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# THE UTILITY OF THE PARTICIPATORY APPROACH FOR SUSTAINABLE DEVELOPMENT ASSESSMENTS

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# THE UTILITY OF THE PARTICIPATORY APPROACH FOR SUSTAINABLE DEVELOPMENT ASSESSMENTS

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To my mommy and buwa.

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## Preface

This dissertation is an assemblage of four articles that I have co-authored with my advisor, Dr. Audrey L. Mayer. Prior publication is recorded as a footnote citation in the first page of the corresponding chapter in the dissertation for each chapter that has been published or accepted for publication in a peer-reviewed journal.

The first article in this dissertation, 'Critical review of a top-down sustainable development framework: The Millennium Project in Nepal' will be submitted to a peer reviewed journal in the near future. For this article, I reviewed the Millennium Development Goals' assessment framework in the context of sustainable development in Nepal. I am the primary author of this article. Dr. Mayer provided support in concept design and editing of this article.

The second chapter, 'Use of the participatory approach to develop sustainability assessments for natural resource management' is a review of the bottom-up approach to develop sustainability criteria and indicators for natural resources. It was published in the *International Journal of Sustainable Development and World Ecology* (21(4):369-379). For this paper, I reviewed 13 case studies that used the participatory approach to develop sustainability assessment frameworks. While I am the primary author, Dr. Mayer provided support in concept design, writing and editing of this work.

The third article, 'Criteria and indicators for a bioenergy production industry identified via stakeholder participation' is in press in the *International Journal of Sustainable Development and World Ecology*. Here, I thoroughly describe the first part of my research (developing a preliminary list of criteria and indicators for woody bioenergy production using a participatory process) that Dr. Mayer and I jointly conducted. I am the main author of this paper and did the majority of data collection and analyses. Dr. Mayer provided support in research design, data collection, and provided editorial guidance for this work.

The fourth article, 'Use of multiple criteria analysis to develop a regional assessment tool for bioenergy production' is under review in the journal *Biomass and*

*Bioenergy*. In this article, I describe the use of multi-criteria analysis to narrow the preliminary list to a smaller, workable set of criteria and indicators for woody bioenergy production in the Western Upper Peninsula of Michigan. I am the main author and did the majority of data collection, analyses and interpretation for this paper. Dr. Mayer contributed to this work through editorial guidance and support in research design, data collection and analyses.

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I am especially thankful to my mother Sushma Vaidya and father Mahesh L. Vaidya for always inspiring me and supporting me. I also want to thank my sisters Supreema and Mily, and brother Manjeet for their love and support. Last but not the least, I thank all my friends I met in Houghton and friends from back home (Nepal) for always being there to support, motivate, listen and importantly, for being there!

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## Abstract

'Sustainability' may be a generalizable concept; its definition however, heavily depends upon context. Understanding the context (sociocultural, environmental, socioeconomic, political etc.) is crucial for defining and assessing the sustainability of any given socio-ecological system. This point underlies our research design and objectives. The primary objectives of this research were to understand the sustainability context in the Upper Peninsula of Michigan, and to use it to develop a sustainability assessment framework for a potential forest-based bioenergy industry in the region. We first reviewed top-down and bottom-up sustainability assessment frameworks. Then we used the best-suited approach i.e. bottom-up participatory approach, to pursue our objectives.

First, we critiqued a top-down sustainable development framework: the Millennium Project framework. We evaluated the generic environmental indicators employed by the Millennium Project to assess progress of developing countries toward environmental sustainability, based on the indicators' relevance, comprehensiveness, practicality and sensitivity in a developing country's context. We used Nepal as a case study for this analysis. Our results suggested that, while international (top-down) development and assessment frameworks play an important role in inserting broad sustainability concerns (e.g., biodiversity, water and sanitation, and environmental management) into country-level development agendas, indicators to monitor progress towards such goals are more effective if based on the on-the-ground realities (i.e., are relevant and practical).

Next, we reviewed 13 case studies where a bottom-up approach was used to develop sustainability criteria and indicators (C&I) for natural resource management. This review suggested that while bottom-up approaches may be important for highlighting grassroots concerns, reliance on local belief systems alone might not be sufficient to produce C&I which conform to sustainable thinking. Collaborative learning among stakeholders and experts is the best approach to promote the holistic

understanding of a socio-ecological system, which in turn can enhance sustainable decision-making.

We used these reviews to design case study research: to generate a regional sustainability assessment framework for forest-based bioenergy production in the Upper Peninsula (UP) of Michigan. We used participatory research techniques including focus groups, semi-structured interviews, a workshop and multi-criteria decision analysis to understand stakeholders' concerns, values and preferences with regard to wood-based bioenergy production in the UP. These were translated into sustainability criteria and indicators for assessing sustainability of forest-based bioenergy industry in the UP. The final set of C&I were 5 criteria and 31 indicators (in parentheses): Economic (6), Environmental (7), Social (8), Policy and regulations (4) and Institutional capacity (6). This set reflected the general balance across sustainability dimensions valued by the stakeholders.

# CHAPTER I: Introduction

A number of attempts were made in the 1970's and before, to acknowledge the linkages between humans and nature (Ehrlich and Ehrlich 1970; Meadow et al. 1972; Commoner 1972). However, these attempts had little effect on international development frameworks at the time. The 1987 Brundtland Commission Report, for the first time, popularized the concept 'sustainable development' at a global scale, as a new development paradigm that recognized the interdependencies between man-made systems (such as market, governments, society etc.) and the environment (WCED 1987). The report defines sustainable development as '… development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987). It played a vital role in raising awareness among development practitioners and policy makers about overlooked social and environmental externalities associated with 'development'. While the Brundtland Commission's definition remains one of the most cited definitions of 'sustainable development', it has also been widely criticized for being too broad and vague (Daly 1996; Mebratu 1998; Redclift 2005). Numerous attempts have been made to narrow down and conceptualize this broad concept, however there exists little consensus on its definition. Agenda 21, a set of principles made public following the 1992 Rio Conference, provides guidelines to pursue sustainable development. It highlights a need for public participation, environmental consciousness and democratic decision-making as prerequisites of sustainable development. It also highlights collaboration between different stakeholders and all levels of governance as key to sustainable development. Today, there is a political consensus among world leaders and stakeholders on the need for sustainable development.

International development organizations rely upon international harmonization (through a soft-law approach) and normative discourse to facilitate sustainable development policy convergence across different levels of governance, and across national and subnational boundaries (Busch and Jörgens 2005; Happaerts 2012). Policy convergence is a mechanism through which societies adopt globally agreed upon policy

goals, content, instruments, outcomes or models to deal with common policy problems (Bennett 1991). Policy convergence may occur through either coercive mechanisms such as the compliance of national governments with legally binding agreements (i.e., called hard laws), or through non-coercive measures such as guidelines, principles or goals (i.e. called soft-law approach) (Bennett 1991; Abbott and Snidal 2000; Happaerts 2012). International certification schemes, sustainability assessment frameworks, sustainable development targets, and non-binding agreements are generally used as tools for facilitating non-coercive policy convergence for sustainable development. The use of these tools for sustainable development policy convergence stems from the growing perception of sustainable development as a meta-policy, which promotes the development of similar policies at other governance levels (O'Toole 2004; Happaerts 2012). While policy convergence encourages sustainable literacy and policy innovations to permeate into local government agenda setting, this can be hampered if the meta-policy does not reflect the priorities of lower-level governments (Happaerts 2012). In other words, development targets which are identified in a top-down manner (that is, by experts) in an attempt to guide development (through policy convergence) at more local levels may fail in the absence of bottom-up influence (e.g., through participatory methods).

'Sustainability' is a concept that embodies holistic understanding, democratic and equitable decision-making and resilience thinking (WCED 1987; UNCED 1992; Bass et al. 1995; Gibson 2006; Mayer 2008). It is recognized as a multi-scalar, multi-dimensional goal that involves not only widely generalizable considerations, but also key concerns pertinent to local ecosystems, policy situations, public preferences and institutional capacities (Gibson 2006). Now, how can we decide whether a system (can be a country, community, production system, city etc.) is progressing toward this goal - sustainability? This is where a sustainability assessment comes to play. Sustainability assessment is a tool used to monitor the progress of a society toward sustainability, and to facilitate and guide sustainable development policy analysis and convergence. Although there are numerous sustainability assessment tools in use (such as Ecological Footprint, Pressure State Response Framework, Cost-Benefit Analysis etc.), the focus of this dissertation is

on one of the dominant assessment frameworks (Buytaert et al. 2011) i.e., criteria and indicators (C&I) system. Criteria are standards or conditions that define sustainability of a system, and indicators are measurable variables used to determine if the sustainability criteria are met. What makes these C&I operational is a threshold, which is essentially a value or a value-range of an indicator (may vary over time, depending upon biophysical, socio-economic or policy contexts) that represents sustainability limit of a system in a multidimensional space.

Contrary to underlying principles and theory that partnership between different stakeholders and interest groups is a key to sustainable development (WCED 1987; UNCED 1992; Bass et al. 1995; Gibson 2006; Hák et al. 2007), sustainability assessments have historically been based on generalizable knowledge and overriding interests of a handful of experts and policy-makers. As a result, many existing 'sustainability' assessments focus only on few dimensions of development (usually biophysical or economic), essentially rendering them incomplete (Daily and Erhlich 1996). While this conventional top-down approach may identify one set of generalizable considerations, it is not sufficient to capture the context-specific and interdisciplinary concerns and issues (especially at more local scales) without which holistic understanding of a system is impossible (Bass et al. 1995; Morse et al. 2001; Fraser et al. 2006; Reed et al. 2006; Hák et al. 2007). In some cases, such an approach to decision-making has also been associated with the failure of well-intended development projects, along with misunderstandings between project implementers and the people (Kapstein 1981; Justice 1989; Murphy et al. 2009; Datta and Chatterjee 2011; Alley 2014).

Many have suggested that the participatory approach (or the involvement of key stakeholders) is the best suited to define sustainability and to generate assessment tools to monitor progress of a society or community toward sustainable development (Morse et al. 2001; Kasemir 2003; Gibson 2006; Fraser et al. 2006; Reed et al. 2006; Franklin and Blyton 2011). The bottom-up participatory approach has also become a powerful way to strengthen relationships between experts and non-experts, decision-makers and the public. Importantly, the bottom-up participatory approach can be a way to enhance the

understanding of socioecological systems for sound and sustainable decision-making (Fraser 2006; Gibson 2006).

In this dissertation, we attempt to shed light on the relative importance of the bottom-up approach for developing sustainable development assessments for local and regional level implementation. The specific objectives of this dissertation were first to identify and make a case for an appropriate research method (which we do in Chapters II and III), and then to use it to develop a sustainability assessment for forest-based bioenergy production (as we do in Chapters IV and V). Biomass-based energy production under certain conditions has been touted as a sustainable development mechanism, which can improve economic conditions (Schneider and McCarl 2003; Kebede et al. 2013) and reduce net $CO_2$ emissions (Farrell et al. 2006; Hill 2007; Searchinger et al. 2008), two common goals of sustainable development programs.

Chapter II focuses on how a top-down, global-level development framework and sustainability assessment align with the sustainability goals of the national-level socioeconomic systems for which they are intended. The work described in Chapter II is motivated by the question, "When is a top-down (international) sustainable development and assessment framework appropriate for national and local level implementation?" To answer this question we used Nepal as a case study, and assessed the relevance and effectiveness of the goals and indicators generated by the United Nations Millennium Project in a Nepalese context. We employed a content analysis method to evaluate environmental indicators, used by the Millennium Project as a tool to assess developing countries' progress toward environmental sustainability. We used peer-reviewed journal articles and gray literature from national and international governments, and analysed the data obtained from the Government of Nepal and United Nations affiliates' websites. We found that top-down international commitments are crucial for the propagation of broader sustainability goals, and for motivating national and local governments to integrate these concerns into their development agendas (i.e., policy convergence). However, whether these goals can be properly monitored, let alone met, is contingent upon a proper context and bottom-up planning. This chapter contributed to our understanding of the limitations of top-down sustainability assessments and the global development framework for

implementation at smaller scales. This chapter motivated us to explore a bottom-up approach as an alternative to developing a sustainability assessment framework.

In Chapter III, we explored the opportunities and challenges associated with the use of bottom-up approaches. While the literature is fraught with arguments describing the applicability of the bottom-up approach to pursue sustainable development, very little scholarly information exists on its definition and application in the development of sustainability assessments. We reviewed 13 case studies from different parts of the world, all concerning natural resource management. This chapter provided practical examples of the issues that could arise during the implementation of a participatory approach. It also provided an overview of the variety of definitions and practices of this approach across natural resource management sectors. Our review suggested that, while bottom-up approaches may be important for understanding grassroots concerns, relying solely on community-led identification of sustainability criteria and indicators may not necessarily comply with the fundamentals of sustainable development. It also suggested that collaborative learning among stakeholders and experts is a best practice to enhance the holistic understanding that is crucial for sustainable decision-making.

Chapter IV and V discuss our use of a participatory approach in the development of sustainability criteria and indicators for forest-based bioenergy production in the Western Upper Peninsula (WUP) of Michigan. This research was guided by the question, "What is an effective set of sustainability criteria and indicators that can reflect the local sustainability definitions and goals of WUP stakeholders with regard to the bioenergy production in the region?" For data collection, we used qualitative research methods: focus group meetings, semi-structured interviews, and a workshop. We employed multiple-criteria analysis to analyze our data and reduce an initial long-list of criteria and indicators to a practical set, supported by existing data. Based on the local concerns and preferences derived from the above-mentioned methods, we developed a set of 5 criteria and 31 indicators (in parentheses): Economic (6), Environmental (7), Social (8), Policy and regulations (4) and Institutional capacity (6). This set reflected the general balance across sustainability dimensions valued by the stakeholders. While most of the criteria and indicators included in this set have been cited frequently in the literature as important

indicators for sustainable bioenergy production, some of the criteria and indicators (such as concerns regarding genetically engineered and non-native feedstock species, use of local feedstock, and loss of recreational values) were unique to this region.

There has been a lot of discussion and preliminary investigations pertinent to bioenergy production in the Upper Peninsula of Michigan (MSU 2009; USDA 2011; Balaskovitz 2014a, 2014b; Ali 2015). Most of the earlier attempts to promote and produce biomass-based energy in the region have mostly concentrated on local electricity generation (Quackenbush et al. 2015). Research on innovative ways to efficiently use wood-biomass to produce transportation fuel is also ongoing (Shonnard et al. 2008; Jenkins & Sutherland 2014). The set of C&I which we have developed here can be used as a before-after monitoring tool as a bioenergy industry develops in the region, to assure that it meets context-specific sustainability goals as it develops.

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# CHAPTER II: Critical review of a top-down sustainable development framework: The Millennium Project in Nepal[1]

**Ashma Vaidya and Audrey L. Mayer**

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[1] The material contained in this chapter is planned for submission in the future.

## *Abstract*

In the three decades since 'Our Common Future' harmonized development policies around a new sustainable development paradigm, experts have consistently emphasized the importance of a democratic and equitable approach to define and achieve sustainable development for all countries. However, this is rarely achieved in practice, as targets and indicators are often defined by a suite of experts or a few stakeholder groups, far removed from on-the-ground conditions. For example, the United Nation's Millennium Development Goals' (MDGs) assessment framework utilized an expert-led approach and promoted a one-size-fits-all framework for all developing countries. The MDG is one of the largest and most widely adopted commitments in the international development regime. While progress towards these targets has been routinely reported at the national scale, less is known whether these targets actually reflect context-specific sustainable development. Through our evaluation of the MDG framework in the context of Nepal, we highlight how a top-down sustainability assessment can fail to align with the sustainability concerns of a developing country. We focused our evaluation on the set of indicators for MDG 7 (environmental sustainability), based on their relevance and comprehensiveness in the Nepalese context. Our analysis suggests that generic indicators such as forest cover may be relevant, but they may not provide a useful information about the problems they were designed to assess. For example, the MDG assessment uses forest cover as an indicator of forest degradation and deforestation, however, forest cover alone does not capture the degradation resulting from common practices in Nepal such as (over) grazing, fuelwood collection, monoculture within community forestry systems, nor conversion to plantations. While the Millennium Development Goals do align with broad sustainability concerns and development of the country, most of the indicators used to monitor progress may not reveal the true development conditions in Nepal. Our results support the need for a bottom-up contribution to the indicator selection process at local and national levels.

**Keywords:** sustainability assessment, Nepal, Millennium Development Goals, indicators

# 1. Introduction

Since the establishment of the United Nations in the late 1940s, international development goals have been a powerful driver of international cooperation and policy harmonization or convergence (Baster 1972; McGranahan 1972; Jolly 2003; Kates et al. 2005; Hulme 2009; Happaerts 2012). Economic growth has been a commonly used measure of development progress since the 1950s, however its primacy over other measures, and its appropriateness for this use, is widely debated (Myrdal 1968; Baster 1972; Seers 1972; Adelman and Morris 1973; Hicks and Streeten 1979; Mitchell 1996; Morse 2013; Costanza et al. 2014). Interest in other development measures (such as environmental quality, water access, food security, social equity and empowerment) was low until the late 1980s, when sustainable development finally emerged as a new development paradigm (Mitchell 1996; Morse 2015). Intra- and inter-generational equity were popularized by the Brundtland Commission and adopted as key developmental principles (WCED 1987). As a result, cross-sectoral development projects and sustainability assessment frameworks began to proliferate after the 1990s (Mitchell 1996; Fukuda-Parr 2008); at present, there are more than 170 indices that treat development as a multidimensional concept (Bandura 2008).

The term ‘development’ is often used interchangeably with ‘sustainable development’ to indicate a confluence between economic viability, inter and intra-generational justice and equity, and environmental protection (WCED 1987, Kates et al. 2005). The most widely known attempt to operationalize sustainable development is the United Nations’ (UN) Millennium Project. In September 2000, the Millennium Declaration was adopted at the United Nations General Assembly. The Millennium Development Goals (MDGs) are a set of eight international development goals to be met by 2015, as measured by 21 targets and 60 indicators (in 2005; previously the set consisted of 18 targets and 48 indicators). Many regard the eight Millennium Development Goals (MDGs) as a standard bearer for systematic monitoring and promotion of international development (Sachs & McArthur 2005; Fukuda-Parr 2008). Manning (2010) and Vandemoortele (2011) argued that is one of the few international

projects that recognizes sustainable development as more than economic growth, and others see it as a culmination of all past commitments and rhetoric of the UN and OECD members into a single, comprehensive development framework (Jolly 2003; Sachs 2004; Fukuda-Parr 2008). However, many suggest that this has not been achieved (Easterly 2009; Leo 2010; Waage et al. 2010; Vandemoortele 2011; Fakuda-Parr et al. 2013). At the end of this 15 year project (in 2015), world leaders demonstrated their commitment to its continuation by adopting more comprehensive Sustainable Development Goals (SDGs). It suggests that this is an opportune time to analyze how the MDGs and the measures used to assess progress are reflective of the reality on the ground.

There are numerous assessments designed to measure sustainable development by different groups (such as United Nations Commission on Sustainable Development; Consultative Group on Sustainable Development Indicators; European Environmental Agency; Wackernagel et al. 1994; Ura et al. 2012 etc.). While some measure human impacts on the environment (such as Ecological Footprint and Environmental Sustainability Index), others measure socioeconomic conditions (such as Human Development Index, Gross National Happiness, Genuine Progress Index etc.). Few assessments combine these different measurement systems and cover multiple dimensions of a development process as the MDG does. However, MDG and many such global assessments largely downplay the fact that not all countries have comparable data; methods for data measurement can vary by country, and different countries may have different sustainable development priorities. This may introduce inequities into the ranking systems based on such global assessments, and make them unreliable and meaningless in many countries (Easterly 2009). Another concern regarding MDGs was that MDG targets did not do much to ensure that development benefits reached economically and socially marginalized populations in the greatest need of assistance. Inequality and poor governance have long been associated with poverty and slow development, but these were mostly overlooked by the MDGs (Gupta and Abed 2002; King and Rose 2005; Bond 2006; Saith 2006; Greig et al. 2007; Fukuda-Parr 2008). Many argued that using the MDG targets as a common yardstick to assess performance for all developing countries was unfair and could encourage the 'misrepresentation of

outcomes' and the distortion of statistics (Saith 2006; Easterly 2009; Vandemoortele 2011). The participation of developing countries in setting international development goals is generally limited (Mitchell 1996; Fukuda-Parr 2008; Hulme 2009; Fehling et al. 2013). Often, goals are defined by a small group of experts and donor agencies (King and Rose 2005; Bond 2006; Hulme 2009; Fehling et al. 2013). Representatives from developing countries and NGOs are usually invited far later in the decision-making process (Hulme 2009; Fehling et al. 2013). Soliciting feedback and endorsements from member countries (usually heads of state) may be argued as a form of consultation and participation to a certain extent (Fukuda –Parr 2008), but rarely rise to the level of equitable impact on the process.

When global targets are applied to national or local levels, the implementation of development goals then becomes a top-down process (Manning 2009). Many donor agencies and national governments have used MDGs as their 'consensus objectives' to define development needs at national and local levels, without paying much heed to local contexts and priorities (Fukuda-Parr 2008). However, development projects motivated by global goals may not gain community support and risk ineffective implementation (Mitchell 1996; King and Rose 2005; Fukuda-Parr 2008; Hák et al. 2016). Moreover, when decisions regarding development are made without adequate contextual knowledge (including institutional capacities, governance, and financial resources), crucial issues are often missed such as data availability, available grassroots support, and practicality/applicability. This can hinder the implementation of development policy and the effectiveness of the indicators. Another limitation of a top-down approach (particularly in the development sector) is its failure to acknowledge the diversity of needs stemming from the uneven pace of development in different countries (Fukuda-Parr 2008). This raises doubts about the reliability and credibility of expert-determined development indicators when comparing national progress towards generalized international development goals.

There are growing calls to examine the impacts of MDGs on developing countries (Fukuda-Parr 2008; Fukuda-Parr et al. 2013). A study of MDG indicators from 1990 to 2010 showed that less than half of the 126 countries studied showed any marked

improvement since the adoption of the Millennium Project in 2000 (Fukuda-Parr et al. 2013). At least 30% countries either showed no improvement, or regressed in half of the indicators examined. In another study, Fukuda-Parr (2008) examined the impact of MDGs on the Poverty Reduction Strategy Papers (PRSPs)[2] of 22 developing countries. She carried out a content analysis of the PRSPs and policy frameworks of 21 donor initiatives, and compared their priorities and targets with those of MDGs. She concluded that almost all of the 22 PRSPs showed commitment to the MDGs; the focus of most of the PRSPs were poverty, health and education. Although MDGs received a high degree of acceptance by nations and donor agencies, little evidence was found to suggest their influence in resource allocation and planning frameworks (Fukuda-Parr 2008). This finding is similar to what Happaerts (2012) found in his analysis of the influence of international sustainable development policies on operational goals and instruments at the subnational levels of several countries (Happaerts 2012). Conversely, a study conducted by Hailu and Tsukada (2012) suggested that Official Development Aid (ODA) from aid agencies were sensitive to the progress that developing countries were making toward MDG targets. Since the adoption of MDGs, the flow of ODA has concentrated more toward the countries performing poorly in achieving MDG targets[3]. Further research is needed to determine whether donor agencies use (lack of) progress towards MDGs as a compass to prioritize countries for aid, or if they also supported specific MDG-driven action plans in these countries.

