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Review

What drives sustainable biofuels? A review of indicator assessments of biofuel production systems involving smallholder farmers

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ABSTRACT

The contribution of biofuel production to sustainable development in rural areas requires policy and practice that understands the opportunities and risks faced by smallholder farmers. Potential opportunities for smallholders include access to markets, access to employment, local infrastructure developments and spill over effects such as new agronomic knowledge. Potential threats include loss of land entitlements, social exclusion, environmental degradation, dependency upon the biofuel industry and diminished food security. Although a multitude of issues is acknowledged, many studies are focused on specific issues and knowledge remains fragmented. Further, much of the indicator-based literature does not acknowledge the importance of case-specificity nor the link between the processes and circumstances that drive indicator results. This article reviews indicator assessments of biofuel production involving smallholders and highlights the importance of holistically considering a range of social, economic and environmental criteria. Further this review stresses the need to link drivers with indicators. Drivers include decisions and circumstances of a biophysical, socio-economic and governance nature with relevance at field, farm and higher levels. The link between drivers and indicators is crucial to justify indicators and to identify the scope for policy to influence progress against indicators. A conceptual model is provided that summarises important processes determining sustainability of biofuel production involving smallholders. This model can also be used as a starting point for more detailed analysis capturing and quantifying relationships between specific drivers and indicators on a case-by-case basis. This type of analysis is particularly valuable in regions where biofuel policy and developments are unfolding and multiple stakeholders (e.g. smallholders, companies, NGOs and governments) are involved. We highlight that regulation and certification of biofuel production often needs to be complemented with improvements in governance structures and, that policy targeting smallholder involvement with biofuel production should account for a diversity of smallholder characteristics.

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1. Introduction

Sustainable biomass for biofuel production from agricultural crops continues to ignite debate and discussion (Buyx and Tait, 2011). A significant body of scientific literature on this subject has been produced and in practice, investments in biomass for biofuel production continue to multiply across the globe. Simultaneously, policies on the sustainability of these investments are being developed, re-developed and negotiated. A large number of these investments are in Africa, Asia and Latin America. Consequently, smallholder farmers are directly implicated. Smallholder farmers are a large, diverse and often vulnerable constituent of rural populations. The role of and implications for smallholders are two important aspects of the sustainability discussion.

The roles and experiences of smallholders with biofuel production are many and controversial. Potential opportunities for smallholders include access to markets, access to employment, local infrastructure developments and spill-over effects such as new agronomic knowledge. Potential threats include loss of land entitlements, social exclusion, environmental degradation, dependency upon the biofuel industry and diminished food security. There is reasonable consensus as to which issues are at stake. This is evidenced by the consistency between different sustainability frameworks consisting of well-formulated sets of principles and criteria (Diaz-Chavez, 2011; FAO, 2011; Markevičius et al., 2010; van Dam et al., 2010). Principles are 'universal' basic truths or attributes of a sustainable system and criteria are the rules that govern judgement on outcomes from the system. Examples of these frameworks are those created by the Roundtable on Sustainable Biofuels (RSB, 2010) and the Roundtable on Sustainable Palm Oil (RSPO, 2007). Furthermore, many similar issues resonate within NGO position papers and national and supra-national government policy (e.g. Fritsche et al., 2006; Government of Mozambique, 2009; NEN, 2009; Schut et al., in press). To date, a practical stumbling block for sustainability assessment and implementation of policy has been the translation of principles and criteria into indicators (means of assessing performance against criteria). This is symptomatic of three gaps in the literature, which provide motivation for this article.

First, studies are often narrow rather than holistic, yet most sustainability issues require insights from several disciplines. While a substantial body of indicator-based literature assessing biofuel sustainability is emerging from different disciplines, the literature remains relatively fragmented. Gasparatos et al. (2011) provided a useful interdisciplinary perspective by reviewing the biofuel literature using the ecosystems services framework. These authors clearly demonstrate that there are many trade-offs associated with biofuel production and that the nature of trade-offs is highly case-specific.

Second, the literature tends to dwell on the desire to prescribe universal sets of indicators (e.g. McBride et al., 2011) rather than acknowledge case-specificity. However, in reality, specific issues prove more and less important on a case-by-case basis. This can be deduced from the fact that smallholders are a diverse group (Tittonell et al., 2005), that biofuel production can be arranged in a variety of ways (Watanabe et al., 2012) and that socio-economic and institutional contexts are also diverse (Schut and Florin, submitted for publication). To explore and explain these differences, and what they mean for sustainable production of biofuels and related policies, it is essential that indicators enable one to ask useful questions. Fixed sets of indicators tend to lose meaning if simply extrapolated between situations.

Third, indicators are not usually explicitly linked with the processes that drive their results. When acknowledging the diversity of biofuel production systems and exploring sustainability, the importance of explaining indicator results is paramount. This is mirrored by the assertion of Schiere et al. (1999) that research should aim more at understanding processes rather than focussing on static detail. Factors that influence and determine indicator results such as crop management decisions, smallholder characteristics and biofuel market characteristics are termed drivers of sustainability. Understanding the relationships between drivers and indicators of sustainability enables one to influence and predict sustainability outcomes (Le et al., 2011) as well as provides additional justification and practical meaning to indicators.

To support policy and practice, this article addresses the need for more integrated and holistic research that tackles the breadth of realities of smallholder involvement with biofuel production. Accomplishing two specific objectives does this. First, to provide an up-to-date inventory of commonly reported indicators and drivers. To do so we review the body of literature dealing with indicator-based sustainability assessments of farming systems with special attention to biofuel production systems involving smallholders. Second, to synthesise this review with a conceptual model that links indicators with drivers of sustainability for biofuel production systems.

2. Defining and operationalising sustainability

We define a sustainable production systems as: ''systems that have an economically and socially acceptable, stable production level while natural resources in the ecosystem are protected and soil and water degradation is avoided'' (Smyth and Dumanski, 1993). The system boundaries for this study capture production activities undertaken by smallholder farmers. This predominantly covers biomass for biofuel production but some degree of post-harvest processing could be included. Complete conversion of biomass to biofuel is beyond the scope of this article. Spatial levels of analysis can include field, farm and region. Management decisions by farmers and other players in the biofuels industry are captured.

We use a hierarchical indicator selection framework of principles, criteria and indicators (van Cauwenbergh et al., 2007) to operationalise sustainability consistently with ongoing biofuel discussions (Florin et al., 2012). In the first row of Table 1, five principles that directly relate to the definition of sustainability (Smyth and Dumanski, 1993) are presented. These principles have been used by other authors for