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Integrating social and value dimensions into sustainability assessment of lignocellulosic biofuels

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ABSTRACT

The paper clarifies the social and value dimensions for integrated sustainability assessments of lignocellulosic biofuels. We develop a responsible innovation approach, looking at technology impacts and implementation challenges, assumptions and value conflicts influencing how impacts are identified and assessed, and different visions for future development. We identify three distinct value-based visions. From a techno-economic perspective, lignocellulosic biofuels can contribute to energy security with improved GHG implications and fewer sustainability problems than fossil fuels and first-generation biofuels, especially when biomass is domestically sourced. From socio-economic and cultural-economic perspectives, there are concerns about the capacity to support UK-sourced feedstocks in a global agri-economy, difficulties monitoring large-scale supply chains and their potential for distributing impacts unfairly, and tensions between domestic sourcing and established legacies of farming. To respond to these concerns, we identify the potential for moving away from a one-size-fits-all biofuel/biorefinery model to regionally-tailored bioenergy configurations that might lower large-scale uses of land for meat, reduce monocultures and fossil-energy needs of farming and diversify business models. These configurations could explore ways of reconciling some conflicts between food, fuel and feed (by mixing feed crops with lignocellulosic material for fuel, combining livestock grazing with energy crops, or using crops such as miscanthus to manage land that is no longer arable); different bioenergy applications (with on-farm use of feedstocks for heat and power and for commercial biofuel production); and climate change objectives and pressures on farming. Findings are based on stakeholder interviews, literature synthesis and discussions with an expert advisory group.

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1. Introduction

Expectations are high for the development and commercialisation of second-generation biofuels as a sustainable way of meeting renewable transport fuel policy targets [8,13,49]. Set up in response to sustainability concerns over first-generation biofuels derived from food crops, the UK Gallagher Review [42] called for policies to support biofuels based on non-food feedstocks including perennial crops (miscanthus and short rotation coppice willow) and agricultural residues. In light of controversy over the impacts of first-generation biofuels on food security and indirect land-use change (iLUC), the European Commission proposed amendments to the Renewable Energy and Fuel Quality Directives to cap the share of food-based biofuels in its 2020 renewable transport fuel target and to allow only advanced (non-food) biofuels in the post-2020 framework, though, at the time of writing, the changes are yet to be ratified [12].

Some suggest that second-generation advanced biofuels are unlikely to pose any significant ethical or social challenges (e.g., [6,35]). However, others recognise the need for more detailed investigation of potential challenges [3,32,43]. The Gallagher Review acknowledged that advanced biofuel technologies may have limitations depending on the way they were actually developed and implemented. Established to support research into advanced biofuel options that could overcome the problems of first-generation biofuels, the UK Biotechnological and Biological Sciences Research Council's (BBSRC) Sustainable Bioenergy Centre (BSBEC) therefore included work within one of six projects (Lignocellulosic Conversion to Bioethanol or LACE) on the three pillars of sustainability: environmental, economic and social.

This paper aims to clarify the social and value dimensions of sustainability of lignocellulosic biofuels with reference to the UK. Most published studies of sustainability assessment of biofuels focus on first-generation options, though interest in second-generation options is growing. However, key gaps remain in terms of: first, how the social dimension is understood and second, how well it is integrated into sustainability assessments which mainly focus on life-cycle assessments (LCA) of environmental performance. The paper aims to fill the first gap in order to inform future research intended to address the second. This is done by highlighting the values and assumptions that underpin different visions of how lignocellulosic biofuels production might and should unfold.

In existing literature, social aspects tend to appear in the form of a checklist of generic and biofuel-specific criteria, notably, impacts of biomass feedstock cultivation and processing on food security, water security, employment generation and rural development, visual and noise-level aspects in a community, legal compliance and social acceptance (e.g., [30,44]). These studies usefully broaden the scope of sustainability assessment of biofuels beyond life cycle assessment. However, the underlying value assumptions in impact assessment and options for developing the technology in different ways are not really addressed. Also, separating social aspects from environmental and economic ones is not always straightforward. Indeed, this is implicit in Markevicius et al [30] as they list the availability and robustness of systems for monitoring an environmental criterion such as greenhouse gas (GHG) accounting in their list of social criteria.

Restricting social assessment to questions of 'impacts on society' risks ignoring the social and value judgements involved in choices over which impacts to include and how to assess them [17,38]. For example, Thornley and Gilbert [56] point out that some environmental impacts (e.g., eutrophication) are location-specific while others (GHG savings) represent gains/losses to the planet as a whole. How then should these different outcomes in what initially appears as a universally shared criterion be valued? Mohr and Raman [32] find that value questions pervade virtually all sustainability criteria including food security, representing both challenges and opportunities for policy making and debate around bioenergy. In addition, there is extensive social research on bioenergy (reviewed in Ref. [39]) considering wider issues that are not typically included in 'sustainability assessment'. These include aspects related to global trade, land ownership and the potential for social enterprise models that are relevant to biofuel futures (e.g., [63]), but there is currently no place for considering such matters in conventional sustainability assessments. This makes it difficult to identify and evaluate knowledge that is appropriate for biofuel policy making and debate [4]. The paper addresses this gap by distilling the main social and value dimensions that need to be considered in creating lignocellulosic biofuel futures.

2. Theoretical framework: responsible innovation in emerging technologies

This research is grounded in insights from a framework of responsible innovation [36,52] which has been put forward to develop a shared understanding of how to bring societal and value questions to bear on research and innovation. Responsible innovation builds on insights and methods from established work on technology assessment, applied ethics and technology studies [20]. Emerging technologies have been widely assessed in terms of approaches in applied ethics [31,28] and traditions of technology assessment (TA) such as constructive TA [45] and real-time TA [21]. Responsible innovation research builds on these traditions, but aims to draw more attention to the questions of what innovation *should* do and stimulate reflection on why research is unable to 'fix' grand societal challenges despite being framed as a response to them [37,53]. From this perspective, potential impacts and unintended consequences of emerging technologies are placed in a broader framework of alternative values and visions for their future development.

In the biofuels case, a number of studies have highlighted important considerations from the implementation of first-generation, food-based biofuels including impacts on livelihoods, food and water security, and the local and global environment (e.g., [32,44] for overviews). But cross-cutting most of these impact indicators are questions of uneven spatial distribution in terms of where biomass has come from, which regions have borne the negative impacts, which ones benefited and what alternative ways might there be of producing biofuels [39]. Understanding the impacts of biofuels requires getting to grips with these value-based matters and

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