The objective of this paper is to examine the relevance of MDG indicators in a developing country. We use Nepal as our case study. For our analysis, we used peer reviewed journals, gray literature (from governmental and non-governmental organizations) and data from the World Bank, United Nations, and the Census Bureau of Statistics Nepal. First, we describe our methods and provide a bird-eye's view of the

[2] PRSPs are official documents required by the IMF and the WB from the developing countries to apply for any kind of funding as a part of their poverty alleviation and development initiatives. PRSPs are national development plans that are expected to reflect a government's priorities, policy reforms and action plans in relation to poverty reduction.

[3] MDG score index was introduced and used to rank countries in terms of their performance in their progress toward MDG targets (Hailu and Tsukada 2012).

MDGs as compared to the national development framework for Nepal in Section 2. In Section 3, we evaluate the MDG Goal 7 (Environmental Sustainability) indicators to determine their relevance and effectiveness for Nepal. Lastly in Section 4, we summarize the lessons learned regarding the limitations of expert-generated sustainable development indicators in the national or local contexts, and provide policy recommendations based on our findings.

## 2. Methods

We used a content analysis method to evaluate all development plans completed since the 1990s by the Government of Nepal (GoN) to examine their alignment with the MDGs. We identified the major development goals of the country over the past 25 years (from 1990 to 2015) based on the targeted programs and sectoral budget allocations as stated in the development plans. Additionally, we used data obtained from the GoN and UN affiliates' websites, peer-reviewed journal articles, and grey literature from national and international governments for our analysis of MDG 7. We used online database systems such as Google Scholar, Web of Science and ProQuest to search for journal articles related to each MDG 7 indicator. We then used directed content analysis method to conceptually extend our hypothesis that top-down indicators do not necessarily and adequately capture Nepal's progress toward sustainable development. Directed approach to content analysis relies on existing theory or research works to identify coding categories (Hsieh and Shannon 2005). We examined MDG 7 indicators for their relevance and practicality in the context of Nepal's environmental sustainability.

### *2.1. Development goals and indicators*

'Development' is commonly viewed as the fulfilment of certain desirable conditions or a path to progress (McGranahan 1972; Gibson 2006). It is a multidimensional concept that embodies 'values, goals and standards which make it

possible to compare a present state against a preferred one' (Baster 1972; pp. 2). Time-bound targets are often used to quantify development goals (Manning 2009), and indicators are a set of variables that indicate a system's progress toward those targets. Generally, there are three ways that development indicators may be used: i) to diagnose a particular development situation (such as poverty, income inequality etc.); ii) to make development-related predictions (e.g., UN Statistical Department's predictions about world population); iii) and to evaluate progress of a system toward predefined development targets (McGranahan 1972; Mitchell 1996). Development indicators can also be used to encourage development activities, decisions, or policy reforms (Mitchell 1996; Morse 2015; Hák et al. 2016). One development goal may have several indicators, tailored to the stage of development and the context in which the development is taking place (McGranahan 1972).

Some of the frequently cited guidelines for the selection of development indicators are:

i) Data must be available: Availability of data or sound methodology to collect new data for any given indicator is crucial for its practicality or applicability (Baster 1972; Liverman et al. 1988; Mitchell 1996; Mayer 2008; Hák et la. 2007, 2016)
ii) Indicators must be sensitive: Sensitivity to change across time, space and social distribution in the system is the important feature of indicators (Liverman et al. 1988; Mitchell 1996).
iii) Indicators must be relevant: Relevance of the indicators is essential to ensure their utility as a decision-making tool (Liverman et al. 1988; Mitchell 1996; Parris and Kates 2003; Hák et la. 2007, 2016).
iv) Number of indicators must be manageable and adequate: Too many indicators can make the assessment too complicated, expensive and difficult to manage. Indicator sets should be both manageable in number and also comprehensive (McGranahan 1972; Mayer 2008; Hák et la. 2016).

We used this set of features as a framework to evaluate MDG 7 indicators in the context of Nepal.

### *2.2. Case study background: Nepal*

Sandwiched between two economic giants (i.e. India and China; see Fig. 2.1), Nepal is one of the 48 least developed and lowest income countries in the world (UN 2016). Nepal, a country of 28 million, had a GDP per capita (at purchasing power parity) of 2,261 US$ in 2014 which put it in a low-income category (WB 2015). Nepal is divided into 75 governance districts, 14 zones and five development regions. Occupying a total of 147,181 $km^2$, Nepal is ecologically and culturally diverse, with the Himalayas in the north, hills and fragile land structures in the central region, and fertile lowlands and plains in the south, constituting 35%, 42% and 23% of its total land area respectively (CBS 2014a).

Nepal had a state-controlled political system until 1990, after which it adopted a multi-party democracy system following the historic people's movement. The Nepalese socio-political situation has remained volatile, and the country has not been able to make as much progress as was hoped after the adoption of a democratic system of governance. Development progress has been severely hampered by several periods of political unrest, including a ten year long Maoist insurgency (1996-2006), an appropriation of political power by the Monarchy afterwards, the people's movement of 2007 and the subsequent abolishment of the Monarchy in 2008, and a political impasse resulting from a delayed Constitution-making process from 2008-2015. On the other hand, the political transformation in 1990 had allowed an upsurge of pluralism and promoted a market-oriented, neoliberal economy (GoN/UN 2013). The active participation of private sector actors and rise in the number of non-governmental organizations have made some targeted progress towards development goals. Nevertheless, Nepal's development has not been satisfactory mainly due to long-standing issues such as a lack of infrastructure and stable financial resources, weak governing institutions, slow reforms, and a lack of transparency (WB 2010). These challenges have put Nepal into a 'poverty trap' (Bista 2006). Despite an abundant flow of foreign aid and existing development programs, the

country's socio-economic and environmental conditions continue to remain unsatisfactory (WB 2010; GoN/UN 2013).


**Figure 2.1. Map of Nepal (Source: Google Map,** *see Appendix A for documentation of permission to use this material***)**

## *2.3. Before the adoption of MDG*

Since 1990 (baseline year for the MDGs), Nepal has completed altogether five periodic development plans, of which two (Eighth and Ninth) were formulated before 2000 (Table 2.1; MDG-related priorities are shaded). National priorities have been identified based on three categories: target-setting, budget allocation, and commitment shown through specific programs. Nepal realized at the beginning of the Eighth Plan (1992-1996) that economic growth alone may not be sufficient to rescue the nation from the quagmire of poverty and hunger (NPC 1992, 1997). Specific programs were initiated during the Eighth Plan period to improve the livelihoods of the poor population at community and village levels. The main focus of the development plans in the early

1990s were: the devolution of power to local bodies; mitigation of social and economic disparities between regions (hills/mountains versus plains/valleys); optimization of means and resources to enhance national production; economic liberalization; development and modernization of the agriculture sector; infrastructure development to improve social services (such as communication, transport, energy, health care, education, drinking water and sanitation); and the efficiency and effectiveness of foreign assistance.

### *2.4. Post MDG adoption*

The development focus for Nepal changed around 2000, particularly because of the Maoist insurgency and the socioeconomic and infrastructural damages that it caused (NPC 2002, 2007, 2011). Peace, rebuilding/reconstruction, and reintegration were prioritized in the 2000s. In the late 2000s, the country mostly remained preoccupied in building a structural and legal base for its transformation to a Federal Democracy. However, poverty alleviation, mitigating regional disparity in access to basic facilities, decentralization and participatory planning, private sector development, market liberalization, and the revival of the economy still remained priorities of the Tenth, Eleventh and the Twelfth Plans (Table 2.1). Since the 1990s, the devolution of power to local governments and mobilization of private sector and NGO actors in development activities have become major development strategies. The most recent Plans have increased the number of targeted programs to improve socioeconomic conditions of poor, vulnerable and marginalized populations through skill-based/entrepreneurship training and capacity building programs, microfinance and rural loan programs, and by improving their access to education and health care. The success of these programs is debatable, given the regional and caste or ethnic disparity that still exists in multiple dimensions of development across the country (WB 2010; NPC 2014; CBS 2015; Mitra 2016).

The Tenth Development Plan (2002-2007), has been frequently cited as a strategic document for poverty alleviation or the country's PRSP (NPC 2002). Consistent with what Fukuda-Parr (2008) found in the PRSPs of 22 other developing countries, the key focus of the Nepalese PRSP was poverty alleviation, health, education, and gender

equality (Table 2.1). The PRSP assured continuation of the pre-existing programs and commitment to the long-standing priorities, many of which were the MDG targets. The Tenth Plan was unclear about its plan of action to expedite Nepal's progress toward MDG targets, however, it explicitly underlined the GoN's commitment to 'provide necessary information in the specified time about the indicators' (NPC 2002; p. 623). The Eleventh and Twelfth Plans on the other hand were clear about the government's interest in prioritizing national development goals that aligned with the MDGs, and to fast-track Nepal's progress toward MDG targets.

**Table 2.1: Summary of Nepal's Development Strategies from 1990-2015 and their alignment with MDGs**

| 2000-2015 | 1992-1996 | 1997-2001 | 2002-2007 | 2008-2010 | 2011-2013 |
|---|---|---|---|---|---|
| **MDG priorities** | **Eighth Plan** | **Ninth Plan** | **Tenth Plan** | **Eleventh Plan** | **Twelfth Plan** |
| **Income poverty** | Training programs, employment generation (agriculture and forest industry, tourism and trade) | Training programs (agriculture & non-agriculture sectors), loans & microfinance (to promote self-employment, entrepreneurship) | Support agriculture, forest, trade & tourism sectors, reduce underemployment & unemployment | Vocational and skill-based training programs (agriculture & non-agriculture sectors), loans, cooperatives & microfinance | Vocational and skill-based training programs (agriculture & non-agriculture sectors), loans, cooperatives & microfinance, improve youth employment rate |
| **Hunger** | Food security, nutrition program | Nutrition program (production, supply, awareness) | Food security (supply, production & awareness) | Food security: sustainable production, supply & awareness | Nutrition Program, Food security (supply, production & awareness) |
| **Education** | Infrastructure, enrolment, scholarships for girls, physically challenged, poor, and marginalized populations. | Increased literacy, vocational education and training, scholarships for girls, physically challenged, poor, and marginalized populations. | Increased literacy, education (formal, informal, special, technical/vocational), scholarships for girls, physically challenged, poor, and marginalized populations. | Education for all including underprivileged children, improve quality of education | Scholarships for girls, physically challenged, poor, and marginalized populations, informal education programs for adults |
| **Gender equality** | Women's empowerment (through vocational and skill training, education) | Female literacy, women's development,(through institutional arrangement for equal opportunity and rights) | Women's education (scholarships/stipends), gender mainstreaming, empowerment and equity in all sectors | Improve women's access to education, economic resources, and participation in state mechanism & local development | Improve women's access to education, economic resources, and participation in governance & local development |
| **Health** | Child survival & health, reproductive health & family planning, Communicable and non-communicable diseases | Child survival & health, reproductive health & family planning, Communicable and non-communicable diseases | Child survival & health, reproductive health & family planning, basic health services, Communicable and non-communicable diseases | Child health & survival, Family planning & reproductive health, Communicable and non-communicable diseases; basic health services | Child health & survival, Family planning & reproductive health, Communicable and non-communicable diseases (through awareness programs, trainings, health camps); basic health services |
| **Environmental protection** | Conservation areas for forest & watershed protection | Community-based forest management, biodiversity conservation, environment awareness & management, water & sanitation | Community-based forest management, water & sanitation, environmental awareness/education/management/ monitoring programs, institutionalization and | Water & sanitation, Implementation of IEE and EIA policies, expansion of conservation areas, management and monitoring programs | Water & sanitation; sustainable forest management, wetland and watershed conservation; climate change adaptation and mitigation: Implementation of National Adaptation Plan of Action |

| | | | | | |
|---|---|---|---|---|---|
| | | | implementation of Initial Environmental Examinations (IEE) and Environment Impact Assessments (EIA) policies | | (NAPA); Energy development |
| **Global Partnerships** | Efficient and effective utilization of foreign assistance (loans, aid, investment) | Foreign assistance (loans, aid, investment) | Efficient & effective use of foreign assistance, promote foreign trade; Promote regional, multilateral & bilateral trade relations | Attract foreign investment to support industry base; Promote regional, multilateral & bilateral trade relations | Attract foreign investment to support industry base; Promote regional, multilateral & bilateral trade relations |
| **Science & Technology** | Communication (telecom), energy technologies | Agriculture/forestry research, appropriate technologies, communication | Communication (telecom), alternate energy, rural/appropriate technology | Alternative energy, international relation and cooperation for research and development | Alternative energy, international relation and cooperation for research and development |
| Other concerns | • Emancipation & capacity-building of bonded laborers<br>• Local development (agriculture & forest sector development, water & sanitation, community-based forest management)<br>• Economic growth through market liberalization<br>• Energy development (hydro)<br>• Physical infrastructure development (transportation, schools, hospitals etc.)<br>• Agriculture intensification and diversification<br>• Monitoring and evaluation | • Emancipation of bonded laborers, eradication of child labor & exploitation<br>• Energy development<br>• Regional balance in infrastructure & socioeconomic development<br>• Devolution of power and function to local bodies, involving local communities.<br>• Promotion of public-private partnership<br>• Agriculture intensification and diversification<br>• Monitoring and evaluation | • Rehabilitation & welfare of ex-bonded laborers, children & marginalized/vulnerable population<br>• Infrastructure development (transport, telecommunication, irrigation)<br>• Energy development<br>• Reduce regional disparity<br>• Devolution of power and function to local bodies, involving local communities, good governance.<br>• Peace & security: reconstruction, rebuilding<br>• Good governance and corruption control<br>• Monitoring and evaluation | • Rehabilitation & welfare of ex-bonded laborers, children, marginalized/vulnerable population & victims of domestic violence and armed conflicts<br>• Revitalize economy through infrastructure development to support agriculture, tourism & industries<br>• Energy development<br>• Constitution building, general election<br>• Peace, reconstruction/resettlement & reintegration<br>• Natural disaster management<br>• Youth mobilization programs<br>• Good governance, corruption control<br>• Monitoring and evaluation | • Natural disaster and crisis management<br>• Physical infrastructures (rural transportation, irrigation, hydro-power and alternative energy, drinking water supply, schools and hospitals)<br>• Youth mobilization to stop human trafficking and trade<br>• Improved services and facilities for senior citizens and disabled population<br>• Constitution building, general election<br>• Peace, reconstruction/resettlement & reintegration<br>• Monitoring and evaluation |

## 3. Results and Discussion

In this section, we evaluate the environmental indicators in the MDG assessment framework for Goal 7. We first provide a background of the indicator or indicator set. We then outline the national trends or status of the indicator/s. Finally, we evaluate each indicator based on its relevance and comprehensiveness in the Nepalese context. We omitted the indicators that are clearly irrelevant to Nepal (e.g., marine protected areas, since Nepal is a land-locked country) or not discussed in the global and national MDG reports (even if they were in the original MDG list).

### *3.1. Target 7A. Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environment resources*

#### *3.1.1. Sustainable Development governance*

Most of the conservation-related projects initiated during the Eighth Plan (1992-1996) period focused on regulating illegal trade of wildlife and forest resources, and on building capacities of local communities to implement community-based forest and watershed management (NPC 1997; Chaudhary 2000). The Ninth Plan (1997-2001) remained focused on programs for raising awareness about the significance of biodiversity (especially rare and endangered species) and the importance of local-indigenous knowledge. Similar to forest resources, an emphasis on water resources has remained consistent throughout development plans, primarily for their importance to energy (hydropower) generation, residential water supply, flood-control, irrigation, and industry (NPC 1992; Kandel 2010).

In the 1990s, Nepal signed a number of international and regional accords (the 1992 Rio Convention, the 1992 UN Convention on Biological Diversity, Ramsar Convention on Wetlands, Kyoto Protocol, South Asian Cooperation Environmental Program, etc.) which provided an impetus to mainstream ecological integrity and sustainable development into Nepal's development agenda. As a result, a number of environmental acts were signed into law and conservation strategies were developed. In

1994, GoN facilitated the Biodiversity Profiles Project with financial support from the Government of the Netherlands, and released the first Biodiversity Profiles of Nepal, a comprehensive and scientific documentation of biological diversity in Nepal (Bhuju et al. 2007). However, due to a lack of institutional capacity, financial resources, public awareness, and technical expertise, conservation strategies developed during this period were not as effective as desired (NPC 2002). Furthermore, although the Plans occasionally highlighted environmental problems resulting from excessive deforestation and rapid urbanization, development plans in the 1990s failed to deliver specific action plans to mitigate them (NPC 1992, 1997).

The 1990s provided a firm foundation for integrating environmental consciousness and a sustainable development concept into the development framework of Nepal (NPC 2002). Importantly, environmental education was integrated into the school curriculum from the primary level to the University degree to strengthen the technical and institutional capacity to meet environmental sustainability goals (NPC 2007). Environmental sustainability received greater nation-wide attention in the new millennium, which led to the institutionalization and accelerated growth of environment-related NGOs (from 386 in 1997 to 1196 in 2007; NPC 2002; CBS 2014a). The Eleventh Plan (2008-2010) in particular played a key role in institutionalizing environmental monitoring and auditing frameworks, and in mainstreaming climate change and environmental concerns into political and development agendas. International commitments made during early Plan periods (such as Kyoto Protocol, Clean Development Mechanism, Biodiversity Conservation Strategy) were acted upon at various scales in collaboration with INGOs, NGOs, community-based organizations (CBOs) and civil societies over this period (NPC 2007; NPC 2012). By the Twelfth Plan period (2011-2013), Nepal had developed and implemented a number of conservation

projects, regulatory policies and standards, and a National Adaptation Plan of Action to mitigate the impact of climate change in various parts of the country (NPC 2012)[4].

### *3.1.2. $CO_2$ emissions and energy consumption*

*Background:* The implementers of the Millennium Project in Nepal did not set any target for $CO_2$ emissions, energy consumption, or energy use per unit of GDP (GoN/UN 2013). The assumption was that reduced or steady $CO_2$ emissions per capita would meet the energy efficiency goal (energy use per unit of GDP), implying sustainable economic growth (GoN/UN 2013).

Ever increasing $CO_2$ emission has put the global community at risk from climate change (IPCC 2014; Wheeler and Braun 2013). The Fifth IPCC Assessment Report suggests that the risks associated with extreme weather events, for example, are likely to get worse and more variable with increasing global temperature (IPCC 2014). As for Nepal, the impacts of increasing temperature have been observed in agriculture (e.g., erratic rainfall patterns, increased incidence of pest and diseases), national food security, biodiversity, glacier melting (increasing the probability for glacial lake outbursts and downstream flooding), and reduced energy generation (hydroelectricity[5]) and water supplies (Bajracharya et al. 2007; Malla 2009; Bartlett et al. 2010). Global temperatures are likely to continue to rise for the foreseeable future regardless of mitigation efforts, as a result of historical emissions (Pielke et al. 2007; IPCC 2014). Nevertheless, political commitments to combat climate change and promote sustainable development have remained largely skewed toward mitigation, primarily concentrating on greenhouse gas (GHG) emissions reduction (Füssel 2007; Pielke et al. 2007; Lobell et al. 2008; Measham et al. 2011); the mitigation-focused '$CO_2$ emissions' as an MDG indicator is indicative of this lack of attention to adaptation.

[4] Drinking water and sanitation are listed as social sector or health sector issues (for their strong correlation with water-borne diseases) and not in the list of environmental issues in the Periodic Plans of Nepal (NPC 2002, 2007).
[5] Hydropower is the primary source of electricity in Nepal (NPC 2014).

*Current state:* Nepal's $CO_2$ emissions increased by almost 600% between 1990 and 2011, mainly from transport fuel and firewood combustion (WB 2015). However, Nepal's per capita emissions were very low at 0.16 metric tons in 2011, when compared to average emissions of 10 (developed regions) and 3 (developing regions) metric tons per capita (WB 2015; UN 2015).

*Evaluation based on Nepalese context*: The relevance of per capita $CO_2$ emissions as an indicator for energy efficiency and sustainable development is debatable for Nepal, where industrial production is minimal[6] and the majority of total energy consumed goes toward meeting basic needs such as cooking and heating (Fig 2.2). Low $CO_2$ emissions per capita in Nepal therefore does not translate into improved energy intensity or sustainable economic development, as almost 85% of Nepal's GDP is generated by traditional agriculture and service sectors, which combined consume less than 10% of total energy consumption (WB 2010; WECS 2014). Moreover, the majority of Nepal's $CO_2$ emissions result from the combustion of transportation and household fuels (GoN/UN 2013).

The relationship between $CO_2$ emissions and the nation's economy is complicated, primarily because major energy sources (i.e., firewood, agricultural waste, animal dung) can be carbon neutral, are generally obtained by the people free of cost, and may not directly involve any economic transactions (CBS 2012). Nepal can reduce its $CO_2$ emissions per capita and energy use per GDP simply as a result of growth in the service sector and increased flow of remittances (WB 2010; NPC 2014b), with no improvement in sustainable development.

The focus on $CO_2$ emissions and energy use per GDP, MDG 7 overlooks most of the environmental problems associated with energy use and production in Nepal, some of which are more relevant than $CO_2$ emissions. These two indicators also obscure many environmental problems related to the kinds of energy sources used in Nepal. The majority of households use traditional technologies and fuel types (Fig. 2.2), which are

[6] Contributes 15% to GDP, and is responsible for about 8% of the national energy consumption (WCES 2014).

characterized by low energy efficiency and high emissions of indoor air pollutants (Smith et al. 2000; Rehfuess et al. 2006). Burning of unprocessed biomass fuels (such as firewood, agricultural wastes and animal dung) releases particulate matter ($PM_{10}$ and $PM_{2.5}$) that can contribute to regional climate change (Haywood and Ramaswamy 1998; Jacobson 2001; Bond et al. 2004; Bond and Sun 2005; Ramanathan and Carmichael 2008; Kaspari et al. 2014). Black carbon ($PM_{2.5}$) can change regional radiative budgets, cause aseasonal glacier melting, and impact the hydrological cycles in the region (Ramanathan and Carmichael 2008; Bond et al. 2004). Black carbon and other indoor air pollutants are generated mostly in traditional stove types, but also in some improved (unprocessed) firewood-burning cook stoves (Smith et al. 2000).

