addressing the complexity, iv) applying indicators, v) analysis of feasibility, vi) analysis of acceptability, and vii) taking decision.

[1] The acronym SIByl-LACAf is a tribute to the legend of Greek oracle named Sibyl, represented as an old woman with the ability to make clever and accurate predictions. In this sense, the use of the acronym SIByl to our approach for assessing sustainable projects expresses the intention of traveling through the unknown, connecting elements and arguments to result in correct evaluation [4].