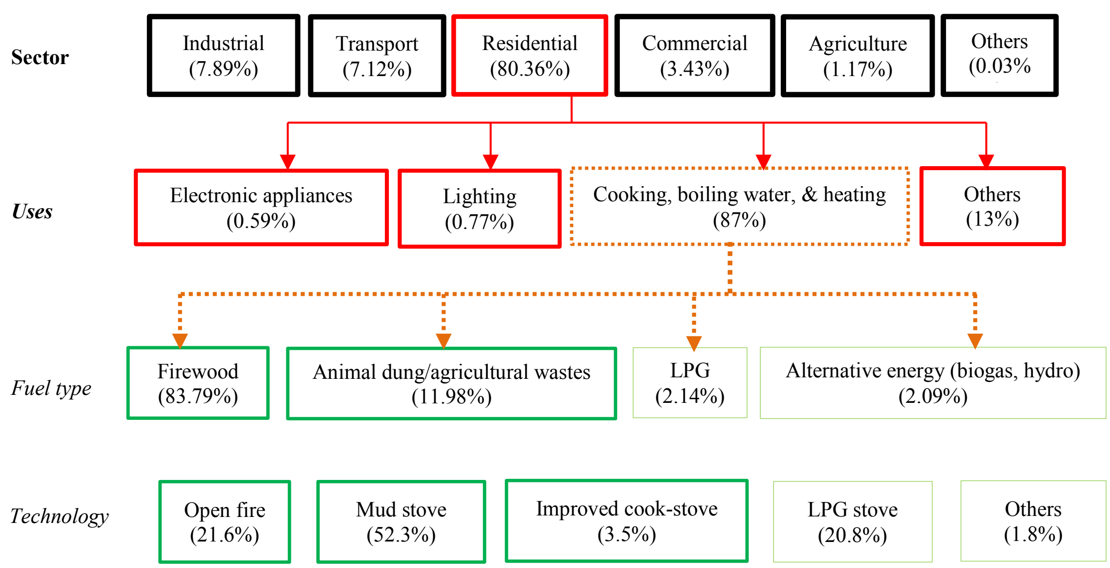



**Figure 2.2. Distribution of energy consumption by sector, residential use, fuel type and technology (Data source: CBS 2012; WCES 2014). The first branching in the flowchart indicates the distribution of residential energy consumption by uses. The second branching shows the distribution of energy consumption for household cooking and heating by energy sources. The bottom row shows the distribution of energy used for cooking and heating by the technologies used**

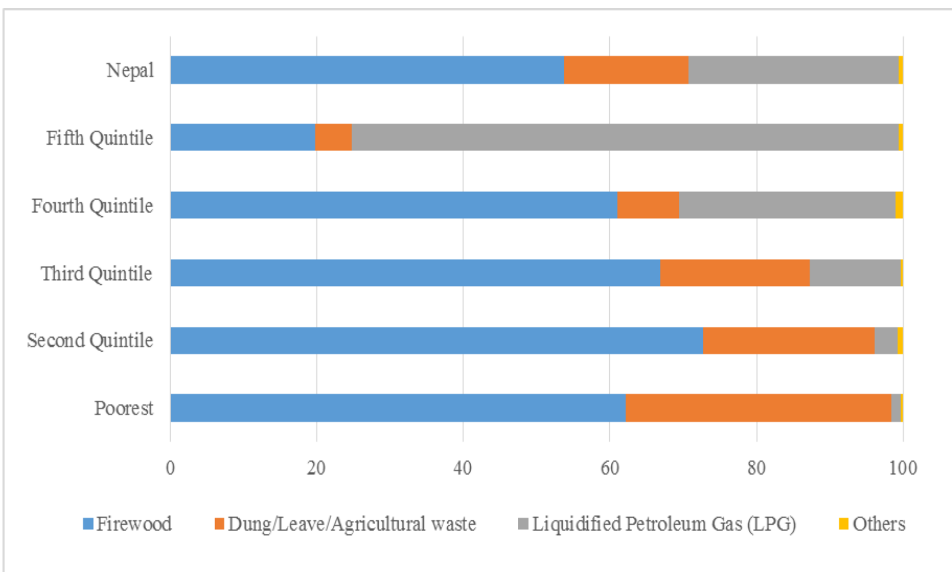
Indoor air pollution from unprocessed biomass burning has also been associated with respiratory, pulmonary and skin diseases (Smith et al. 2000; Rehfuess et al. 2006; Ranabhat et al. 2015). The World Health Organization (WHO) estimates that more than 50% of pneumonia resulting in mortality of children under five years of age is attributable to PM from solid fuel burning. Similarly, diseases or illnesses attributable to indoor air pollution claim more than four million lives annually world-wide (WHO 2016). A number of studies in Nepal have also shown a strong correlation between particulate matter from traditional cook stoves and diseases like acute lower respiratory infection, chronic bronchitis, and chronic obstructive pulmonary disorder (Kurmi et al. 2010; Ranabhat et al. 2015). Respiratory disease is one of the leading causes of deaths in Nepal; it causes more deaths annually than the diseases used as sustainable development indicators in MDG 6 (tuberculosis, malaria and HIV/AIDS; GBD 2010; Ranabhat et al. 2015). Women and children spend more time than men near cook stoves, and the pollution disproportionately impacts women and younger children (Rehfuess et al. 2006; Ranabhat et al. 2015). Furthermore, firewood (and water) collection in many areas takes up a considerable amount of time, leaving limited time for women and girls for education and income-generating activities (Von Schirnding 2002; Baland et al. 2010).

Energy source and access in Nepal embodies the multidimensionality of poverty and sustainable development. However, $CO_2$ emissions and energy use indicators for Target 7A fail to reflect these challenges. Unfortunately, the population in the bottom consumption quintiles relies more on unprocessed biomass fuels than people in the higher quintiles, making them disproportionately vulnerable to the impacts of poor energy and technology choices. More than 95% of the bottom two consumption quintiles in Nepal rely primarily on either firewood or animal/agricultural wastes as a primary cooking fuel, while almost 75% of richest quintile use LPG as their primary cooking fuel (see Fig 2.3; CBS 2015). There has been little progress in these challenges in the past 15 years.

Due to a lack of fossil fuel reserves and slow progress in the development of modern renewable energy technologies, it is very likely that the majority of Nepalese will remain dependent on biomass fuel for years to come. However, improved household energy technologies and fuel types with higher efficiency and low emissions are

imperative to meet all health, gender equality, education, poverty reduction and environmental sustainability goals for Nepal and many other developing countries (Rehfuess et al. 2006). The proponents of MDGs often claim that the purpose of this framework is to influence the international normative discourse, and facilitate the MDG-motivated policy convergence at national levels (Sachs and McArthur 2005; Vandemoortele 2009; Happaerts 2012). However, indicators for such a purpose cannot be generated without a holistic understanding of local energy systems (including energy production, distribution, use, and the socio-economic and environmental factors that govern them).

a)



b)

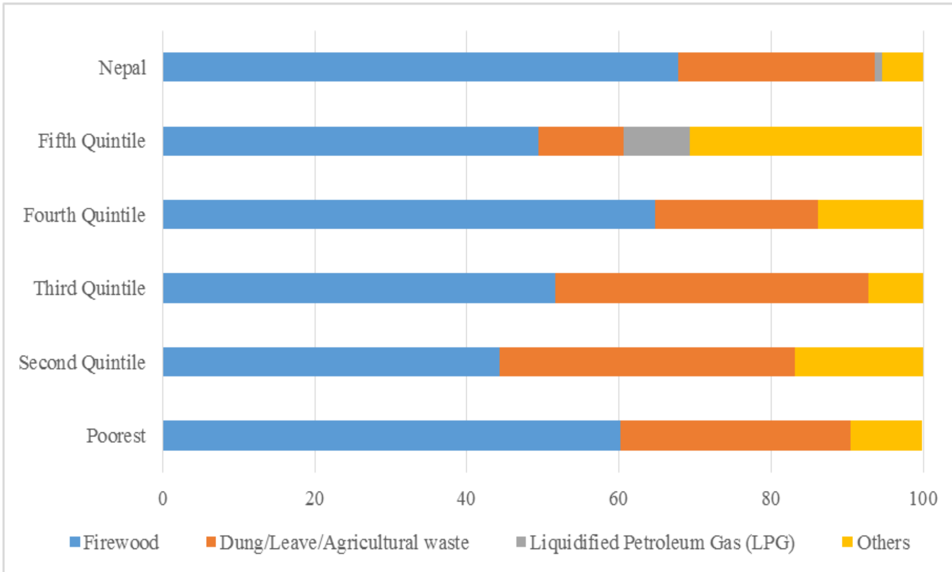



**Figure 2.3. Primary cooking fuels by consumption quintiles for a) 2014 and b) 1996 (Data source: CBS 2015a)**

### *3.1.3. Forest cover*

*Background*: The World Bank estimates that over 240 million people live within or around forest ecosystems globally, and at least 1.6 billion people directly benefit from forests in different ways (WB 2015). In recent decades, overexploitation of forest resources through large-scale logging and forest-land conversion by humans have put a tremendous pressure on the global forest ecosystems. This has resulted in a significant loss of carbon stocks and degradation of the biophysical, ecological and economic characteristics of many forests (Dixon et al. 1994; Geist and Lambin 2002; Mayaux et al. 2005; WWF 2016). In Nepal, at least 65% of the population is directly dependent on forests for firewood, agriculture, cattle grazing, and income (CBS 2012). Deforestation and forest degradation in Nepal drive soil erosion and landslides, biodiversity loss, longer walks for women and children to collect firewood, habitat loss, and increased encroachment of wild animals into villages (Chaudhary 2000; Khatri 2010)

The Millennium Project intended to address these issues by introducing 'forest cover' as an indicator under MDG 7. According to the UN, 'forest' is defined as an area

larger than 0.05-1 ha of land, 10-30% of which is covered by trees that stand more than 2-5m tall at maturity (UNFCCC 2002). The MDG progress reports recommended forest cover as an indicator of deforestation and depletion of carbon stocks (UN 2015). For Nepal, a target was set to increase forest cover to 40% of the total land area in 2015, from 29% in 1995 (GoN/UN 2013).

The adequacy of 'forest cover' as a sole indicator of forest quality is contested (Acharya and Dangi 2009; Sasaki and Putz 2009; Paudyal et al. 2015). It cannot comprehensively assess forest degradation, carbon sequestration, or ecosystem health (Acharya and Dangi 2009; Coomes et al. 2012; Stephenson et al. 2014). Decline in forest cover does not necessarily mean deforestation or forest degradation; it can be a result of sustainable forest management (e.g., prescribed clearcutting) or natural succession (Acharya and Dangi 2009; Hansen et al. 2013). Similarly, an increase in forest cover does not necessarily contribute to sustainable development as it may include an increase in plantations (as they meet the definition of 'forest cover' stipulated by the UN) or farmland abandonment that may not benefit the environment or local communities (Sasaki and Putz 2009).

*Current status:* The Forest Resource Assessment reported an increase in the forest cover (>10% canopy cover) to 40% of the total area in 2014 from 29% in 1994 (DFRS 2015). This implies that Nepal succeeded in meeting the MDG target for forest cover. A number of studies have suggested that the expansion of forest area in Nepal may be due to the growth of the community forestry system (Khatri 2010; Baland et al. 2013; Niraula et al. 2013; Paudyal et al. 2015; Poudel et al. 2015; DFRS 2015). Other studies have attributed the increase in forest cover to the migration of populations from the forested mountains and hill areas to urban areas (mostly in the plains), releasing forests from harvesting pressure and increasing land abandonment and subsequent invasion by tree and shrub species (Jaquet et al. 2015; Paudel et al. 2014).

*Evaluation based on Nepalese context:* Nepalese forests have largely remained protected from large-scale deforestation primarily due to a lack of policies (such as subsidies or other incentives) and industrial infrastructure that are common to other developing

countries (such as Cambodia and Liberia) with large forest resources (Magrath et al. 2013). However, forest degradation may result in long-term adverse impacts on forest health, biodiversity and biophysical properties, none of which are well-represented by forest cover estimates (Sasaki and Putz 2009). For instance, although forest cover has grown significantly over the past 20 years, the Forest Resource Assessment suggests that almost 68% of the total forest area is impacted by grazing, with another 30% affected by other disturbances such as residue collection, logging, bark removal and coppicing (DFRS 2015). Forest area and cover do not reflect ground-level forest conditions such as land degradation resulting from grazing and removal of residues, nor do any changes in vegetation type (Acharya 2000; Acharya and Dangi 2009).

Many argue that in order to protect forest ecosystems and arrest forest degradation, it is crucial first to agree on the definition of forest degradation, which at the moment is fuzzy and often understated (Acharya and Dangi 2009; Sasaki and Putz 2009). While the definition of forest health and degradation should embody socio-ecological significances of the forest, indicators to monitor forest health should reflect the nature of disturbances and the intrinsic properties of the forests. Only then can indicators be useful to influence management strategies and policy reforms. Participatory ecosystem services valuation has been proposed by a number of local experts to improve these ground-level forest quality assessments; they also suggest that forest managers and local communities should be made aware of the broader implications of forest degradation (Acharya and Dangi 2009; Khatri 2010; Paudyal et al. 2015).

Forest and land conservation has been a crucial element in Nepal’s development plans since the 1960s (Heinen and Kattel 1992a; Acharya 2002; Kandel 2010). In 1973, the GoN legislated the National Park and Wildlife Conservation Act to curb deforestation and depletion of natural resources. Since this approach paid little attention to local communities’ needs and concerns (such as their reliance on these areas for food, fodder, timber and fuel), forest and land degradation remained major environmental problems of the time (Chaudhary 2000). The GoN soon realized that a participatory approach was indispensable to sustainably manage the forest, which led to the introduction of the community forestry system. There is negligible private forest ownership in Nepal; almost

all forestlands are owned by the state and operated under various management strategies, of which community forestry system is one (Magrath et al. 2013). The 1993 amendment of the Forest Act of Nepal supports the devolution of management and use rights of some state-owned forests to Community Forest User Groups (CFUGs). These groups hold the rights to use and manage the state-owned forestland as per legal frameworks agreed to by CFUG and the District Forest Office (Acharya 2002; Magrath et al. 2013). The GoN also introduced buffer zones to improve national forest protection; these are areas, which give access to natural resources for local communities living around protected areas (NPC 1992, 1997).

There are currently over 18000 CFUGs (an increase from 12000 in 2001), and community forests encompass over 28.5%[7] of the total forest area in Nepal (NPC 2002; CBS 2014a). About 17% of the total forestland is managed under the protected area system, and the rest of the forest is managed by the government (DFRS 2015). While community forest management and other participatory resource management systems have been effective in protecting forests and ensuring socioeconomic development of rural communities, their benefits specifically to poor and disadvantaged groups within rural communities remain elusive (Thoms 2008; Khatri 2010; GoN/UN 2013; Dahal et al. 2014; Yadav et al. 2015). Similarly, their contribution to resilient forest ecosystems and biodiversity is uncertain (Acharya 2003). However, some studies suggest that local forest users have positive attitudes towards protection of biodiversity and forest ecosystems (Mehta and Heinen 2001).

### *3.2. Target 7B. Reduce biodiversity loss, achieving a significant reduction in the rate of loss by 2010*

*Background:* Protected areas are used worldwide to preserve threatened species, biologically diverse ecosystems and exceptional landscapes. These areas include National Parks, Conservation Areas, Wildlife Reserves, Nature Reserves, Wilderness Areas, Strict

[7] It occupied just about 5% of the total forest area in 2002.

Protected areas, and Habitat Management Areas. (IUCN 2014). These titles reflect different management objectives and conservation goals, typically accomplished through different intensities of protection from human influence or resource utilization (IUCN 2014). Protected areas can contribute to a sustainable supply of natural resources, food security, and the resilience and well-being of communities inside and around them (IUCN 2013; UN 2015).

Although Nepal constitutes only 0.03% of the world's total surface area, Nepal has considerable topographic variability (ranging from 67m above sea level to Mt. Everest, the highest peak in the world) and diverse ecological zones (ranging from tropical to nival bio-climatic zones; Bhuju et al. 2007). As a result, Nepal houses a wide spectrum of flora, fauna and ecosystems. It supports over 4% of all mammal species, over 3% of plant species, and 9% of bird species found in the world (MoFSC 2011; CBS 2014b). However, biodiversity protection has become challenging due to Nepal's growing population and its increasing reliance on forests and natural resources, far-reaching road networks, and human migration (Chaudhary 2000; Bhuju et al. 2007). The Millennium Project expects protected areas to contribute not only to environmental protection, but also to poverty reduction and inter-generational equity (UN 2015; Naughton-Treves et al. 2005). However, target setting for protected area is determined simply as a proportion of total land area.

*Current status:* In Nepal, protected areas encompass more than 23%[8] of the total land area, higher than the MDG target for Nepal of 17% (GoN/UN 2013; CBS 2014a). Nepal has altogether 20 protected areas (ten national parks, three wildlife reserves, one hunting reserve and six conservation areas), and protected areas cover 80 out of 118 ecosystems recorded in the national database (Table 2.2; CBS 2014a). Nepal lacks a complete dataset on species threatened with extinction (GoN/UN 2013). For instance, of the 208 mammal species recorded in the national database, 38% of mammal species known are data-deficient, 23% has been declared as nationally threatened with extinction and 4% of

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[8] Includes buffer zone area; about 4% in the total proportion of protected area is buffer zone area.

species are declared as critically endangered (Jnawali et al. 2011). Much of the conservation efforts in Nepal have remained focused on large animals (such as snow leopard, Bengal tigers, gharial, snakes etc.) and bird species (Bhuju et al. 2007).

*Evaluation based on Nepalese context:* The first wildlife conservation project in Nepal was initiated in the late 1960s with the technical and financial assistance from the United Nations Food and Agriculture Organization (FAO) and the United Nations Development Programme (UNDP) (Heinen and Kattel 1992a). The 1972 UN Conference on the Human Environment had played a pivotal role in injecting environmental consciousness into development planning in Nepal (Khadka et al. 2012). However, interest in local biodiversity remained limited to a few local and international scientists until biodiversity conservation gained political interest in the 1990s. Since the 1994, Nepal has made significant progress (Bhuju et al. 2007). While 15 protected areas were constituted prior to the Millennium Project, five of them (2 national parks and 3 wildlife reserves, constituting about 17% of total protected land area) were added after 2000 (CBS 2014a). Thirty-six percent of the total protected areas is forested, while the rest of it supports meadows and snow-capped mountains (Magrath et al. 2013; CBS 2014a; DFRS 2015). The rich biodiversity that characterizes Nepal is not always adequately represented and conserved by protected areas, which has raised questions about the contribution of protected areas to conservation goals (Chaudhary 2000; Magrath et al. 2013).

Nepal's mountains contain the highest number of ecosystems (52 out of 118 present), occupy the largest land area, have the greatest temperature and altitudinal gradients, and are the most biologically diverse physiographic zone (Acharya 2003; Bhuju et al. 2007; CBS 2014a). Agenda 21 in the Rio Declaration also recognizes mountains as 'the areas most sensitive to all climatic changes in the atmosphere' and 'highly vulnerable to human and natural ecological imbalance' (Chapter 13, Agenda 21; UNCED 1992). Yet, they occupy only 13% of the total protected area (PA) coverage in Nepal (Table 2.2). Although mountains have the greatest coverage of community forests (i.e., almost 70% of the total), the protection of threatened species has mostly remained limited to the community forestry system (Acharya 2003; Khadka and Schidt-Vogt

2008). In fact, a study of community-managed forests in the mid-hills region showed that communities' preferences for certain species and silviculture practices are gradually changing forests into plantations (Acharya 2003; Acharya and Dangi 2009). Nevertheless, biodiversity conservation has yet to be mainstreamed into community forest management in Nepal (Acharya 2003; Khadka and Schidt-Vogt 2008).

**Table 2.2. Distribution of PAs across the physiographic zones (Data source: Bhuju et al. 2007; CBS 2014a)**

| Physiographic zone | Bioclimatic zone | Elevation (m) | Proportion of total land area | PA | Ecosystems | |
|---|---|---|---|---|---|---|
| | | | | % of total PA land coverage | Total no. | Covered by PA |
| High Himalayas | Nival, Alpine | above 5000 | 23 | 71 | 43 | 32 |
| Mountains | Alpine, Sub-alpine, Temperate Monsoon, Subtropical | 2000-5000 | 50 | 13 | 52 | 33 |
| Terai Siwalik | Tropical | <500-1000 | 27 | 16 | 23 | 15 |

In the past 25 years, Nepal formulated a number of laws and policies relevant to PAs. However, due to weak monitoring and enforcement capabilities (Magrath et al. 2013), Nepalese PAs suffer a high rate of encroachment, illegal hunting, poaching and trafficking of rare and threatened species (Heinen and Kattel 1992b; Bhuju et al. 2007; Oli et al. 2013). Many field offices in PAs are understaffed, and lack logistical support and financial resources to pursue management and conservation goals (Heinen and Kattel 1992b; Magrath et al. 2013; Oli et al. 2013). A lack of coordination among different agencies (e.g., Department of National Parks and Conservation Areas, District Development Committee, Village Development Committee, and District Forest Office) is often cited as one of the greatest challenges in meeting the conservation goals of PAs (Jnawali 2011; Magrath et al. 2013). The 2011 National Red List Series suggested that the primary threat to threatened species in Nepal however, is 'habitat loss, degradation and alteration' (Jnawali et al. 2011).

The 1992 World Park Congress agreed on the definition of PA, as parks and reserves intended to benefit the environment and human society across multiple scales (Barzetti 1993; Naughton-Treves et al. 2005). While it is difficult to state with certainty if PAs in Nepal meet this definition, available evidence suggests that PAs have failed to ensure biodiversity conservation or meet the needs of local communities (Allendorf 2007; Karanth and Nepal 2012). In some places, PA objectives and regulations may conflict with basic rights (such as traditional livelihoods, collection of food, fodder, firewood, thatch, water) and the security of indigenous and local inhabitants (Heinen and Kattel 1992b; Allendorf 2007; LC 2011; Karanth and Nepal 2012). Conflict between parks and people is a common issue for many national parks in Nepal (Heinen and Kattel 1992b; Allendorf 2007; Pravat and Humphreys 2013). Local people around the PAs often have negative attitudes toward park management, and some view conservation projects as only benefitting the government (Allendorf 2007; Karanth and Nepal 2012). PAs are viewed more favorably if they contribute to local income through employment opportunities (Heinen and Kattel 1992b; Allendorf 2007).

Tourism is one of the important sources of foreign exchange in Nepal, and provides employment to many locals in and around the PAs. PAs receive the largest number of tourists of any tourist destinations in Nepal (MCTCA 2013)[9]. This has also been one of the key drivers for the government to convert national forests into National Parks and Reserves (LC 2011). However, the increased volume of tourists in PAs has been associated with increased cost of products for local inhabitants, increased demand for firewood and other natural resources, and disruption to natural habitat around the PA (Nepal 2000). Employment opportunities in the tourism industry have only benefitted a few mostly well-off people (such as lodge owners, landholders) in rural communities, while making supplies expensive and limited for poor populations (Heinen and Kattel 1992b; Nepal 2000). It is particularly stressful for mountain communities with limited supplies of food and forest resources. Tourism has also generated an accumulation of

[9] According to the Ministry of Culture Tourism and Civil Aviation (2013), more than 49% of total tourists who visited Nepal visited Natural Parks or Wildlife Reserves in 2012.

non-biodegradable wastes around the PAs (Nepal 2000). The concept of carrying capacity has been discussed occasionally in the development plans of Nepal (NPC 1997), and a number of regulations have been stipulated to control excess tourism in PAs. However, their implementation has been ineffective (Nepal 2000; Magrath et al. 2013). As we consider all of these issues associated with the PA system in Nepal, the contribution of increased area of PAs to biodiversity conservation, poverty alleviation and the sustainable development of rural communities seems uncertain.

### 3.3. *Target 7C. Halve the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015*

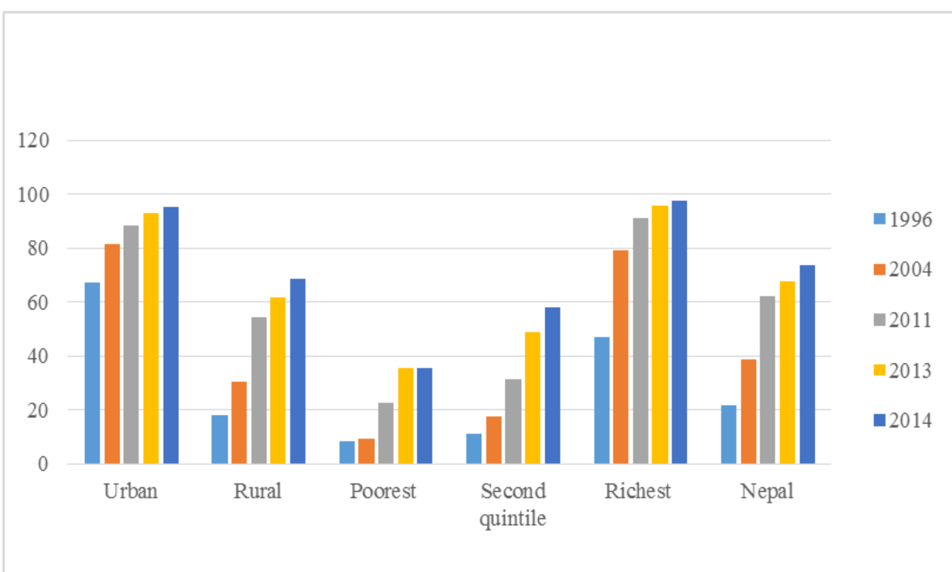
*Background:* Although water availability and sanitation are virtually universal in developed nations, water scarcity and water-borne diseases are common problems in many developing countries (Montgomery and Elimelech 2007). Access to clean drinking water and sanitation facilities are critical to fighting diarrheal diseases, which kill about 842,000 people every year (WHO 2014). The Global Burden of Disease Study (GBD 2010) suggested that diarrheal diseases are the second largest communicable causes of premature and preventable deaths in Nepal. The study also suggested that poor sanitation was one of the leading risk factors for diarrheal diseases. Generally 'improved access to water' is used to imply access to water from protected or covered sources (WHO/UNICEF 2005). Improved sanitation on the other hand, refers to 'connection to a public sewer or septic system or use of ventilated pit latrines and some simple pit latrines' (WHO/UNICEF 2005).

*Current Status:* More than 88% of the Nepalese population had access to improved drinking water in 2014 (i.e., piped water and/or water from covered wells; excludes rivers, streams, and open wells) as compared to 70% in 1995; it surpassed the MDG drinking water target of 73% (CBS 1996, CBS 2015a, GoN and UN 2013). However, these numbers tell very little about the drinking water situation on the ground, which is far from satisfactory. Only 52% of the population has access to piped water, which is

often considered the safest source of drinking water (NPC 2014b, CBS 2015a). This figure is even lower for populations in low-income groups (29% for the lowest consumption quintile) and for the population in the Terai plain (19%) where more than 50% of Nepalese reside (CBS 2012; CBS 2015a). In other words, almost half of the Nepalese population still lacks access to improved (piped) drinking water, and the inequality in drinking water access across income groups and regions is very wide (CBS 2012, 2014c, 2015a; GoN/UN 2013).

Almost 67% of Nepalese population had toilet facilities at home in 2014, as opposed to only 22% in 1995 (CBS 1996, CBS 2015a). Over a quarter of the population still practices open defecation, which is detrimental to human health and the environment (CBS 2015a). As for sewage infrastructure, only about 20% of population has a proper sewer system (CBS 2015a) and only 48% of families with children practice safe disposal of children's feces (CBS 2015b). Considering the increased number of NGOs and funds pouring in for this cause (CBS 2014a, 2014b), this rate of improvement cannot be deemed satisfactory. Furthermore, the disparities among rural and urban populations, and populations in different consumption quintiles, have persistently remained wide (Fig. 2.4 a & b).

a)



b)

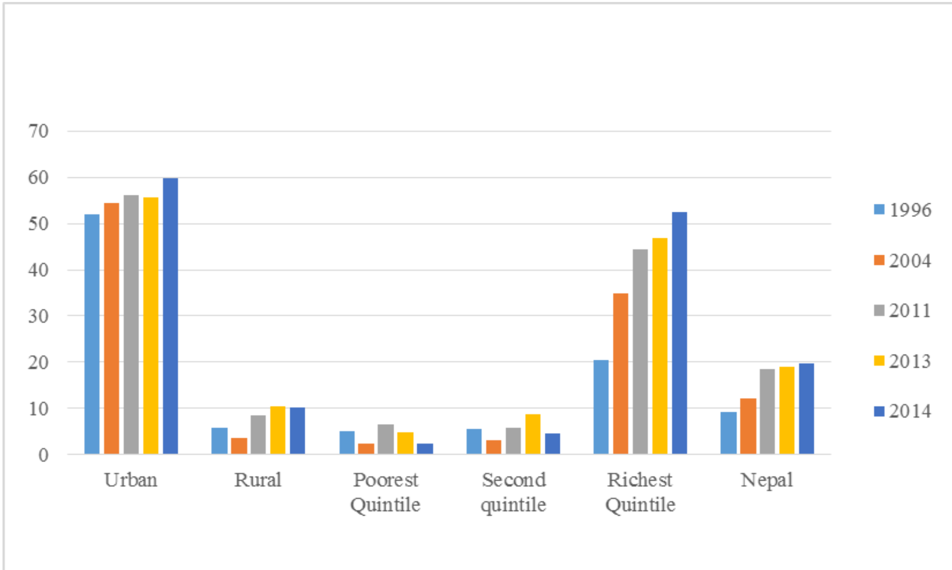



**Figure 2.4. Distribution of population with access to sanitation facilities: (a) toilet facilities, (b) sanitation systems (Data source: CBS 1996, CBS 2012, CBS 2014a, CBS 2015a)**

*Evaluation based on Nepalese context:* Having a proper sanitary system in place is as crucial as having a toilet facility because in the absence of a proper sewage system, there is a possibility for the wastewater to leach into and pollute groundwater systems or nearby water sources. This is exemplified by the finding of one of the largest household surveys in Nepal that determined that more than 70% of household drinking water sources in 2014 were contaminated with *Escherichia coli* (*E. coli*). This points to fecal contamination of drinking water sources (Bain et al. 2014; CBS 2015b). A number of past studies in the Terai and mountain regions have found similar results, raising doubts about the drinking water quality of Nepal (Atreya et al. 2006; Rai et al. 2009). This may explain why waterborne diseases are so prevalent in Nepal; children under 5 are the most affected by diarrheal outbreaks (Fink et al. 2011; Alley 2014; CBS 2015b). Conditions in urban areas are worse because in the absence of proper sewer systems, urban sewage is often dumped in nearby river systems without any treatment (GoN/UN 2013), allowing pollutants to disperse and travel long distances. Therefore, unless the safety of 'improved' drinking water and sanitation can be proven (through the use of a 'quality'

indicator) and ensured, their contribution to sustainable development cannot be established.

Despite the long history of GoN's interest in improving people's access to improved sanitation and drinking water sources, progress has been extremely slow and uneven, with Terai populations benefiting the least (CBS 2012). The use of poor quality drinking water (usually collected from rivers, streams, or open wells), and unhygienic practices such as open defecation, are not only tied with income but also embedded in some societies as social norms. A lack of awareness about health and hygiene is prevalent and consistent across different income quintiles; it is however, higher among the poor population (Karn et al. 2011). A case study of the Far Western region (Nepal) in 2009 suggested that one in five people in the highest income quintile still practiced open defecation (Alley 2014). Nevertheless, these issues have historically been treated as poverty-driven issues (UNDP 2006), with little regard to socio-cultural contexts and embeddedness. Such top-down and unilateral perception of problems have resulted into simplistic and short-term solutions such as subsidies and incentives-based solutions, which are frequently described by local activists as inefficient and unsustainable (Alley 2014). A study conducted in 2011 by the National Planning Commission (with support from several donor agencies) concluded that a lack of institutional capacity, low coordination among various actors on the ground, and unreliable technical and financial support are responsible for the poor implementation of water and sanitation policies (GoN/UN 2013).

### *3.4. Target 7D. By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers*

*Background*: Urbanization has often been associated with better access to basic amenities, cleaner environment, and better employment opportunities. These associations however, have declined in recent decades due to rapid and haphazard expansion of urban areas in many parts of the world, accompanied by a surge in slum populations (UN 2014). Slums (or increasingly referred to as "informal settlements") are defined as low-

income settlements characterized by a lack of basic amenities, substandard housing structure, hazardous locations, and insecure land tenure (UN-Habitat 2003). A study by suggested that over 43% of slum dwellers live in developing countries, even though the bulk of developing regions are mostly rural (UN 2014). The Millennium Project recognizes growth in slum populations as one of the key challenges to sustainable development in developing countries. As a result, the MDG 7 Indicator 32 focuses on improving living conditions of slum populations through access to secure land tenure, with the assumption that clear land tenure contributes to better management of the environment and human health.

*Current Status*: Nepal's urban population increased from 14% in 2001 to 17% in 2011 (CBS 2012). The National Population Census of Nepal does not differentiate urban populations between slum dwellers and non-slum dwellers (CBS 2012), as the government-managed cadastral system does not provide information about land rights/management in informal settlements (NPC 2007; Paudyal and McDougall 2010). The sanitation indicator that the UN-Habitat uses to assess the living conditions of urban poor (UN- Habitat 2003) is typically not reported separately for slum dwellers (CBS 2012). In other words, Nepal lacks a complete data set on the size of informal settlements nor the living conditions in these neighbourhoods (GoN/UN 2013). Census attempts by NGOs and researchers concentrate on the major cities, and largely overlook the slum populations in smaller cities (LSGS 2003, 2008; Paudyal and McDougall 2010; Toffin 2010; Shrestha 2013).

*Evaluation based on Nepalese context*: The Millennium Project uses land tenure rights to identify people living in slum conditions. Most of the population in informal settlements in Nepal consists of migrants from rural areas or other districts, although not all of them are landless (LSHLC 2000; Paudyal and McDougall 2010; Toffin 2010; Shrestha 2013). A study found that over 40,000 families lived in informal settlements of which about 10,000 had landholdings elsewhere (LSHLC 2000). The number of people living in informal settlements (with and without landholdings) may have risen in the past decade

as a result of the Maoist insurgency that disproportionately affected rural areas between 1996-2005, and also because of the abolishment of bonded labor in the Terai region (LC 2011; CC 2012). The state provided some land plots to the most vulnerable populations, however these lands are often too small and are usually just enough for shelter (LC 2011). While landless populations typically suffer worse conditions in terms of security and income, even those with land are generally very poor (Paudyal and McDougall 2010). Therefore, even if the country had an updated cadastral system with information about landlessness and land tenure, it would still not capture the total slum population in the country. The state recognizes this growing population as an important development challenge and has formed a number of policy and programs to facilitate resettlement and provide socio-economic security (NPC 2007; GoN/UN 2013). However, a lack of data for more appropriate indicators is the biggest hurdle in implementing these polices and meeting targets (Paudyal and McDougall 2010; LC 2011).

## 4. Conclusion

International declarations and commitments are a significant driver of policy convergence and harmonization (Busch and Jörgens 2005; Happaerts 2012). They have pushed broad development concerns into the political and development agendas of Nepal. Growing environmental consciousness or awareness in Nepal is one example, which may be credited to numerous international commitments on biodiversity conservation and forest protection, particularly since the 1970s. The Millennium Project is a global program that has provided all developing countries with a framework to expedite progress towards expert-identified sustainable development goals. As in many other least developed countries, sustainable development in Nepal has been hindered by political, social, and geographical limitations. However, in comparison to many other developing nations, Nepal has fared well in a number of MDG indicators (GoN/UN 2013). However, our review suggests that even this progress must be examined more closely, as it may not reflect regional development conditions. In particular, the relevance, adequacy and

sensitivity of the MDG indicators to the changes in the living conditions of poor and vulnerable populations should be taken into consideration. Participation of local experts and stakeholders will be imperative to clarify the influence of context on this progress, and to identify more relevant, practical and cost-effective indicators where necessary.

Sustainable development is a social process that requires grassroots initiatives (Vandemoortele 2009), and is based on the notion that the human-nature system cannot function sustainably if any of its subcomponents is broken (Cabezas et al. 2003). Although the concept may have become a catchphrase among scholars, policy makers and development practitioners, the participation and acceptance of the concept by stakeholders are imperative for it to truly materialize. In Nepal, community forestry (CFUGs) is often used as one of the few examples of management systems with the potential to drive sustainable development (Gautam et al. 2004; Dahal and Chapagain 2008). The popularization of CFUGs in Nepal was mostly pushed by government organizations and INGOs, originally to address forest degradation and deforestation issues of the 1980s (Thoms 2008). Studies of Nepalese forestry systems have suggested that participatory decision-making and management of resources produced far better results (measured in terms of forest condition and trends) than those that had little or no participation of the community in decision-making (Dev et al. 2003; Yadav et al. 2003; Gautam et al 2004; Thoms 2008). In addition to forest conservation, CFUGs have contributed to improvements in social, biophysical and financial situations of their beneficiary communities. The influence of external agencies (such as Department of Forests, United Kingdom’s Livelihoods and Forestry Programme) has played a vital role in instilling the desirability of inclusive governance and multi-stakeholder participation in Nepalese societies, which are typically characterized by a long-established caste systems and wealth-driven social stratification (Thom 2008). However, decision-making in these systems is largely community-driven. This ensures that local concerns and issues are not compromised when addressing top-down recommendations. On the other hand, there are some cases in which women, poor and other marginalized groups have been systematically excluded from benefit sharing and the decision-making processes of forest management within the CFUG (Dahal and Chapagain 2008; Thoms 2008; Dahal et al.

2014; Yadav et al. 2015). In addition, most CFUGs have a minimal concern for resilient forest ecosystems and biodiversity (Acharya 2003; Dahal and Chapagain 2008). These situations may be mitigated by discussions and workshops focused on the benefits of biodiverse forests at smaller scales (e.g. hamlet-scale) and ensuring representation of all major social groups in decision-making processes (Timsina et al. 2004; Banjade et al. 2009). An opportunity for collaborative learning among experts and CFUG members can largely contribute to filling some of these gaps (Banjade et al. 2009). Khadka and Vacik (2012) used a series of hamlet-scale workshops and meetings between CFUG members, management committee and researchers to identify sustainability criteria and indicators for a community forest in Nepal. The process involved awareness building, collaborative learning and discussions. As a result, their participatory action research led to sustainability criteria and indicators that represented all key dimensions of sustainability, were relevant and comprehensive.

Parris and Kates (2003) categorize decision-making and management, advocacy, participation and consensus building, and research and analysis as four key objectives of measuring sustainable development. These objectives cannot be met using sustainable development indicators that are incomplete, irrelevant, meaningless, and illegitimate. Importantly, development indicators should be such that they can easily be communicated to those whose decisions and actions are vital in the pursuit of sustainable development i.e. community, local experts, and development practitioners.

The relevance of MDGs to Nepal is undisputable, as many of the development priorities identified by the Government of Nepal overlap with one or more Millennium Development Goals and targets (Table 2.1), even prior to the start of the Millennium Project. Targets related to MDGs such as access to improved drinking water and sanitation, and conservation of forest resources, have been major development goals of Nepal since the 1970s (NPC 1971). Much of the recommendations made by INGOs (such as UNDP, FAO, WHO) to the Nepalese government in the 1970s, with regard to natural resource conservation and management, stemmed from their research of the local context and needs (Heinen and Kattel 1992a). In recent years, recommendations and monitoring frameworks have increasingly become a top-down phenomenon, mostly based on the

programmatic interests of donor agencies and international interest groups (Bond 2006; Fehling et al. 2013). Most of the environmental indicators for MDGs exemplify this trend. This approach has worked well in terms of influencing Nepal to act upon various broader sustainable development issues. However, this success, defined by a top-down approach, has not reached the poorest and most vulnerable populations.

Most of the MDG environmental indicators generated through top-down international deliberations have failed to meet the relevance and practicality criteria for good indicators in the Nepalese context (Table 2.3). In particular, climate change and energy efficiency indicators will need major modifications to measure progress in Nepal. The MDG indicators have little relevance and efficacy in a country where the energy use and economic growth is governed by subsistence farming and, tourism-based and remittance-based service sectors. Context-based research on energy sources including pollution-reducing technologies, environmental impacts, and sociocultural contexts, is vital to generate better indicators that are relevant, practical and comprehensive.

**Table 2.3. Summary of the evaluation of MDG environmental indicators (X indicates a positive relationship, ~ indicates a tenuous relationship)**

| Indicators | Measuring | Relevance | Data availability | Adequacy | Sensitivity |
|---|---|---|---|---|---|
| $CO_2$ per capita | Energy efficiency | | X | | |
| Energy used per GDP | Sustainable economic development | | X | | |
| Forest cover | Deforestation and forest degradation | X | X | | ~ |
| Proportion of protected area coverage | Biodiversity conservation | X | X | | ~ |
| Improved water | Safe drinking water supply, disease | X | X | | ~ |
| Improved sanitation | Safe drinking water supply, disease | X | X | | ~ |
| Slum population | Improved living conditions of urban poor | X | | | |

As more appropriate indicators for Nepal are designed, it is important that they are cost-effective and manageable in number for implementing organizations. Indicators should also be comprehensive, to enable its users to more accurately identify the means

that can generate desirable ends. MDG 7 indicators for forest and biodiversity conservation, water and sanitation and living conditions of slum populations are all relevant in the context of Nepal (Table 2.3). However, the comprehensiveness of relevant MDG indicators in Nepal is nebulous. The use of such indicators (particularly with a lack of consideration for quality and comprehensiveness) to interpret national sustainable development generates two major implications: i) over/underestimation of accomplishments, and over/underrepresentation of the actual situation on the ground; and ii) poor feedback to decision-makers (policy makers, donor agencies, development workers), risking the misallocation of resources and inappropriate policy actions. Such implications in turn may have bigger repercussions for developing countries, which are heavily reliant on foreign aid for development expenditures. The UNs' decisions (based on tools like the MDG assessment framework) with regard to global priorities have historically had a huge influence on the UN affiliates, INGOs and NGOs' operational frameworks (Bond 2006; Waage et al. 2010). This in turn has a tremendous influence on resource allocation for the national and local level programs, thereby impacting the means and how the means are framed.

A number of scholars and development analysts have criticized the Millennium Declaration for setting goals that are not practical, and for using indicators that are irrelevant, inadequate and tenuous in certain contexts (Antrobus 2005; Attaran 2005; Bond 2006; Saith 2006; Clemens et al. 2007; Easterly 2009; Barnes and Brown 2011; Fehling et al. 2013). Few studies of indicators and targets focus on their utility and effectiveness for meeting sustainable development goals on the ground, with practical examples (Easterly 2009; Waage et al. 2010). Our analysis fills this gap, and we hope it motivates further research on the effective tools and sustainable development frameworks to motivate policy convergence at lower-level governance.

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# CHAPTER III: Use of the participatory approach to develop sustainability assessments for natural resource management[10]

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### *Abstract*

Monitoring progress towards sustainability goals requires a quantitative assessment method including indicators. Indicator sets and goals have typically been developed by experts, which may be scientifically robust but are often difficult to convey to society and may not include all societal values. A participatory assessment approach is emerging as a more holistic method for measuring sustainability. In this approach, local stakeholders play an integral part in the assessment process, assisted by experts. Here I review thirteen case studies from around the world that use a participatory approach to achieve sustainable natural resource management. Although similar in approach, most of them diverge in terms of methodology and extent of community engagement. The final set of indicators in each case is reflective of methodology, extent of community engagement, and amount of time and resources involved in the process. While the participatory approach is growing in popularity and increases the potential long-term success of the process (through increasing stakeholder literacy and ownership), the diversity of participatory methodology can complicate policy recommendations.

**Keywords:** sustainability, natural resource management, local community, participatory approach, indicators.

# 1. Introduction

Assessment of sustainable development programs and policies is necessary to ensure that interventions are successfully implemented and meet their goals (Pope et al. 2004; Gibson 2006a). Generally, approaches for assessing sustainability can be categorized as expert-driven (or top-down), or expert-assisted/participatory (or bottom-up; Reed et al. 2006). Historically, the development of criteria and indicators (C&I) for sustainability assessment, particularly for resource management, has chiefly relied upon an expert-driven conceptualization of sustainability (Fraser et al. 2006; Reed et al. 2006; Ness et al. 2007; Astier et al. 2012; Dahl 2012). Expert-driven indicators are produced by science-based assessment of sustainability principles and their interpretation through statistical tools (Reed et al. 2006). However, this approach has been criticized for marginalizing local issues and contexts (Morse & Fraser 2005; Sheppard 2005; Astier et al. 2012; Dahl 2012). Despite being intricately bound to ecosystem resources and services, local stakeholders are often left out of sustainable program development, assessment, and decision-making processes (Astier et al. 2012).

The sustainable management of natural resources is often complicated by a diversity of demands from different sectors of a community at different scales. These sectors or groups may have disproportionate access to or control over the resources, particularly if property rights or unequal governance results in the exclusion of some members of the community to the resource itself or its management (Hand 2007; Tarlock 2010). When these sectors or groups are excluded from natural resource management, often their resource use is undervalued and therefore left unprotected, leading to management decisions that are often short-sighted, biased and unsustainable (Upreti 2004; Fraser 2006; Pearson & Gorman 2010; Datta & Chatterjee 2012; Sutcliffe et al. 2012; Henareh Khalyani et al. 2014). Likewise, these sectors may have limited information regarding resource use in other sectors, or how aggregate use relates to depletion thresholds, decreasing the ability of any policy or agency to manage the resources sustainably (Walker et al. 2002). Extensive work on sustainable communal

resource management suggests that there is a great deal of inherent wisdom in communities regarding natural resource use and the social capital available to manage it (Pretty 2003; Ostrom 2009). This valuable knowledge is left untapped when experts exclude these communities from sustainability assessment.

Bolstered by international policy statements such as the 1972 United Nations Conference on the Human Environment and the 1992 Rio Declaration of Environment and Development, researchers and sustainable development experts have increasingly endeavoured to involve local communities and stakeholders in development projects, from conception and implementation through monitoring and evaluation (UNCED 1992; Brosius et al. 1998; Mendoza & Prabhu 2000a; Fraser 2006; Gibson 2006b; Bell et al. 2012; Hoogstra-Klein et al. 2012; Consyns et al. 2013). The participatory approach (also called "participatory learning and action"; Morse 2008, p. 345) relies primarily on the knowledge of key stakeholders or beneficiaries about local context to define sustainability and identify the indicators to be used in sustainability assessment (Brosius et al. 2998; Reed et al. 2006; Bell et al. 2012). This approach (particularly in environmental management projects) has gained popularity, primarily as a result of past failings of expert-led decision-making to gain acceptance for community level implementation (Fraser et al. 2006; Hak et al. 2012). However, local communities may not have knowledge of, or access to monitoring data that are instrumental to robust assessments. Experts involved in the participatory approach can provide this knowledge to communities and assist their efforts to devise their own assessment strategy.

Currently, involving local stakeholders in development projects is seen as a basic human right (involvement in a project that intends to directly impact one's livelihood), and is hoped to improve the ownership and hence the effectiveness of the projects (Chambers 1997; Kellert et al. 2000; Ridder & Pahl-Wostl 2005; Bell et al. 2012; Fredericks 2012). Local stakeholders may hold different perspectives and opinions on the utility and success of sustainable development projects, and these differences indicate implementation weaknesses or limitations where the improvements expected by experts did not emerge (Datta & Chatterjee 2012; Moswete et al. 2012; Sutcliffe et al. 2012; Consyns et al. 2013).The diversity of terms used to refer to the process of local

involvement (e.g. Participatory Monitoring and Evaluation, Stakeholder-based Evaluation/Stakeholder Assessment, Community Monitoring/Citizen Monitoring; Estrella & Gaventa 1998) matches the wide variety of approaches and methodologies used in the process (Bell et al. 2012), leading some to question the validity of the outcomes produced by it (Datta & Chatterjee 2012). Bell et al. (2012) concluded that the most critical need in this area is to bring some structure to the methodology of the participatory approach, as methodological choices alone may greatly influence assessment outcomes. This structure also needs to include a standard set of principles, which define and guide participatory assessments (Ridder & Pahl-Wostl 2005).

Here we review thirteen case studies of participatory sustainability assessment from different contexts, but all focused on resource management issues. We highlight the underlying objectives of each assessment framework, the interventions employed to facilitate community engagement, and the challenges associated with involving local stakeholders in the assessment process. We hope to stimulate more standardization in the participatory approach, and advocate for expanding its use for the development of sound sustainability assessments.

## 2. Background

Pope et al. (2004) define sustainability assessment as "a process to determine whether or not a particular proposal, initiative or activity is, or is not sustainable, and therefore effectively becomes a yes/no question" (p. 607). Quantifiable indicators are often used to develop these 'yes/no' questions (Vilei 2011). Criteria and indicators (C&I) are critically important for evaluating, monitoring and managing sustainable management systems (Mendoza & Prabhu 2000a). A criterion is a broad category or a general concern that represents public interests and scientific principles. Indicators on the other hand, are specific properties of a criterion that can be expressed or assessed in terms of quantitative or qualitative variables (Parris & Kates 2003) or verifiers (Pokorny et al. 2004; Jalilova et

al. 2012). Sustainability C&I should be system-specific, owing to diverse contexts, differences in biophysical and socioeconomic system characteristics, and often diverging motive and interests of stakeholders (Lopez-Ridaura et al. 2005; Vilei 2011). Therefore, while the use of C&I in sustainability assessment is a common practice, their selection is a context-specific undertaking, closely related to the given intervention (Pope et al. 2004). The development of C&I is a complex undertaking even for experts. The involvement of various interest groups and stakeholders greatly complicates the effort, due to conflicting perspectives, diverse socioeconomic preferences and political influences (Johnson 1999), and issues that are not easily quantifiable (Mendoza & Prabhu 2000a). Therefore, the development of sustainability C&I is a challenge that requires: i) a holistic and integrated approach to identify problems, ii) scrupulous planning, iii) transparent and comprehensive methods to obtain information, and iv) 'a link between science and the decision-making it is meant to support' (Levin 1993).

C&I-based sustainability assessments require several components (Parris & Kates 2003). First, the spatial and temporal scope of the assessment must be defined, and a sustainability framework constructed. This framework is influenced by the philosophy and values of the local community with respect to their interpretation of *sustainability* (e.g., humans are a part of nature or separate from it, equilibrium vs. non-equilibrium views of the human-environment system; Gibson 2006a; Newton & Parfitt 2011; Akamani 2012). The framework will determine the criteria that are to be measured, and in turn their measurement requirements will lead to indicators. These indicators should be measurable variables with data that are available or assessable, robust, and predictably respond to changes in the system (Harger & Meyer 1996; Parris & Kates 2003; McBride et al. 2011), but should also be able to influence policy (Hak et al. 2012). Finally, the indicators are sometimes standardized and combined or aggregated, using methods that are also influenced by the sustainability framework (Mayer 2008; Walter & Stützel 2009).

The purpose of a sustainability assessment is to analyse and interpret the long-term social, ecological, economic and policy implications of a specific project, plan or intervention (Gibson 2006a). While most assessments focus on the broad goal of a

sustainable human-and-environmental system, the weighting of indicator categories (e.g., social, environmental, economic, and institutional; Parris & Kates 2003) is often based on the interest of the actors who conduct the assessment. When assessments are expert-driven, indicators are typically given a default equivalent weighting, and sometimes care is taken to include equal numbers of social, environmental, and economic indicators. However, bottom-up approaches with a diversity of stakeholders may not follow the same indicator weighting and inclusion patterns, leading to potentially very different assessments (Vilei 2011; Khadka & Vacik 2012a, Cosyns et al. 2013).

A participatory method is essentially a multidimensional approach to define and understand diverse socio-ecological problems, and may be implemented using a variety of tools and techniques at multiple scales (Beierle & Cayford 2002; Morse 2008). This method gives researchers a localized understanding of sustainability issues through collaboration with groups that are inextricably connected with the system being assessed (Newton & Parfitt 2011). Although not free from trade-offs (such as greater time and resource requirements), the method can be very helpful for generating comprehensive lists of indicators by reducing conflict, building trust and improving social learning (Bell & Morse 1999; Sheppard 2005; Fraser et al. 2006). Reed et al. (2006) suggested that, in addition to enhancing transparency, using the participatory approach in decision-making empowers a community by improving their holistic understanding of the socio-ecological system dynamics, and provides a strong bulwark to policy and development projects.

Here I review several case studies in which a participatory approach was an important aspect of the analysis. As this is an emerging approach, there are a fairly limited number of cases that comprehensibly demonstrate the integration of public participation in sustainability assessment and decision-making processes. I focused on case studies pertinent to natural resource management that provided a thorough overview of their methodology and would represent a diverse collection of examples of the approach.

# 3. Methodology

Case studies were selected from multiple electronic databases: Web of Science, Google Scholar, ProQuest Research Library, JSTOR, and Elsevier. The key words 'sustainability indicators' and 'participatory' or 'stakeholder', produced over 400 results between1996 and 2013. From these results, only about fifty were directly related to the participatory development of sustainability indicators. Thirty-one were case studies, and the remaining were either syntheses or insights about use of top-down versus bottom-up approaches to develop sustainability indicators. Most of the case studies in the list focused on urban planning, rural development, energy production, health care systems, manufacturing and agro-based industries, infrastructure developments and natural resource management.

Our review of participatory sustainability assessment is based on the information derived from the thirteen case studies (Table 3.1 & 3.2) focused on natural resource management. These studies are concentrated on land or protected area management (6 forest use and management, 1 rangeland management, 2 national park management, 1 marine park management), fisheries (2), and sustainable agriculture (1), in developing and industrialized countries (Fig. 3.1). The sustainability assessment framework used was primarily ex-ante and focused on policy change, development of operational analysis framework or monitoring and management strategies with an exception of one where an ex-post assessment of fisheries management system was intended for its impact evaluation in the region (San Miguel Bay, Philippines; Andalecio 2011). In most cases, it was driven by a genuine concern for systemic, long-term sustainable management. However, for a few cases the process was driven by stakeholders' interest to sustainably optimize the benefits of the system or to build compromise among stakeholders with conflicting interests and priorities (Videira et al. 2003; Adrianto et al. 2005; Simon & Etienne 2009; Andalecio 2011; Marques et al. 2013).


**Figure 3.1. Countries (indicated by red circles) wherein case studies featured in this article were conducted (Map Source: Google Map;** *see Appendix A for documentation of permission to use this material***)**

## 4. Results and Discussion

Although ‘participatory approach’ is the common link among the case studies, the primary goals and objectives of each assessment, level of community engagement, roles assumed by researchers and experts, and tools used to finalize a set of sustainability indicators make each case unique. In some cases, the term ‘participatory’ implied the participation of community members only (Cromwell et al. 2001; Simon & Etienne 2009; Santana-Medina et al. 2013), while in others, a ‘participative phase’ included representatives from concerned public, private and civil sectors (Mendoza & Prabhu 2000a; Videira et al. 2003; Pokorny et al. 2004; Adrianto et al. 2005; Balana et al. 2010; Andalecio 2011; Jalilova et al. 2012; Marques et al. 2013). The level of community engagement in the process ranged from involving less than a few local community members, end-beneficiaries or their leaders (Mendoza & Prabhu 2000a; Balana et al. 2004), to including more than 20-30 beneficiaries or local community members (Cromwell et al. 2001; Simon & Etienne 2009; Jalilova et al. 2012; Khadka & Vacik

2012b; Marques et al. 2013; Santana-Medina et al. 2013). The number of community members involved in the process depended more on the type of approach or tools employed for the assessment, rather than the objective or the spatial extent of the project. While in some cases, participative analysis was limited to tailoring and contextualization of the expert-driven set (Mendoza & Prabhu 2000a; Pokorny et al. 2004; Adrianto et al. 2005; Balana et al. 2010; Andalecio 2011; Jalilova et al. 2012), in other cases, community participation was sought from the beginning to the end of the process, and occasionally even for the implementation phase of the sustainability assessment (Simon & Etienne 2009; Khadka & Vacik 2012b). Likewise, the role of researchers and experts also ranged from only facilitating or mediating to actively participating in the development of the final set of C&Is. All case studies evaluated sustainability indicators and used a participative multiple-criteria analysis (MCA), but there was a diversity of techniques used to develop sustainability indicators.

### *4.1. Types of participatory approach*

Depending upon the spatial and organizational scope of the system being evaluated, I found that the 'participatory approach' has been defined, interpreted and implemented in one of two ways: either expert-assisted, where participants drive indicator selection with help from experts; or expert-initiated, where experts provide participants with an indicator list from which participants can identify sets.

#### *4.1.1. Expert-Assisted Approach*

In an expert-assisted participatory method, participants involved in the identification of sustainability indicators are key stakeholders or those individuals or organizations that benefit from or are affected by the system, or whose decisions or actions can change the behaviour of the system. In this case, participants play key roles in defining problems, identifying sustainability indicators (either by providing key pieces of information or by participating in the selection process) and generating a final set of

indicators. In this approach, researchers use tools such as interviews, focus group discussions, and large workshops to collect opinions about C&I. The sustainability indicators are then based entirely on the information and judgments provided by the key participants.

This type of approach tends to use two kinds of stakeholder groups: community-based or system-based. In community-based groups, participants are community members or end-beneficiaries alone, and researchers often only facilitate discussions and allow participants to define problems and solutions (Cromwell 2001; Fraser et al. 2006; Simon & Etienne 2009). While such participation may provide critical information about the system, the analyses of the problem are often driven by immediate concerns of the stakeholders, and hence may fail to effectively address all aspects of sustainability and long-term goals (Cromwell 2001; Fraser 2006; See Table 3.1). When participants are not provided adequate information on the concept of C&I development and a basic theory of sustainability, it is more likely that this approach will generate incomplete set of indicators.

In system-based groups, participants are a mix of representatives from public, private and governing sectors that can influence the behaviour of the system under analysis (Videira et al. 2003; Khadka &Vacik 2012b; Marques et al. 2013; Santana-Medina et al. 2013). This kind of participation relies largely on collaborative learning and system dynamics modelling, and often entails more intensive activities and a greater level of commitment of time and resources. However, this approach enables participants to pick indicators based on their demonstrated or modelled utility to monitor the system, thereby expediting the C&I analysis and consensus building process (Videira et al. 2003; Marques et al. 2013).

### *4.1.2. Expert-Initiated Approach*

An expert-initiated approach is essentially a participatory technique where pre-existing framework or sets of indicators developed by non-local experts are used as a starting point, followed by a participatory assessment to narrow the list (See Table 3.2).

Participative groups can either be community-based or system-based depending on the objectives and goals of the study and time and resources available. In cases where expert-initiated C&I lists are used as a starting point, researchers tend to spend relatively less time on defining problems, collaborative learning about the system, and instead devote more time on seeking consensus among participants about indicators and management strategies during participatory sessions (such as workshops). Reed and Dougill (2002) argue that the indicators generated by external agents and experts without prior knowledge about the intrinsic characteristics of the system often fail to address key and unique issues associated with the system, and do not sufficiently incorporate the diverse perceptions, interests and opinions of all key stakeholders. However, due to the accessibility, measurability, efficiency, ease of use and reduced time requirements, the expert-initiated approach is a more extensively practiced strategy for sustainability assessment. This approach was used most often in sustainable forest management projects.

**Table 3.1. Overview of case studies using the expert-assisted approach**[11]

<table>
<tr><th rowspan="2">Reference</th><th rowspan="2">Study site</th><th rowspan="2">Area of interest</th><th rowspan="2">Participative process</th><th colspan="7">Indicators</th></tr>
<tr><th>Total no.</th><th>E</th><th>Eco</th><th>S</th><th>P</th><th>I</th><th>Others</th></tr>
<tr><td rowspan="2">Khadka & Vacik (2012)</td><td rowspan="2">Shree Gyneshwar Community Forest User Group (2.08 km$^2$), Narayani Zone, Nepal</td><td rowspan="2">Community forest management (Community-based)</td><td rowspan="2">15 advisory and 13 executive committee members of CFUG, 23 general users, 20 local facilitators</td><td rowspan="2">44</td><td>(8)*</td><td colspan="2">S-Eco (9)*</td><td rowspan="2">(6)</td><td rowspan="2">(12)</td><td rowspan="2"></td></tr>
<tr><td colspan="2">E-Eco(9)</td><td></td></tr>
<tr><td rowspan="2">Fraser et al. (2006)</td><td rowspan="2">South Kgalagadi (a), South West Khgalagadi (b), mid-Bolteti (c) regions of Botswana</td><td rowspan="2">Rangeland management (Community-based)</td><td rowspan="2">Local residents (communal and commercial pastoralists, rich and poor, extension workers)</td><td rowspan="2">(a) 9<br>(b) 14<br>(c) 13</td><td>(b) 4<br>(c) 2</td><td>(a) 2<br>(b) 1</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td colspan="2">E-Eco<br>(a) 7<br>(b) 9<br>(c) 11</td></tr>
<tr><td>Cromwell et al. (2001)</td><td>30 villages, Malawi</td><td>Sustainable agriculture (Community-based)</td><td>Smallholder farmers</td><td>15</td><td></td><td></td><td></td><td></td><td>(1)</td><td>T-L(4)</td></tr>
</table>

[11]Here, CFUG: Community Forest Users' Group; E: Ecological/Environmental; Eco: Economic; S: Social; P: Policy and Governance; I: Institutional; T: Technological; L: Logistics; n/a: Not available.

| Reference | Study site | Area of interest | Participative process | Indicators | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **Total no.** | **E** | **Eco** | **S** | **P** | **I** | **Others** |
| Videira et al. (2003) | The Rio Formosa National Park (~170 km²), Portugal | National park management | About 42 representatives from private, public and government organizations (including municipality, environmental NGOs, habitants' associations, universities, fisheries and tourism industries, regional administration) | 250 | (n/a) | (n/a) | (n/a) | (n/a) | (n/a) | (T) |
| Santana-Medina et al. (2013) | Agua Blanca Community (2880 ha), located within Nevado de Toluca National Park (520 km²), Mexico | National Park management | 15-20 local inhabitants from Agua Blanca community (youth, housewives, students, pastoralists, field workers, masonry workers, community leaders, local authorities, and others) | 65 | (22)<br>E-Eco(2) | (2)<br>S-Eco(10) | (8) | | (11) | T(10)* |
| Simon & Etienne (2009) | Causse du Larzac (63 km²), France | Communal forest management | 31 farmers (10 communal forest/civil society managers), 3 local technical partners, 4 researchers (2 modelers) | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Marques et al. (2013) | The Marine Park Luiz Saldanha, (53 km²), Portugal | Marine park management | A team of experts on sustainability indicators and marine coastal science; 34 representatives from public, private and civil sectors including universities, NGOs, media, businesses and developmental agencies. | 26 | (11)* | Soc-Eco(7) | | P-I(8) | | |

* Weighted more heavily by the participants

**Table 3.2. Overview of case studies using the expert-initiated approach**

| Reference | Study site | Participative process | Indicators | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **Total no.** | **E** | **Eco** | **S** | **P** | **I** |
| *Area of Interest: Forest management* | | | | | | | | |
| Mendoza & Prabhu (2000a) | Forest Management Unit (1250 km$^2$), Kalimantan Indonesia | 4 full-time FMU staff, 2 villagers, 1 academic lecturer, 1 government employee, 1 social scientist, 1 full-time employee at CIFOR | 84 | (13)<br>E-Eco (16) | S-Eco (18) | (16) | P-I (17) | (4) |
| Jalilova, Khadka & Vacik (2012) | 4 forest enterprises in Fergana and Chatkal mountain ridges (~728 km$^2$), Kyrgyzstan | 48 participants (12 from each forest enterprise- consisting of foresters, social workers, representatives from private and public sectors, farmers) | 45 | (13)<br>E-Eco (11)* | S-Eco (9)* | | P-I (12) | |
| Pokorny et al. (2004) | Amazon Basin, South America | Four stakeholder groups (Local managers, local actors, local government and researchers) | 51 | (12) | (23) | S-P-I (16) | | |
| Balana et al. (2010) | Community forests, highlands of the Tigray Province, Ethiopia | 3 socio-economists, 2 local extension and rural development agents, 3 community leaders, 2 senior guards of enclosures, 1 soil and water expert from District agriculture Office, 1 forester, 1 local researcher working on soil, water and vegetation. | 37 | (11) | (8) | (3) | (9)<br>P-I (10) | (3) |

| Reference | Study site | Participative process | Indicators | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **Total no.** | **E** | **Eco** | **S** | **P** | **I** |
| *Area of Interest: Fisheries* | | | | | | | | |
| Adrianto et al. (2005) | Yoron Island, Kagoshima prefecture, Japan | 2 from fishery business, 10 from fishery community and 3 fishery-related decision-makers | 18 | (5) | (5) | (5)* | (3)* | |
| Andalecio (2011) | Seven coastal municipalities totaling 1145 $km^2$ of land, surrounding the San Miguel Bay, Philippines | Coastal resource users (members of Municipal Fisheries and Aquatic Resource Management Councils (MFARMCs)) including representatives from local government units, private sectors, non-governmental organization, and fishers. | 24 | (5) | (4) | (4) | (6) | (5) |

* Weighted more heavily by the participants

### *4.2. Sustainability indicators*

Although sustainability indicators generated through any techniques are ideally expected to meet the sustainability objectives of the system or the project, they often reflect the diverse interests and preferences of the participating stakeholders (Pokorny et al. 2004; Adrianto et al. 2005; Andalecio 2011; Jalilova et al. 2012). The resulting indicators are also often too general, vague, irrelevant and immensurable to be useful for management or policy-making, especially when stakeholders with very little technical/scientific knowledge are involved in identifying and developing C&I (Cromwell et al. 2001; Fraser et al. 2006; Khadka & Vacik 2012b; Santana-Medina et al. 2013). This result was more evident in the cases that did not involve system-profiling exercises and when participants were not provided any background information about sustainability concepts. In the Cromwell et al. (2001) case in particular, farmers (who were the key participants) were not provided adequate information about the sustainability concept or about the primary goal of the assessment, which was to assess overall sustainability of a governmental agricultural scheme in the area. As a result, most of the C&I generated were too short-sighted, and only addressed the farmers' immediate concerns (e.g., access to seed, farmland size, tools and implements, and fertilizer and manure application schedules). They failed to address any long-term environmental and economic goals of sustainable development in the area. Similarly, in the case documented by Santana-Medina et al. (2013), the initial set of indicators generated by stakeholders were mostly immeasurable, impractical, and irrelevant for the project's targets (e.g., number of trees in the forest, places for moss collection, height and weight of children) and they considered social and economic indicators as the least important in their evaluation. Therefore, these cases underscore the need for capacity building of participant stakeholders through raising awareness about the concept of sustainability, its relationship with system dynamics, and the use of C&I for meeting sustainability goals of the project.

In the majority of the cases, while the final set of C&I defined the three common sustainability dimensions (environmental, economic and social), often policy interests

were included in the list as an equally important aspect, especially where an expert-initiated approach was used. However, when experts (local as well as non-local) generated the C&I sets, stakeholders often found it difficult to comprehend some terms and indicators, such as ‘stakeholders’, ‘local actors’, ‘natural limits’ and ‘not significantly’ (Pokorny et al. 2004, p. 39), ‘volume of nautical traffic’ (Marques et al. 2013, p. 41) and ‘total cost and income of the marine protected area for private and public organizations’ (Marques et al. 2013, p. 42). When indicators were generated first-hand by stakeholder participants, participants were more able to explain their decisions and effectively contribute to the assessment.

The number of indicators for each criterion varied among cases and with the area of interest (e.g. sustainable forest management projects had more indicators than fisheries, See Table 3.2). For expert-assisted approaches, the number of indicators across sustainability criteria varies greatly (ranging from nine for South Kgalagadi, Botswana to 250 for Rio Farmosa Natural Park, Portugal); and not all the principal sustainability criteria were deemed important in all cases. In cases where participants were oriented on the concept of sustainability, and adequate time and resources were invested into system profiling and understanding system dynamics in the beginning of the project (Khadka & Vacik 2012b; Santana-Medina et al. 2013), stakeholders were more cognizant of sustainability concepts.

### *4.3. Identification of participants/stakeholders*

Knowledge about the natural resource dynamics and existing or potential conflicts over natural resource management can help researchers identify key actors for the sustainability assessment. In most cases where community members were identified as key stakeholders, this identification relied on the knowledge of local facilitators or managers (Cromwell et al. 2001; Simon & Etienne 2009; Khadka & Vacik 2012b). Alternatively, researchers start with a sketch of the system boundaries and components, such as government or nongovernment institutions and industrial sectors, and explore how these components might interact, and then choose participants to represent these

components (Videira et al. 2003; Pokorny et al. 2004; Adrianto et al. 2005; Jalilova et al. 2012; Marques et al. 2013). Often when the system under evaluation is under the jurisdiction of government agency or civil sector, the identification of stakeholders becomes more complicated and tends to require larger scale (local, regional, national and sometimes, even international) consideration.

The quest for a diverse set of participants must be weighed by the potential for discussions to be dominated by individuals or groups who have more access to information, or are more dominant or powerful in the system (Kasemir et al. 2003; Vilei 2011); this could include the dominance of researchers in the expert-initiated approach. In such cases, this effect can be moderated by the skill of facilitators (Kasemir et al. 2003) and the formation of working groups of individuals with same level of expertise or power.

Prell et al. (2009) argued that while homogeneity in stakeholders encourages unhindered communication and a smooth exchange of information, it is also likely to reduce the diversity in ideas and perspectives. The French case (Simon & Etienne 2009) demonstrated the impact of homogeneity and a tight social network system on the decision-making process. According to the researchers' evaluation of the process, all the participants in the process (farmers and forest managers) were from the same community and had a strong communal network; while this allowed unhindered communication, it also diminished the diversity of opinions (Simon & Etienne 2009). Decisions or proposals made by the forest managers were quickly agreed upon by the farmers, suggesting some degree of farmers' submissiveness to the managers. Therefore the researchers suggested that, although the process might have been participatory by definition, the objective of the participatory approach could not be met to the fullest due to the dominant role of forest managers, which influenced the expressions of other participants (Simon & Etienne 2009). Vilei (2011) reported the similar findings in her study on local perceptions of sustainable farming systems in the Philippines, where discussions and group activities were primarily influenced by the group leaders and those individuals viewed as successful (farmers) in the society. In the Malawi (Cromwell et al. 2001) and Botswana (Fraser et al. 2006) cases, the sustainability indicators were largely

concentrated in one or two categories (See Table 3.1*)*, also suggesting a homogenous stakeholder group.

There is no consensus on the optimal representation system or group size in participatory assessments; this is a context-specific decision. In the Mendoza and Prabhu (2000a) and Balana et al. (2010) cases (both concerning sustainable forest management), there was a range from two or three community members to ten or thirteen stakeholder representatives, respectively. While the final indicator set reflected a diversity of sustainability dimensions, an expert-initiated approach (developed by experts at the Centre for International Forestry Research (CIFOR)) assured that outcome. Indeed, the minimal participation of non-scientific individuals from the public involved in the final indicator evaluation suggests that public perceptions may have been insufficiently represented by the indicators.

### *4.4. Collaborative learning*

Collaborative learning has emerged as an improved version of the participatory approach to aid better understanding of socio-ecological systems, and to develop sustainable management strategies, particularly in natural resource management (Daniels and Walker1996; Kellert et al. 2000; Videira et al. 2003; Schusler et al. 2003). However, its application to develop sustainability assessments is still rare. Collaborative learning is an active learning process that involves ‘activities that encourage systems thinking, joint learning, open communication, and focus on appropriate change’ (Daniels and Walker 1996; p. 81) within a socio-ecological system. It may involve activities such as workshops, group exercises, meetings, collaborative system modelling etc. In an expert-initiated approach, experts generally base their indicator selection on the scientific literature rather than on local context and knowledge, or open communication and learning among stakeholders. The participatory expert-assisted approach presents an opportunity for local stakeholders including local experts to learn from each other allowing for holistic learning, and so it is important to ensure that discussions are interactive and information flows both ways (Daniels and Walker1996). Both researchers

and stakeholders must have a holistic understanding of their respective roles in the system, and also how the system elements that they represent influence the entire system dynamics (Ostrom 2009; Prell et al. 2009). Collaborative learning allows for the identification of conflicts and challenges concerning sustainable management in the system, and provides an opportunity to exercise compromise strategies for conflicting interests and priorities across different stakeholders (Khadka & Vacik 2012a, 2012b). It also provides opportunity for researchers to build trust and develop a cordial relationship with stakeholders, which can contribute to building a favourable working environment for both researchers as well as the participants (Khadka & Vacik 2012a).

In any participatory approaches, while researchers must be open to indigenous knowledge, they must also help stakeholders to comprehend system dynamics and their role in decision-making processes to ensure their compliance and trust in the resulting management strategies (Andalecio 2011; Marques et al. 2013). Stakeholders need to have a basic knowledge about institutional processes and linkages between various components of the system, for them to develop into resource experts (Marques et al. 2013). Many have stressed the need for sustainability education, training and awareness for the participants at the beginning of the participatory C&I development (Sheppard 2005; Marques et al. 2013; Santana-Medina et al. 2013). Marques et al. (2013) adds that educating participants about sustainability objectives and involving them in system profiling alone are not sufficient and that relevant information and data should be made available to the stakeholders to build their capacity for fair analysis of C&I and decision-making.

### *4.5. Time factor*

Regardless of the approach used, the requirement for more time and resources compared to an expert-only approach was indicated by many as a major limitation. Time required often range from few weeks (Mendoza & Prabhu 2000a; Pokorny et al. 2004; Balana et al. 2010) to a few years (Fraser et al. 2006, Simon & Etienne 2009; Khadka & Vacik 2012b), with longer time periods required when system modelling and system-

based participation from public, private and civil sectors are included. Sheppard (2005) argued that the participants' ability to engage effectively and equitably might not be achieved without adequate time to empower participants to fully engage in the process. If community involvement is not complemented by adequate training for stakeholders about key concepts of sustainability and system dynamics, stakeholders may find it difficult to logically explain their preferences, and the results may not meet the sustainability assessment goals or may lack credibility or equity (Jalilova et al. 2012).

### *4.6. Challenges and opportunities*

Mendoza and Prabhu (2005) suggested that without systematic and transparent public involvement, questions might arise regarding the credibility, equity, and effectiveness of the results. However, expert-assisted approaches with researchers in only a facilitator role may result in indicators that do not address the long-term issues in sustainable natural resource management. Therefore, an adaptive learning process that uses a combination of top-down and bottom-up methods has been utilized by a number of experts to address the above-mentioned shortcomings of participatory techniques (Fraser et al. 2006; Reed et al. 2006; Buchholz et al. 2007; Astier et al. 2012; Khadka & Vacik 2012b; Marques et al. 2013). However, methodological consistency has yet to emerge regarding the level of community engagement, the amount of experts' input, the overall sustainability assessment framework and the format of reporting sustainability indicators development activities.

The level of adoption of the sustainability indicators by local stakeholders is an outcome that most of the papers failed to discuss explicitly. Marques et al. (2013) and Santana-Medina et al. (2013) show some concern over the possibility of having local stakeholders adopt and continue to perform sustainability assessment on their own. However, they argue that due to the low level of technical literacy common in real settings and lack of adequate resource and expertise among local stakeholders, it might not always be as practical to expect local stakeholders to assume the role of monitors. They further underscored the need for adequate support by experts to maintain the

integration of local stakeholders in the sustainability assessment process and in the development of management strategies.

## 5. Conclusion

Ensuring the sustainable governance of natural resources, particularly when they are enmeshed into the intricacies of socio-ecological systems (Berkes 2004), is an unavoidably challenging endeavour (Angelstam et al. 2013). Resource mapping and management must contend with diverse values, worldviews, stratification (social, economic and cultural) within stakeholder groups, land and resource needs (Leach et al. 1999; Karjala & Dewhurst 2003; Axelsson et al. 2013), along with varying abilities and willingness of stakeholders to respond to policy and project interventions (Angelstam et al. 2013). Resource management and sustainability assessment in such systems require strong communication (Upreti 2004; Angelstam et al. 2013), planning, and collaborative learning among local stakeholders, researchers, policy-makers and managers, using both qualitative as well as quantitative methods (Kates et al. 2001; Berkes 2004; Angelstam et al. 2013). However, expert-driven, top-down (traditional) approaches usually ignore these fundamental requirements in formulating natural resource policies (Fraser et al. 2006; Reed et al. 2006; Balana et al. 2010; Datta & Chatterjee 2012; Moswete et al. 2012; Sutcliffe et al. 2012). Expert-driven strategies rarely account for interference with social norms and practices, and impact to resource access necessary for local livelihoods (Fraser et al. 2006; Datta & Chatterjee 2012; Moswete et al. 2012; Sutcliffe et al. 2012). Furthermore, usually driven by the ecological, environmental and social interests of small fraction of the society, expert-driven approaches tend to pay little, if any, attention to equity issues such as justice, poverty, and indigenous rights (Bosius et al. 1998; Gibson 2006b; Khadka and Vacik 2012a). Indeed, interventions intended to meet sustainable development goals may sometimes be perceived as irrelevant or even a threat to stakeholders' livelihoods, prompting public opporition, when sustainability goals are not

well-communicated (van der Horst et al. 2002; Upreti 2004) and local participation is not integrated into natural resource management and policy evaluation (Vilei 2011; Datta & Chatterjee, 2012).

The most important challenge encountered during participatory indicator-based sustainability assessment is translating the vastness of local knowledge and interest into a relevant, manageable, comprehensive and assessable set of indicators. The number and quality of indicators generated through participatory techniques largely depend upon how local stakeholders (and the experts assisting them) perceive sustainability and how well they understand the socio-ecological system dynamics and their role within them. The smooth and effective incorporation of local participants' perspectives into indicator set development entails: i) technical adeptness (Videira et al. 2005; Simon & Etienne 2009); ii) transparency (Mendoza & Prabhu 2000a, 2005; Marques et al. 2013; Santana-Medina et al. 2013); iii) use of simple terms and local language (Mendoza & Prabhu 2000a, 2000b; Jalilova et al. 2012; Marques et al. 2013; Santana-Medina et al. 2013); iv) an ability to win trust and build a good rapport with local stakeholders (Khadka & Vacik 2012b); v) their understanding of the system dynamics (Videira et al. 2003; Khadka & Vacik 2012b; Marques et al. 2013; Santana-Medina et al. 2013); vi) their understanding of sustainability concept and objectives (Khadka & Vacik 2012b); vi) their willingness to work closely with researchers (Santana-Medina et al. 2013); and vii) adequate time to form and execute an adaptive and participatory framework.

Advocacy for the participatory approach has grown significantly over the past few decades (Grimble & Wellard 1997; Warburton 1998; Walker et al. 2002; Kasemir et al. 2003; Fraser et al. 2006; Reed et al. 2006). Community engagement in decision-making processes has a positive impact on increasing a sense of ownership among community members about the assessment. A participatory approach to assess sustainability increases its utility through "buy-in" by all stakeholders, and contributes to the effective and democratic implementation of a development project or policy (Mendoza & Prabhu 2000a; Reed & Dougill 2002; Marques et al. 2013; Santana-Medina et al. 2013). However, the involvement of the public in decision making processes may not produce effective, long-term management strategies if participant groups are not adequately

inclusive and if the necessary time and resources are not invested in empowering participants to become resource experts (Chambers & Beckley 2003). Local knowledge can play a vital role in filling some of the important knowledge gaps in the scientific modelling of human-and-natural systems. Indeed, in those systems where communal resource governance structures have long been endemic, a participatory approach would seem to be the best suited to the social context (Pretty 2003). However, it is often necessary to enhance local knowledge through collaborative learning among stakeholders and experts about the socio-ecological system before it can be incorporated into system models at larger scales, to offset any biases or prejudices that are inherently embedded in local belief systems.

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# CHAPTER IV: Criteria and indicators for a bioenergy production industry identified via stakeholder participation [12]

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**12** Vaidya A and Mayer AL. In Press. Criteria and indicators for a bioenergy production industry identified via stakeholder participation. International Journal of Sustainability and World Ecology. DOI: 10.1080/13504509.2015.1135830. (*See Appendix C for documentation of permission to republish this material*)

***Abstract***

As bioenergy production expands and new bioenergy-based technologies emerge, there is growing concern regarding the sustainability of their ecological and socioeconomic impacts. Comprehensive sustainability assessments are needed to address this concern and to assure that the development of the bioenergy industry meets sustainability goals. Most sustainability assessments for bioenergy are expert-driven, broad and largely motivated by an interest in optimizing international trade in bioenergy. As a result, social and cultural sustainability targets are vague or underdeveloped. In this study we identified sustainability criteria and indicators (C&I) for a regional bioenergy production industry in Upper Michigan, using stakeholder participation. Semi-structured interviews and focus group meetings were used to elicit participants' concerns and opinion. These concerns were translated into sustainability criteria and indicators, many of which could be supported with available science. Some of the C&Is identified by participants were unique to the region. Sustainability C&Is were broadly categorized into economic (C=5; I=22), environmental (C=6; I=12), social (C=3; I=9), policy and regulations (C=3; I=13), and institutional capacity (C=4; I=13). While participants could identify indicators for most of the criteria many of which are also supported by existing literature, further research and validation will be necessary to identify measurable, practical and bias-free indicators for all criteria. Once validated, this assessment tool can facilitate context-specific and sustainability-oriented decision-making for a wood-based bioenergy industry in the region.

**Keywords:** bioenergy, participatory method, sustainability assessment, Upper Peninsula of Michigan, woody biomass

# 1. Introduction

Biofuel production has increased significantly in the past few decades, driven by growing concerns over energy security, climate change impacts, and unsustainable attributes of fossil fuels. Today, biofuels provide 3.5% of the world transportation fuel supply (IEA 2015) and ethanol derived from food crops (such as corn, sugarcane, soy, etc.) constitute the bulk of global biofuel production (Caspeta et al. 2013). However, purported adverse impacts of direct and indirect land conversions (such as increased food prices, competition for agricultural land and water, and greenhouse gas emissions from land-use change; Liu et al. 2015) resulting from large-scale expansion of the crop-based biofuel industry have motivated a shift to second-generation biofuel production (Timilsina 2014). Second-generation biofuels (also referred to as advanced biofuels) are defined by the US Energy Independence and Security Act 2007 as ethanol derived from non-grain materials (such as wood, grasses and municipality wastes), and biodiesels derived from feedstocks other than soy or cornstarch (Schnepf & Yacobucci 2010). Many have argued that second-generation biofuels have relatively smaller environmental and socioeconomic costs than fossil fuels and crop-based biofuels (Farrell et al. 2006; Hill 2007; Searchinger et al. 2008; Halvorsen et al. 2009; Balan et al. 2013).

The use of processed forest biomass in different forms (such as wood chips, pellets, and transportation fuel) to meet energy requirements has been growing rapidly (Sikkema et al. 2014). Forest-based bioenergy is already an established industry with supporting mandates in Europe (McCormick 2011; Thiffault et al. 2015). As a leading producer of biofuels (predominantly derived from corn), the US also has biofuel policies and/or programs that recognize woody biomass as potential second-generation feedstock (i.e. EISA 2007; Schnepf & Yacobucci 2010). Whether a forest-based bioenergy industry can bring socioeconomic and environmental benefits at local and national scales remains to be demonstrated (Thiffault et al. 2015).

Using the participation of local and regional stakeholders, we identified sustainability criteria and indicators (C&Is) to identify and monitor progress toward

sustainability as a regional forest-based bioenergy industry develops. Our results suggest that regional stakeholders have a much wider diversity of concerns (as reflected through a preliminary set of C&I) than represented in existing certification schemes and assessments. In Section 2 we review literature on top-down versus bottom-up sustainability assessment. We briefly discuss conventional sustainability assessments for bioenergy production and summarize six case studies that used a participatory approach for monitoring bioenergy systems. Section 3 provides an overview about methodology (focus group meetings and interviews), and we present our results (criteria and indicators, and their underlying context) as elucidated by participants in Section 4. Finally we provide a conclusion of our research in Section 5.

## 2. Background

### *2.1 Sustainability*

Sustainability is generally understood as an integrative function of social, environmental and economic wellbeing of a society (Gibson 2006; Ribeiro 2013). Currently a number of interpretations of 'sustainability' exist in the literature, most of which reflect the fundamental elements proposed by the Brundtland Commission (WCED 1987). Sustainability is an adaptive and evolving concept, which recognizes that there is no universal solution or alternative paradigm to development (Escobar 1997). The concept recognizes the need for a context-specific and holistic understanding of socio-ecological systems for development-oriented decision-making (Morse 2015). This includes 'cross-fertilization of disciplines' (Morse et al. 2001, p. 14), bringing together all stakeholders (Gibson 2001, 2006), and empowering grassroots decision-making (UNCED 1992). Furthermore, the definition of 'sustainability' provided by the Rio Declaration 1992 clearly suggests a participatory approach that is interdisciplinary, multi-stakeholder and democratic for its operationalization.

## *2.2 Sustainability assessment framework*

A sustainability assessment framework (SAF) helps ensure that management strategies or developmental interventions contribute to predefined sustainability goals (Gibson 2006; Pope et al. 2004). A SAF is a set of principles, based on the values and knowledge of concerned stakeholders, operationalized by specific criteria and indicators that can monitor a community's resilience, progress towards sustainability goals (Kurka & Blackwood 2013), and sustainable development (Fraser et al. 2006). Criteria are the necessary conditions for sustainability, and indicators are the measurable elements that signal changes in the system relative to criteria. Criteria and indicators (C&Is) are widely used instruments in projects regarding sustainable resource management and community development (Vaidya & Mayer 2014). Vera and Langlois (2007) argued that a good set of C&I will provide a comprehensive overview of an entire energy production system, along with the interactions among criteria and long-term implications of current decisions and behaviours.

### *2.2.1. Expert-led sustainability assessment*

Common C&I-based assessment techniques include Life Cycle Assessment/Impact (LCA/I), Cost Benefit Analysis (CBA) or Environmental Impact Assessment (EIA), particularly in manufacturing industries or for production systems. These techniques employ specific quantifiable C&Is that are defined by researchers or experts, generally with little to no input from stakeholders from non-scientific backgrounds or non-experts. Since international trade requires some degree of standardization, consistent sustainability criteria are imperative (Scarlat & Dallemand 2011), which may justify the dominance of universal C&I or assessment frameworks (Florin et al. 2014; Moser et al. 2014). These expert-driven assessments often sideline social concerns (particularly of underrepresented or disadvantaged stakeholders) and focus exclusively on economic and/or environmental dimensions (Lindner et al. 2010; Ribeiro 2013; Bosch et al. 2015). This expert-led, top-down approach has been frequently

criticized for failing to adequately address grassroots concerns and sustainability goals of local communities (Reed & Dougill 2002; Fraser et al. 2006).

### *2.2.2. Sustainability assessment tools for bioenergy*

International and national-level certification schemes and sustainability assessment tools have been developed for bioenergy production, often by experts through top-down mechanisms with little input from non-experts (Schouten et al. 2012). These top-down frameworks include generic sustainability criteria without context, resulting in tools that are difficult to quantify and use for local implementers (Lewandowski & Faaij 2006; Diaz-Chavez 2011; Thiffault et al. 2015). Used alone, expert-led assessment systems may not sufficiently inform policy and regulations, and may result in project decisions that are not supported by or are irrelevant to many stakeholders (Lindner et al. 2010; Ribeiro 2013; Withers et al. 2015). Moreover, Elbehri et al. (2013) argued that complying with most of these assessment systems and certification schemes is often too expensive, largely making them inaccessible to regional or small-scale bioenergy industries. Examples of such assessment tools are the Roundtable on Sustainable Biomaterials (RSB), Roundtable on Sustainable Palm Oil (RSPO), Roundtable for Responsible Soy (RTRS), Global Bioenergy Partnership (GBEP 2011), International Sustainability and Carbon Certification (ISCC), Bonsucro and ISO 248. Few of these assessments incorporate social and cultural elements such as indigenous rights, poverty, equity or access to local resources, conflicts, and transparency (Boström 2012; Datta & Chatterjee 2012; Ribeiro 2013); these are important criteria for social sustainability.

### *2.2.3. Bottom-up sustainability assessment*

The participatory approach emerged in the 1970s as a platform to provide a voice to poor and oppressed populations (Chambers 1994). Today, the approach is widely considered to be a democratic and transparent mechanism of decision-making. It is an interdisciplinary approach to understand a particular socio-ecological system and identify

problems and solutions, some of which may be unique to it (Kurka & Blackwood 2013). For the effective implementation and use of assessment in policy decisions, C&I sets should reflect local sustainability goals, context and capacities, and be feasible for local stakeholders to use (Fraser et al. 2006). To achieve this, shared understanding must be developed that 'invokes all forms of rationality' (Blackstock et al. 2007; p. 729), which is not possible without the use of a participatory approach (Bell & Morse 2004; Blackstock et al. 2007; Buchholz et al. 2009; Kurka & Blackwood 2013).

Building consensus among larger, diverse groups of stakeholders with a wide range of objectives is often a challenging endeavor (Grimble & Wellard 1997; Buchholz et al. 2009; Diaz-Chavez 2011; Johnson et al. 2013; Florin et al. 2014). Majority voting, a commonly used techniques in multi-stakeholder processes, can overshadow important sustainability issues by undermining the voice of the minority. This approach often fails to capture the concerns of all stakeholders and does not generate feasible C&Is (Buchholz et al. 2009; Schouten et al. 2012). Therefore, for any participatory technique to effectively contribute to equitable decision-making, it is important that it acknowledges differences among stakeholders and involves as much stakeholders' engagement as is possible.

The participatory approach for natural resource management, particularly land and forest management, has gained widespread popularity in recent years (Vaidya & Mayer 2014). However, its utility for a SAF for bioenergy is yet to be widely realized. There are few case studies that have used participatory techniques with high variability in how they define participatory methods, where the criteria and indicators originated, which component(s) of bioenergy production is considered, which stakeholders are involved, and assessment outcomes (Table 4.1). While some of the criteria or indicators listed are common across the cases (such as GHG emissions, profitability/economic viability and employment opportunities), others were unique to the type of stakeholder groups involved and the socioeconomic and cultural contexts.

All of the studies summarized in the Table 4.1. used a participatory approach (either expert-initiated or expert-assisted; see Vaidya & Mayer 2014) with varying degrees of stakeholders' engagement. There is an implicit assumption that the local

stakeholders rely on the local (and current) context, as well as their knowledge and experience, to develop their perceptions about new development projects including bioenergy systems (Haatanen et al. 2014). The effectiveness of these SAF remains uncertain.

**Table 4.1. Previous case studies using a participatory assessment for bioenergy projects**

| References | Study area | Participants/ Stakeholders | Criteria | | | |
|---|---|---|---|---|---|---|
| | | | Environmental | Economic | Social | Technological & Governance |
| Kurka & Blackwood (2013) | Scotland (Tayside and Fife) | Total# 13; local authorities, regulatory bodies, business support agency. | • GHG emissions<br>• Air quality<br>• Waste | • Economic viability<br>• Regional energy self-sufficiency | • Regional job creation<br>• Regional food security/Change of landscape and land use | • Energy Efficiency<br>• Technology |
| Haatanen et al. (2014) | Finland (Kainuu, North Savonia, South Savonia, North Karelia and South-East Finland) | Total# 16; Bioenergy and biodiversity experts, business, energy, nature conservation and game management | • GHG emissions<br>• Biodiversity<br>• Habitat protection<br>• Soil carbon | • Economic viability of forestry<br>• Optimization of by-products<br>• Energy solution<br>• Forest management<br>• Subsidies | • Multiple uses of land/forest (production, recreation, protection)<br>• Impact on rural population<br>• Forest owners'/Consumers' attitudes | • Diverse feedstock<br>• Feedstock requirement<br>• Energy efficiency<br>• Workforce<br>• Zonation |
| Upreti (2004) | United Kingdom (Yorkshire, Cricklade, Wales and Cambridge-shire) | Total# N/A; Local councilors, developers, environmental NGOs, local leaders, active members' local action groups | • Impact on wildlife, rare species, aquatic and terrestrial ecosystems<br>• Local weather system<br>• GHGs emissions<br>• Air quality<br>• Waste | • Impact on property prices<br>• Employment opportunities for local people<br>• Impact on tourism and livestock<br>• Market assurance<br>• Compensation<br>• Location of the power plant (proximity to residential areas) | • Traffic<br>• Noise and odor<br>• Accidents<br>• Land use and agricultural change<br>• Aesthetic<br>• Public health | • Benefits to community versus environmental and social cost |
| Adams et al. (2011) | United Kingdom (online survey) | Total# 72; Feedstock producers (farmers/suppliers), plant developers/owners, government/policy advisors, primary users. | • GHG emissions (Climate change mitigation)<br>• Waste (utilization) | • Economic viability (profit)<br>• Developmental and operational cost<br>• Capital costs<br>• Energy security<br>• Transport distance<br>• Financial support | • Local planning<br>• Competition for investments<br>• Food price<br>• Reliance on imports | • Resource availability<br>• Policy and standards<br>• Technology<br>• Efficiency (energy, resource)<br>• Land availability<br>• Viable logistics and supply systems |
| Puy et al. (2008) | Spain (Catalonia) | Total# 23; Local and national government, researchers, technicians, business persons from local forest industry, NGO representatives, ecologists, forest owners. | • Sustainable harvesting<br>• Transport/combustion emissions<br>• Infrastructure impacts<br>• GHG emissions<br>• Waste | • Competitive in wood market<br>• Economic viability<br>• Market assurance<br>• Market regulations Transportation (within 50 km)<br>• Forest fires impacts on plants | • Direct benefits<br>• Positive indirect impacts<br>• Compliance with urban planning<br>• Communication with the public | • Short combustion processes<br>• Harvesting technology<br>• Plan requirements for biofuel standards (size, moisture content, net calorific value)<br>• Logistics & supply systems |
| Cruse et al. (2012) | United States (Iowa) | Total# 14; Biofuel research scientists, 44 farmers & agricultural professionals | • Wildlife habitat<br>• Water quality<br>• Soil carbon sequestration | • Farm net income<br>• Energy balance | • Acceptable transportation requirements<br>• Rural development | • Reliable supply of feedstock<br>• Technology (conversion)<br>• Logistics (storage)<br>• Availability of labor |

# 3. Methods

### *3.1. Study Area*

Our study was conducted in the Western Upper Peninsula (WUP) region of Michigan USA. Over a century ago, the economy of this region was largely dependent upon mining and clear-cut logging industries, which declined as mining and forest resources were depleted. By the 1960's, the decline in employment opportunities and industrial base drove a rapid population decline, which has lasted for several decades. Today, the forests have recovered to volumes prior to the logging boom, and forest products and logging industries are the major contributors to the UP economy (Rickenbach et al. 2005; Froese et al. 2007; Haugen et al. 2014). About 80% of the total WUP land is forested (Mayer & Rouleau 2013). The land base ownership is evenly split, with about one third publicly owned (much of it in Ottawa National Forest), one third privately owned by large timber investment corporations, and the remainder owned by roughly 30,000 non-industrial (or family) forest owners (Schubert & Mayer 2012, Lind-Riehl et al. 2015).

A number of initiatives are in progress to recover the forest industry and local economy in the region (MSU 2009; USDA 2011; Balaskovitz 2014a, 2014b; Ali 2015). The region encompasses over 56,000 acres of retired agricultural land scattered among 1,200 fields, and has a favourable climate (adequate water availability and soil productivity) for short rotation woody coppice (Froese & Abbott 2012). Several bioenergy initiatives are also underway in the WUP, primarily through programs managed by the Western Upper Peninsula Planning and Development Region (see www.upbioenergy.com), suggesting that a sustainability assessment for a forest-based bioenergy production system is timely and important. However, the bulk of existing research on wood-based biofuel production concentrates on enhancing and assessing its techno-economic feasibility and compatibility with existing infrastructure (Shonnard et al. 2008; Zhang et al. 2011, 2015; Froese & Abbott 2011, 2012; Handler et al. 2014; Jenkins & Sutherland 2014). Stakeholders' concerns and perceptions regarding an emergent regional bioenergy industry so far have been ignored. The decisions of

land/forestland owners, businesses, and consumers regarding acceptable land and resource use will play a crucial role in ensuring the overall sustainability of this industry.

### *3.2. Participatory assessment*

We used a qualitative participatory approach to develop a sustainability assessment for a forest-based bioenergy production industry in the UP. We collected data using a combination of three different participatory techniques: focus groups, interviews, and one workshop. Here we will limit our discussion to the focus groups and interviews, since the preliminary list of criteria was generated from these activities.

We used a three-step formula provided by Reed et al. (2009) to identify relevant participants for qualitative studies. First, we identified sectors that were highly likely to be impacted by a biofuel production system[13] in the study area (such as the forest industry, forestlands, environmental interest groups, local economic actors, government and non-government sectors). This task focused on the following questions: what are the sub-components of the system and how are different components connected to each other? Which organizations are involved with which components of this system? Next we identified individuals, groups, and organizations likely to be impacted or to impact the forest-based bioenergy production system (i.e. key actors or stakeholders from each of the components as shown in Table 4.2). This was mostly achieved through local contacts (including snowball sampling), Internet searches and literature reviews. A literature review helped us to simplify the bioenergy production system into various components, which in turn made it easier to identify key stakeholders through the use of snowball sampling and Internet searches.

Potential participants were invited to participate in the study through email and/or physical addresses. An invitation letter contained a brief description about the project, information about expected commitments from the participants, compensation for

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[13] The production system of a bioenergy industry may be divided into four key components: i) feedstock production; ii) production plant (conversion and processing); iii) energy use, including distribution and consumption; and iv) decision making and sustainable management (Lewandowski and Faaij 2006; Buchholz et al. 2007, 2009; Elghali et al. 2007; Ribeiro 2013)

participants' time and travel expense, and a request to forward the invitation to invitees' contacts in case of their inability to participate. Participants were distributed between different stakeholder groups as shown in Table 4.2.

**Table 4.2. Distribution of different participants over different stakeholder groups**

| **Stakeholders' professional background** | **Represented component/s** |
|---|---|
| Farmer | Feedstock Production, Decision making and sustainable management |
| Landowner | Feedstock Production, Decision making and sustainable management |
| Tribal community member | Feedstock Production, Decision making and sustainable management |
| Timberland management company | Feedstock Production, Decision making and sustainable management |
| Venture Capitalist mainly from forestry services industry | Biofuel Production, Decision making and sustainable management |
| Forester and consultant | Feedstock Production, Decision making and sustainable management |
| Biologist and Ecologist | Decision making and sustainable management |
| State government agencies from agricultural, rural development, and forestry sectors | Decision making and sustainable management, Biofuel Production |
| Non-Governmental Organizations, Local Interest Groups | Decision making and sustainable management |
| Current/potential users of wood-based energy | End Uses |

### *3.3. Data Collection*

The data collection involved two steps: focus group meetings and individual semi-structured telephone interviews. Altogether 36 individuals participated in the study; 21 participated in a focus group meeting and an interview. Eight participants who could not attend a focus group meeting (mostly due to long traveling distance to the meeting venues) participated in only individual phone interviews. Focus group discussions, interviews, and the review of prior case studies contributed to the formulation of a list of sustainability criteria and illuminated their underlying context.

### *3.3.1. Focus group meetings*

Focus group meetings were conducted to gain insight on collective values and concerns regarding the sustainability of a potential bioenergy industry. We conducted seven focus group meetings with a heterogeneous group of stakeholders, from three to six participants, representing different components of the bioenergy system (as shown in Table 2). Each focus group meeting began with a brief PowerPoint presentation by one of the authors about the project, the stakeholders' role in the project, the objectives of the project, and a brief outline of the research activities. Focus group meetings were tape-recorded.

While facilitating the focus group meeting, special care was taken not to let any one participant suppress or dominate the free exchange of knowledge and opinions. Conversely, the moderator also did not allow the group to digress too much from the main topic. Examples of the questions asked were 'what do you think about having forest-based bioenergy production in your region?' and 'what may be the biggest challenges for forest-based bioenergy to grow in this region?' (See Appendix 3.1). Through the focus groups, we gained a communal understanding of the potential issues and opportunities (ecological, economic, social, policy, governance and institutional) associated with forest-based bioenergy development in the region. This in turn helped us to develop specific questions for our research activity (i.e. individual interviews) that could lead us to sustainability criteria and indicators that are relevant to the WUP community with regard to regional bioenergy production.

### *3.3.2. Individual semi-structured interviews*

Each interview lasted about 40 minutes on average. While the focus groups generated broad sustainability criteria by concentrating on broad themes (such as prospects of wood-based biofuel production in the WUP), the follow-up interviews used more specific questions to identify potential indicators (See Appendix 4.2 for a sample questionnaire). For some participants, these interviews offered an opportunity to share information or perspectives that they were not comfortable sharing in the focus group. Along with an opportunity to share their perceptions and concerns, individual interviews

allowed our participants to describe the underlying contexts[14] that may have influenced them. In-depth understanding of the underlying contexts was important for the validation of the interview and focus group data.

The focus group meetings and telephone interviews were tape-recorded. The data were first translated directly into codes, and then into potential criteria and indicators through the technique of content analysis. The data from focus group meetings were analysed through conventional content analysis (where we avoided using any pre-conceived categories to analyse the data, allowing the data to guide the categorization process; Kondracki et al. 2002). Conventional content analysis is a qualitative technique, which involves conversion of data into texts, followed by inductive identification of categorical themes within text contents (Berg 1989). On the other hand, interview data were analysed through the technique of directed content analysis (where themes derived from the focus group meetings and literature review guided the categorization of stakeholders' concerns). One frequently cited challenge of using content analysis to analyse qualitative data is ensuring or proving reliability and validity of the findings (Manning 1997; Hsieh and Shannon 2005; Babbie 2007). Many have suggested that credibility for these kinds of analyses may be ensured through the process of peer debriefing, triangulation, negative case analysis, and referential adequacy (Manning 1997). In our case, we validated our findings through negative case analysis[15] (by allowing information saturation, and by reviewing peer-reviewed journals and grey literature from state and regional agencies, which also partially served the purpose of triangulation). At the stakeholder workshop (the third phase of our study which we discuss in chapter V), we further validate our findings by soliciting feedback from our participants on the C&I generated from the focus groups and interview data.

While focus group meetings and interview data were used to generate preliminary list of C&I and to understand the influence of local context on sustainability concerns of the community, we used a literature review also to differentiate general and expert-driven criteria from context-specific criteria.

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[14] Most of this could be validated through a review of peer-reviewed journals and grey literature.
[15] Negative case analysis may be defined as a process that involves revising or confirming the patterns suggested by data analysis, by exploring further or discussing the elements of the data (RJWF 2008)

# 4. Results and Discussion

The focus groups and interviews identified the concerns and priorities of regional stakeholders regarding forest-based bioenergy development. Most of the C&I highlighted by the participants largely overlap with the environment and economic criteria used in the sustainability frameworks in the literature. Most of the criteria have been cited in the literature extensively and are also included in international sustainability assessment and certification schemes for bioenergy (Tables 4.3 & 4.4). Indicators such as competitive cost, employment, GHG emissions, energy efficiency, and bioenergy production impacts on soil, air and water were cited by our stakeholders and are also included in other assessments. On the other hand, our study also revealed some underlying concerns of the participants, which were context-specific and not echoed in the literature. While broad C&I are important for consistency and comparability, they may not necessarily be relevant, measurable or adequately revealing to influence management and policy decisions at all scales (Efroymson et al. 2013; Dale et al. 2015).

Below we describe criteria (and indicators for some criteria) as highlighted by our participants in five broad categories: economic, environmental, social, policy and regulations, and institutional capacity. However, we do not evaluate which concerns are valid for this region.

## *4.1. Economic criteria*

Economic concerns were common across all stakeholder groups. Job creation (I.Ec.1.1), use of local resources (I.Ec.1.2.), reduced cost of energy (I.Ec.2.3.) and economic viability of the industry (I.Ec.3.1.) were considered by many as vital to sustainable community development (Table 4.3). These criteria are similar to those in other case studies of bioenergy development (Puy et al. 2008; Adams et al. 2011; Kurka & Blackwood 2013). Economic criteria were also found to be the most cited and well-developed criteria in the literature. Buchholz and Volk (2012) argue that the predominant

use of economic criteria in assessing sustainability of new industries may be due to their easily monetizable and quantifiable attributes.

A number of our participants also raised concerns that were not widely noted in the literature, particularly involving the use of local resources (I.Ec.1.2.) to primarily benefit the local population through small-scale energy production. Some participants also expressed concern about the amount of energy per volume that can be derived from the forest resources as opposed to fossil fuel (I.Ec.3.3), which they believed was an important consideration of any transportation fuel supply chain. Market acceptance and adaptability (C.Ec.4.) were also of concern, which has not been addressed adequately in the existing sustainability assessments or the literature.

**Table 4.3. Economic criteria as suggested by participants, and their sub-criteria/indicators**

| Criteria. Economic. # | Sub-criteria/Indicators | Supported by existing SFA/literature |
|---|---|---|
| C.Ec.1. Contribution to local economy | I.Ec.1.1. Employment | Acosta et al. 2014; Buchholz et al. 2009; Dale et al. 2013; Global Bioenergy Partnership (GBEP 2011); Kurka & Blackwood 2013; La Rovere et al. 2010; Lindner et al. 2010; Markevičius et al. 2010 |
| | I.Ec.1.2. Use of local resources | |
| | I.Ec.1.3. Value-addition to forest products | GBEP 2011 |
| | I.Ec.1.4. Infrastructure development (roadways, railways, hospitals, training institutes) | |
| C.Ec.2. Energy Security | I.Ec.2.1. Net energy import dependency | Adams et al. 2011; Dale et al. 2013; GBEP 2011; Kurka & Blackwood 2013; La Rovere et al. 2010; Markevičius et al. 2010 |
| | I.Ec.2.2. Consistent/reliable supply of energy products | Dale et al. 2013; Kurka & Blackwood 2012; La Rovere et al. 2010; Markevičius et al. 2010 |
| | I.Ec.2.3. Competitive cost of biofuel | Benjamin et al. 2009; Buchholz et al. 2009; Dale et al. 2013; Kurka & Blackwood 2013; La Rovere et al. 2010; Lewandowski & Faaij 2006; Markevičius et al. 2010 |
| C.Ec.3. Economic viability | I.Ec.3.1. Cost of production/operation | Adams et al. 2011; Augustenborg et al. 2012; Buchholz et al. 2009; Dale et al. 2013; Kurka & Blackwood 2013; La Rovere et al. 2010; Lindner et al. 2010; Markevičius et al. 2010; Stupak et al. 2007 |
| | I.Ec.3.2. Energy return over investment (EROI) (energy efficiency in production and use) | Buchholz et al. 2009; Dale et al. 2013; GBEP 2011; Kurka & Blackwood 2013; Lattimore et al. 2009; Lewandowski & Faaij 2006; Lindner et al. 2010; Markevičius et al. 2010; RSB; RSPO; |
| | I.Ec.3.3.Energy from forest-based biomass compared to energy from fossil fuels | |
| | I.Ec.3.4. Travel distance between collection points of feedstock and production and distribution points | Adams e al. 2011; Benjamin et al. 2009; Lindner et al. 2010; Puy et al. 2008 |
| | I.Ec.3.5. Return over investment | Dale et al. 2013; Kurka & Blackwood 2013; La Rovere et al. 2010; Lewandowski & Faaij 2006; Markevičius et al. 2010 |
| | I.Ec.3.6. Resource efficiency of the process (efficiency in resource use); fuel production per volume of feedstock or hectare | Buchholz et al. 2009; Lewandowski & Faaij 2006; Markevičius et al. 2010 |
| | I.Ec.3.7. Scale of production | Benjamin et al. 2009; Buchholz & Volk 2012; Markevičius |

| | | |
|---|---|---|
| | | et al. 2010 |
| C.Ec.4. Market Acceptance & Adaptability | I.Ec.4.1. Ability to use diverse feedstock | Buchholz et al. 2009 |
| | I.Ec.4.2. Ability to produce diverse products | Benjamin et al. 2009; Markevičius et al. 2010 |
| | I.Ec.4.3. Return rate; payback time in years | Buchholz et al. 2009; Kurka & Blackwood 2013; Markevičius et al. 2010 |
| | I.Ec.4.4. Cost of returning to previous land use | |
| | I.Ec.4.5. Comparative gain over other investments | Adams et al. 2011; Buchholz et al. 2009; Kurka & Blackwood 2013 |
| | I.Ec.4.6. Technology, infrastructure, machinery and equipment | Acosta et al. 2014; Benjamin et al. 2009; Kurka & Blackwood 2013 |
| C.Ec.5. Competition for resources | I.Ec.5.1. Price and availability of forest products | Benjamin et al. 2009; Lewandowski & Faaij 2006; Stupak et al. 2007 |
| | I.Ec.5.2. Availability of lands for other purposes (price, availability) | Acosta et al. 2014; GBEP 2011; Markevičius et al. 2010; RSB; RTRS |

### *4.1.1. Contribution to local economy*

Most participants deemed the forest products industries as crucial for the local economy, which is why the recent decline in the number of logging firms and forest-based industries (mainly paper and pulp industries) has been widely concerning[16]. A new industry base was viewed as necessary to retain employment opportunities and the young population in the area, and to facilitate infrastructure development for public services. Participants also stated that for the emerging industry to be sustainable, it was important to improve the local economy by using local resources for local energy production. In particular, representatives of timber companies and venture capitalists emphasized that few of the economic benefits from the forest products industry in the WUP remain there[17]. Rather than exporting wood to other states at cheaper prices, establishing local facilities to process raw wood and export finished (value-added) products at higher prices was a commonly expressed development goal.

[16] The number and size of logging firms (and the forest products industry generally) have declined significantly in the past decade (Rickenbach et al. 2005; Becker et al. 2009; Leefers & Vasievich 2010; Shivan & Potter-Witter 2011), frequently attributed to reduced demand (Becker et al. 2009).

[17] The UP accounts for only 29% of Michigan's total area, but supports more than 45% of the state's forests (Pugh et al. 2012). A majority of Michigan's logging companies are from the UP, however less than 11% of the total forest products manufacturers (primary as well as secondary) in Michigan are based in the UP (MDNR 2014).

### *4.1.2. Energy security*

Despite the small and sparsely-distributed population, energy security in terms of transportation fuel was not viewed as an important priority. Alternatively, small-scale power generation plants using woody biomass was of greater interest. Many participants expressed dissatisfaction toward the import of energy from outside the state, and viewed bioenergy as a potential opportunity to divert the economy to the local market. Some participants were concerned about the import of petroleum and electricity to the WUP from elsewhere while the WUP's raw wood is exported to downstate Michigan and neighbouring states. In addition, potential consumers emphasized their desire for a consistent and reliable supply of energy products at a competitive cost.

### *4.1.3. Market acceptance and adaptability*

Especially for feedstock producers and investors, market acceptance was a big concern; before investing their resources, they need to be sure that there will be a market for their products. Given that the forest-based biofuel industry is just emerging, some suggested that the industry should be able to have greater market adaptability, be able to use diverse feedstocks, and offer diverse products at competitive prices. For the landowners who were retirees (a large component of non-industrial private forest owners in the WUP; Schubert & Mayer 2012), a payback time was an important factor in their decision to use their land for feedstock production. Some participants (primarily those representing timber management companies and venture capitalists) also highlighted a need for a more efficient use of woody biomass, and improving the industry's ability to add value to by-products from logging and other wood processing operations. Potential consumers suggested that their decision to switch to new fuel types was contingent on its energy efficiency, cleanliness, cost, consistent supply, and its compatibility with their vehicle/technologies/infrastructure.

### *4.1.4. Competition for resources*

A particular concern was expressed over the impact of a bioenergy industry on the recreation and tourism industry, which largely rely on natural areas. Some viewed a new bioenergy industry as an opportunity, while for others it meant fiercer competition for or conflict over land and forest resources. Some participants argued that a decline in existing forest-based industries might be an opportunity for a new industry to utilize 'surplus wood'. On the other hand, consumers were concerned about a possible price hike in wood and wood products as a forest-based bioenergy industry emerged. This was especially true for consumers of cordwood for winter heating. Moreover, representatives from a timber management company suggested that demand for forest biomass had increased more recently, boosting prices. Similarly, a lot of marginal or retired land in the region currently grows forage crops (such as hay) and supports grazing land for horses and livestock. Some participants argued that conversion of these lands to a large-scale energy crop plantation might increase competition for marginal lands for forage production, which may not be in the best interest of local livestock owners. Existing assessment frameworks and certification schemes largely fail to address competition for feedstock between bioenergy and other wood and non-wood products (Stupak et al. 2007).

## ***4.2. Environmental criteria***

Some participants expressed strong concerns regarding the uncertainty of impacts on the environment. For example, many were skeptical about growing genetically engineered and non-native species for bioenergy feedstock. However, representatives from timberland management companies and many landowners believed that harvesting is important for the maintenance of healthy and productive forests. Habitat conservation, native species, water and soil quality, and air quality were some of the most frequently stated *environmental criteria f*or the impacts of feedstock and bioenergy production. Most of these environmental criteria are shared with existing sustainability assessments (see Table 4.4). However, some of the criteria we documented (e.g. land use conversion,

concern about genetically engineered species, harvest mechanisms (clear cutting versus selective cutting, use of heavy machinery) and residue management and utilization) are fairly unique to our study.

**Table 4.4. Environmental criteria as suggested by our participants, as supported in the literature**

| Criteria. Environmental. # | Sub-criteria/Indicators | Supported by existing SFA/literature |
|---|---|---|
| C.Env.1. Air quality | I.Env.1.1. GHG emissions; change in carbon sequestration properties | Buchholz et al. 2009; GBEP 2011; Kurka & Blackwood 2013; La Rovere et al. 2010; Lattimore et al. 2009; Lewandowski & Faaij 2006; Lindner et al. 2010; Markevičius et al. 2010; McBride et al. 2011; RSB; RSPO; RTRS; SEKAB 2012; Stupak et al. 2007; Williams et al. 2009 |
| | I.Env.1.2. Air pollution (Particulate matter, NOx, SOx, CO) | Buchholz et al. 2009; GBEP 2011; Kurka & Blackwood 2013; La Rovere et al. 2010; Lewandowski & Faaij 2006; Lindner et al. 2010; Markevičius et al. 2010; McBride et al. 2011; Stupak et al. 2007; Williams et al. 2009 |
| C.Env.2. Ecosystem and wildlife habitat | I.Env.2.1. Biodiversity | Acosta et al. 2014; GBEP 2011; IDB 2009; Lattimore et al. 2009; Lewandowski & Faaij 2006; Lindner et al. 2009; Markevičius et al. 2010; McBride et al. 2011; RSB; SEKAB 2012; Stupak et al. 2007; Williams et al. 2009 |
| | I.Env.2.2. Controlled use of agrochemicals | Markevičius et al. 2010; RSB; RSPO; RTRS |
| | I.Env.2.3. Protection of HCV areas | FSC 2010; Lattimore et al. 2009; Lewandowski & Faaij 2006, Markevičius et al. 2010; RSB; RSPO; RTRS; Stupak et al. 2007 |
| | I.Env.2.4. Controlled use of forestland for bioenergy operations | FSC 2010; Lattimore et al. 2009; Markevičius et al. 2010; Stupak et al. 2007 |
| C.Env.3. Invasiveness | I.Env.3.1. Use of non-native species/genetically engineered species for bioenergy production | Buchholz et al. 2009; FSC 2010; IDB 2009; Lattimore et al. 2009; Markevičius et al. 2010; RSB; RSPO; RTRS |
| C.Env.4. Water quality | I.Env.4.1. Water contamination (herbicide, pH, eutrophication) | Buchholz et al. 2009; GBEP 2011; Kurka & Blackwood 2013; Lattimore et al. 2009; Lewandowski & Faaij 2006; Markevičius et al. 2010; McBride et al. 2011; RSB; RSPO; RTRS; Stupak et al. 2007; Williams et al. 2009 |
| C.Env.5. Land/Soil quality | I.Env.5.1. Productivity/yield, soil organic compounds, soil nutrient, pH, soil compaction | Buchholz et al. 2009; GBEP 2011; Lattimore et al. 2009; Lewandowski & Faaij 2006; Markevičius et al. 2010; McBride et al. 2011; Williams et al. 2009 |
| | I.Env.5.2. Land (soil) conservation/management | Acosta et al. 2014; Lattimore et al. 2009; Lewandowski & Faaij 2006 McBride et al. 2011; RSB; RSPO; RTRS; Stupak et al. 2007 |
| C.Env.6. Waste management | I.Env.6.1. Residue management and utilization | Lattimore et al. 2009; Lindner et al. 2010; McBride et al. 2011; RSB; RSPO; Stupak et al. 2007 |
| | I.Env.6.2. Waste management plans (postharvest, post fuel production, and after use) | Adams et al. 2011; Buchholz et al. 2009; FSC 2010; Kurka & Blackwood 2013; Lattimore et al. 2009; Lewandowski & Faaij 2006; Lindner et al. 2010; Markevičius et al. 2010; RSB; RSPO; RTRS; Upreti 2004; Williams et al. 2009 |

Most of our participants, who were predominantly from a non-scientific background, were hesitant to state indicators for environmental criteria and suggested seeking experts' opinion for determining appropriate indicators. They also suggested the

need for more research to ensure a scientific basis for indicators for environmental criteria.

### *4.2.1. Ecosystem and wildlife habitat*

Residents considered the forests and wildlife as a critical part of UP identity. Some of the participants were concerned about the impact that plantations, monocultures and removing woody biomass from natural forests could have on multiple ecosystems; some examples cited were vernal pools, peatlands, wetlands, forests, grasslands, and dead trees (snags and coarse woody debris). The use of herbicides, fertilizers, and heavy machines for harvesting, and possibilities of road expansion and infrastructure development, were also viewed as potential threats to the ecosystems and wildlife in the region.

Most of the participants wanted to conserve native species and maintain biodiversity. Some participants, including tribal members and landowners, argued that biodiversity should be an inclusive term (including smaller organisms and microorganisms as well), and it should be valued and protected for its importance to food webs and ecosystem functions.

### *4.2.2. Concerns about non-native species*

For most of the participants, use of genetically modified or non-native species like hybrid poplar, and grasses such as switchgrass and *Miscanthus* were troublesome. Invasiveness, pests, and plant diseases were seen as the biggest threats from non-native or genetically engineered bioenergy species, as well as their impact on landscape aesthetics. Such resistance to genetically modified or non-native species was also observed in other studies (Cruse et al. 2012). Despite these concerns, some of the farmers and landowners showed interest in learning about other cases where these species have been used without problems, suggesting that the concern could be mitigated by research and outreach.

### *4.2.3. Land/Soil quality and productivity*

Many participants wondered about the long-term impacts of bioenergy plantations on soil stability and fertility, frequently citing clear-cutting as one harvesting method with long-term negative impacts. They were also concerned about the use of heavy equipment during harvesting, which they argued could affect soil structures and wildlife. Participants (including a representative from an NGO, an ecologist who is also a tribal member, and farmers) worried that growing and removing biomass from the land would inevitably reduce the nutrient level of the soil unless soil amendments were applied regularly. Some associated the use of herbicides and soil amendments (chemical fertilizers in particular) with a threat to the environment.

## ***4.3. Social criteria***

Social criteria are often stated in vague terms like 'social cohesion' (Buchholz et al. 2009; Kurka & Blackwood 2013), 'social benefits', 'social acceptability' (Buchholz et al. 2009; Wang et al. 2009), or 'social welfare' (Acosta et al. 2014). Indicators are highly variable across the literature. The most commonly used social criteria for bioenergy sustainability are 'food security', 'human rights' and 'land rights' (Table 4.5). Some of our participants' concerns such as cultural values, their access and control over forestlands, aesthetics, issues like noise, smell and traffic, and the availability of farm land, are occasionally discussed in the literature, but they are rarely addressed in existing assessments. Particularly for social criteria, context and local concerns are important (Boström 2012).

### *4.3.1. Culture and tradition*

With the exception of five absentee landowners (who spent some or all of their youth in the region), our participants have lived in the area for the most of their lives and valued the abundant natural resources and picturesque settings for outdoor activities. For many (tribal members and others), the lands that they currently own were bequeathed to them by their ancestors and remain a part of their heritage. Particularly for the tribal

communities and long-time residents, the forests have remained an indispensable part of their livelihood, history, and culture[18]. While some were open to the idea of economic production on their land, others suggested that they wanted to keep the land as it was, and voiced concerns about possible impacts of a forest-based bioenergy industry on the native culture, land value and landscape aesthetics.

**Table 4.5. Social criteria as suggested by our participants, as supported in the literature**

| Criteria. Social. # | Sub-criteria/Indicators | Supported by existing SFA/literature |
|---|---|---|
| C.Soc.1. Cultural value | I.Soc.1.1. Access to recreational activities in public lands | Buchholz et al. 2009; Hayes et al. 1999; Markevičius et al. 2010 |
| | I.Soc.1.2. Protection of local/tribal heritage and sites | Hayes et al. 1999 |
| | I.Soc.1.3. Access to cultural forest products for local inhabitants | FSC 2010; Hayes et al. 1999, Stupak et al. 2007 |
| | I.Soc.1.4. Aesthetics | Buchholz et al. 2009; Lattimore et al. 2009; Lewandowski & Faaij 2006; Markevičius et al. 2010; Stupak et al. 2007; Upreti 2004 |
| C.Soc.2. Ethical concerns | I.Soc.2.1. Noise, smell, traffic | Buchholz et al. 2009; Kurka & Blackwood 2013; Markevičius et al. 2010; Upreti 2004 |
| | I.Soc.2.2. Protection of land rights and access for local residents | Acosta et al. 2014; Buchholz et al. 2009; FSC 2010; GBEP 2011; IDB 2009; Kurka & Blackwood 2013; Markevičius et al. 2010; RSB; RSPO; RTRS; Stupak et al. 2007 |
| | I.Soc.2.3. Work conditions; fair wage/benefits; safety | Buchholz et al. 2009; Dale et al. 2013; FSC 2010; GBEP 2011; IDB 2009; Kurka & Blackwood 2013; La Rovere et al. 2010; Lindner et al. 2010; Markevičius et al. 2010; RSB; RSPO; RTRS; SEKAB 2012; Stupak et al. 2007 |
| C.Soc.3. Food security | I.Soc.3.1. Change in agricultural land area | Markevičius et al. 2010; Upreti 2004 |
| | I.Soc.3.2. Food and feed (for livestock) price | Adams et al. 2011; Acosta et al. 2014; Buchholz et al. 2009; EC-RED; GBEP 2011; IDB 2009; Kurka & Blackwood 2013; Markevičius et al. 2010 |

### *4.3.2. Ethical concerns*

In addition to concerns about cultural and traditional values, some residents also said that bioenergy plants needed to be built at a reasonable distance from residential areas. They were primarily concerned about the possible noise and smell that may emanate from the plant. Not all participants shared this view. Resident landowners who

[18] For tribal members, forestland is not only the part of their culture or heritage; it also provides numerous benefits to their livelihoods. One tribal member (who was a forester for the tribe) stated:

> *Our culture has lived off the land. Forest is extremely important for sustaining ourselves whether it's directly like fruits, maple sugar, maple syrup…. providing habitat for other animals that we have hunted for food, for medicines that we have used to take care of our people for a long time… crafts, some of the barks, some of the tree species… we use those for making canoes, making baskets, and making everything we use to sustain ourselves. So, it's extremely important*

benefit from forestlands through access to recreational, hunting and fishing areas were mainly concerned about feedstock harvesting impacts on their land access and control.

### *4.3.3. Food security*

Our focus groups discussed both the use of forest resources (e.g., plantations, harvest residues) and bioenergy feedstock crops (such as switchgrass) grown on retired agricultural land. Participants highlighted a need for continuous research and wanted more reliable estimates of biomass harvesting impacts on land use changes and food security. Food security was also an issue for residents who relied on the local forests and their landholdings for their income and food (whether through agriculture or hunting and fishing). Some of the local residents, mainly landowners, a farmer, and environmentalists, argued for restrictions on the use of arable lands for feedstock production, to control competition for land between food and feedstock production.

## ***4.4. Policy and regulations***

Ensuring that a bioenergy industry contributes to environmental protection, economic viability, and social equity may not be achieved solely through scientific and technological advancements (Buchholz et al. 2009). The legal framework and institutional capacity are also important in the pursuit of effective development interventions. Nevertheless, certification schemes and assessment frameworks have largely ignored the role of policy, regulations, and institutional capacity for the sustainable development of bioenergy industries (Scarlat & Dallemand 2011). US Renewable Fuel Standards (US-RFS) and European Commission Renewable Energy Directives (EC-RED) are two policy frameworks that have driven bioenergy development. However, these frameworks remain focused on reducing large-scale GHG emissions and environmental costs, and on establishing supply chains for bioenergy products through fuel standards, mandates and incentives. With the exception of the GBEP and ISO 248, national and international certification schemes mainly focus on corporate social responsibility and international trade, to encourage responsible feedstock

production, biofuel production, and marketing (Scarlat & Dallemand 2011; Elbehri et al. 2013). However, our participants discussed policies and regulations that were more context-specific, which would regulate the sustainable harvesting of feedstock, the use of local resources, subsidies for bioenergy production, and ensure the wellbeing of their community (Table 4.6). Many participants also suggested that without an adequate policy regime and enforcement, it would be difficult to implement and monitor all other sustainability criteria.

**Table 4.6. Policy and regulations criteria as suggested by our participants, as supported by the literature**

| Criteria. Policy & Regulations. # | Sub-criteria/Indicators | Supported by existing SFA/literature |
|---|---|---|
| C.P&R.1. Precautionary and support mechanisms | I.P&R.1.1. Sustainable harvesting guidelines | FSC 2010; Hayes et al. 1999; Lattimore et al. 2009; Lewandowski & Faaij 2006; Stupak et al. 2007 |
| | I.P&R.1.2. Inventory of accessible forest resources | |
| | I.P&R.1.3. Compliance to best management practices | Benjamin et al. 2009 |
| | I.P&R.1.4. Subscription to certification schemes | |
| | I.P&R.1.5. Subsidies and tax incentives | Augustenborg et al. 2012; Benjamin et al. 2009; Lattimore et al. 2009 |
| | I.P&R.1.6. Policies to protect local industry from fluctuating oil prices and foreign competition | |
| C.P&R.2. Compliance with laws and regulations | I.P&R.2.1 Payment of legally prescribed fees, taxes, royalties | FSC 2010; Lewandowski & Faaij 2006; Markevičius et al. 2010 |
| | I.P&R.2.2. Compliance with local standards, laws and regulations | Buchholz et al. 2009; Kurka & Blackwood 2013; Markevičius et al. 2010 |
| | I.P&R.2.3. Compliance with national and international standards | FSC 2010; RSB |
| C.P&R.3. Regulatory policies | I.P&R.3.1. Regulation to prevent the use of agricultural land | Markevičius et al. 2010 |
| | I.P&R.3.2. Regulation to control the use of forestland for harvesting woody biomass | |
| | I.P&R.3.3. Traffic controls | |
| | I.P&R.3.4. Pollution control mechanisms | |

### *4.4.1. Precautionary and support mechanisms*

There was general agreement among the participants that the national and state forests in the UP are largely underutilized. Venture capitalists and timber management companies argued that policies allowing for the harvest of forest resources from public lands are usually biased toward environmental preservation and wilderness concerns, resulting in harvesting far below a sustainable capacity. While participants argued that

sustainable harvesting should be allowed in the national forests, they suggested that there should also be standards to determine sustainable limits to resource use. Although not all participants were aware of certification schemes for forest products (which include standards addressing sustainable harvesting practices), those who were aware of them believed that they would be a positive tool for sustainable bioenergy production.

Most participants expressed ambivalence over subsidies and tax incentives to develop and promote a bioenergy industry. While many believed that an industry should be self-sustaining and should not be subsidized, a few argued that without incentives it may be very challenging for a forest-based industry to establish a production system and persist in the competitive market. In a survey conducted by Buchholz et al. (2009), 137 bioenergy experts from around the world ranked ‘bioenergy system being profitable with no subsidies’ low in importance, relevance and practicality. Those who opposed subsidy-driven bioenergy development recalled the persistent reliance of corn ethanol and fossil fuel industries on subsidies and its counterintuitive impacts on sustainability as a basis for not supporting subsidies and tax incentives.

Several landowners had land enrolled in one or more voluntary incentive programs[19] and suggested that economic incentives might be important to motivate nonindustrial landowners to produce bioenergy feedstock. In their interviews, some landowners (resident and absentee) argued that most nonindustrial forest owners in the region own these lands as a secondary asset or source of income, so they do not prefer to spend a lot of time and money on their lands and would need incentives to get involved in bioenergy production.

### *4.4.2. Compliance with existing laws and regulations*

While participants argued that the community might need a new set of regulations and policies to regulate and support a new bioenergy industry, many argued that policies

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[19] Voluntary incentive programs refer to non-regulatory and incentive-based programs that provide forestland owners the opportunity to retain and manage their forests for timber production, and allow public access for outdoor activities like hunting and fishing (MDNR 2014).

and laws alone are not sufficient. They stressed the need to regularly monitor compliance with existing standards and regulations[20].

### 4.4.3. *Regulatory policies*

Although there are laws in place to protect some high value areas, a participant argued that there are a number of places in the region which may not be designated high conservation value areas (HCVA)[21], yet are important to the local ecosystem and should be off-limits to industrial use. Participants also highlighted the need to have regulatory policies in place to control different kinds of pollution and traffic problems generated by the industry.

## ***4.5. Institutional capacity***

While policy and science are central for establishing a bioenergy system, strengthening institutional capacity is essential for their operationalization (McCormick 2011). Sustainability assessments have largely failed to underscore the indispensability of 'institutional capacity'; it is rarely included as a sustainability principle. While some of the criteria listed in Table 4.7 (such as I.IC.1.1, I.IC.2.3, I.IC.3.2) discussed by our participants have been brought up frequently in the literature and certification schemes, most of these criteria have been overlooked.

### 4.5.1. *Integration and coordination*

Many participants believed that expertise, technologies, and resources of the pre-existing forest industry (paper and pulp industries, sawmills) could be integrated into the new forest-based bioenergy industry to minimize capital cost. They argued that co-

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[20] One of the participants however, expressed concern about the ability of state and federal authorities to override local laws and programs.
[21] HCVA refers to the 'areas of forest or other vegetation types that have particularly high importance for social or environmental reasons' (FSC 2010)

locating new bioenergy facilities with existing forestry facilities could reduce competition for resources. Benjamin et al. (2009) argued that a diverse and integrated forest-products industry (including bioenergy) may be advantageous in terms of human resources, procurement policies, and timber supply networks, and facilitate access and efficient use of utilities such as water, energy and waste treatment facilities. These opinions were frequently expressed by many of our stakeholders. Some local residents also wanted to explore utilizing other feedstock to produce energy, such as municipality wastes and paper waste, which they argued may make competition for raw wood less intense and stabilize the feedstock inputs to bioenergy power plants. On the other hand, some participants expressed concern over the possible use of feedstocks that may not be environmentally benign. They underlined a need to monitor and regulate feedstock conversion and production systems.

A few participants also expressed dissatisfaction toward top-down decisions, which have allowed large companies to come to the community, use resources, and leave after the resources are exhausted (a few of the participants specified mining and logging companies from outside the region). While some disregarded the idea (citing it to be a normal phenomenon), others emphasized the need for long-term relationships between these companies and the community to ensure sustainable community development.

Many participants did expect a new bioenergy industry to create jobs, although a few were concerned about the lack of suitable expertise among the local population, highlighting the need for training institutions. Some suggested that the local universities should work with industry to facilitate the generation and employment of local experts and skilled workers.

### *4.5.2. Communication and outreach*

Those participants with little scientific background felt uninformed and unaware about the challenges and opportunities of a forest-based bioenergy industry, particularly for new energy products such as cellulosic ethanol. One of the participants said *'... not*

*knowing about the system is problematic, [it] largely limits community members' ability to make educated decisions regarding land use and involvement in the project*'[22]. This sentiment was echoed by landowners and decision-makers alike, representing all of the feedstock production stages. Many participants emphasized the need for further research and unbiased communication of research outcomes to the public (a few explicitly identifying local universities), including pilot studies to determine potential trade-offs. Some suggested that they wanted to learn about other case studies from communities with an active wood-based bioenergy industry, to better understand the potential benefits and costs of the industry. Some participating landowners expressed dissatisfaction about the lack of public outreach and consulting services for landowners regarding opportunities that are available for sustainable land use and management.

Most of the landowners argued that the WUP lacks outreach from organizations and agencies to the landowners to educate them about existing government policies, land management opportunities, and incentives programs. They also highlighted the dominance of small land parcels as a challenge for collectively engaging landowners in bioenergy projects. Several suggested the formation of landowners' cooperatives to facilitate collaboration and coordination among private landowners.

**Table 4.7. Institutional capacity criteria and indicators as suggested by our participants, as supported by the literature**

| **Criteria. Institutional Capacity. #** | **Sub-criteria/Indicators** | **Supported by existing SFA/literature** |
|---|---|---|
| C.IC.1. Transparency | I.IC.1.1. Involve key stakeholders in decision-making | Buchholz et al. 2009; Kurka & Blackwood 2013; Markevičius et al. 2010 |
| | I.IC.1.2. Public availability of management plans | Markevičius et al. 2010 |
| | I.IC.1.3. Involvement of local organization/institutions/companies in monitoring and control process | Markevičius et al. 2010 |
| C.IC.2. Integration and colocation | I.IC.2.1. Integrate bioenergy projects into existing developmental projects and programs | |
| | I.IC.2.2. Co-location of bioenergy production on or near existing facilities (e.g., paper and pulp industries) | Benjamin et al. 2009 |
| | I.IC.2.3. Education and training facilities to produce skilled | FSC 2010; GBEP 2011; IDB 2009; |

[22] Participants cited several aspects of bioenergy production that should be monitored: the amount of biomass requirement for fuel production, land types permitted by legislation for feedstock production, types of biomass that could be converted into energy, need for machines and fertilizers, land-area requirements, and the technical and economic feasibility of these operations.

| | | |
|---|---|---|
| | workforce | RSPO; RTRS |
| | I.IC.2.4. Research/development programs for new technologies and processes | Acosta et al. 2014; Lattimore et al. 2009 |
| C.IC.3. Administration and management | I.IC.3.1. Reporting of management and operation plans | Markevičius et al. 2010 |
| | I.IC.3.2. Regular monitoring/evaluation of operational and management systems | Buchholz et al. 2009; FSC 2010; Kurka & Blackwood 2013; Lattimore et al. 2009; Markevičius et al. 2010; RSB; Scarlat & Dallemand 2011; Stupak et al. 2007 |
| | I.IC.3.3. Legal documentation of clearly stated tenure/contracts | Acosta et al. 2014; Augustenborg et al. 2012; Benjamin et al. 2009; FSC 2010; Markevičius et al. 2010; Lewandowski & Faaij 2006; US-RFS |
| C.IC.4. Communication and outreach | I.IC.4.1. Events and workshops for mutual learning and information sharing among stakeholders | Augustenborg et al. 2012; Hayes et al. 1999; Lattimore et al. 2009; Stupak et al. 2007 |
| | I.IC.4.2. Communication of research outcomes and long-term impacts | Lewandowski & Faaij 2006 |
| | I.IC.3.4. A unit to facilitate communication between different stakeholders | |

## 5. Conclusion

This study enhanced our understanding of local stakeholders' concerns and sustainability goals regarding new forest-based bioenergy systems, and generated a context-driven set of criteria and indicators for a regional forest-based bioenergy system. Despite diverse perspectives and opinions, our participants emphasized the need for locally relevant research on the economic and environmental viability of the technology, sustainable harvest limits of forest resources, and appropriate scale of the industry. Importantly, stakeholders underlined some key concerns that are not common to expert-led frameworks, including: local benefits through the use of local resources and skills, market assurance for feedstock producers, access to forestlands for local residents and tribal members, integration of the new bioenergy industry into existing facilities, and communication and outreach. The local context of a heavy reliance on energy imports, a very high energy cost, and a dwindling industrial base, largely explain the stakeholders' desire to use local resources and skills to produce energy locally. Similarly, forests are an integral part of local culture and livelihood, and land rights and access to forest products and forestland were important social indicators for the residents. Forests were an important driver for the region's economic development a century ago and remain so

today. However, residents have witnessed that forests clear-cut by the mining and logging industries have taken decades to regenerate. This explains the willingness to exploit forest resources but with stringent harvest guidelines and monitoring. Given the novelty of the forest-based biofuel industry to the region, market guarantees and assurances were considered to be important for the feedstock producers and investors. These concerns are region-specific and of greater significance to the stakeholders that are likely to be directly impacted by new interventions in the community. Therefore, identification of these concerns should come from bottom-up approaches. Top-down approaches often fail to consider these concerns that are more meaningful and important to local stakeholders. Understanding these contexts and significance using a bottom-up approach enhances credibility and relevance of the sustainability C&I, and also eventually helps tremendously in aggregating, weighting and interpreting indicators in a way that stakeholders can understand.

Participants stated that strong policy and regulations would be needed for sustainable bioenergy development, and sufficient institutional capacity to ensure its effective operationalization. These two sustainability principles are rarely addressed in existing international trade-driven SAFs and certification schemes. Participants also emphasized the need for public involvement in decision-making and the involvement of a local third party to monitor and evaluate the bioenergy system. Although ‘participation’ and ‘transparency’ are often cited as important sustainability criteria in most SAFs and certification schemes, they are vague on the extent of community engagement and the involvement of local parties in monitoring and evaluation.

Involving local stakeholders also permitted us to delve into some ambiguous terms. For example, ‘efficiency’ can mean different things at different stages of a bioenergy production system. The literature has generally failed to acknowledge this variability and often concentrates exclusively on the efficiency in energy production alone (La Rovere et al. 2010; Kurka & Blackwood 2013). In our study, participants cited efficiency as an important indicator (for economic viability) in terms of energy production (I.Ec.3.2), resource use (I.Ec.3.4, I.Ec.3.6) as well as in the end-use of the bioenergy (I.Ec.3.2). Furthermore, the interests, concerns and knowledge shared by our participants, particularly in the focus group meetings, enhanced the collaborative learning

process by exposing everyone involved to a diversity of perspectives. In order to facilitate collaborative learning, it is important for the stakeholders to 'recognize the legitimacy of views other than their own' (Schusler et al. 2003; pp. 318). Focus groups and workshop are some of the techniques that offered an opportunity for an interactive learning process for all our participants. This process also improved the credibility and legitimacy of decision-making processes pertinent to natural resource management.

The focus groups and interviews provided enough detail to form a complete set of criteria. However, these methods did not produce indicators for all criteria (i.e. participants had more difficulty suggesting indicators than criteria). Further research on the socio-ecological and economic contexts will be necessary for the selection and verification of indicators for all criteria (Efroymson et al. 2013; Dale et al. 2015). Furthermore, it must be noted that our (content) analyses of focus group and interview data do not establish or suggest causal relationships between the C&I presented here and the sustainability of bioenergy industry in the region. Historical data will be necessary for that, and also to set baselines. Most SAFs and certification schemes usually do not provide thresholds or limits for indictors, whereas our participants emphasized the need to set limits. Many have argued that not all sustainability criteria can be assessed in quantitative terms or matched with thresholds and targets (Lindner et al. 2010). Further research is needed to build a methodological approach to limit-setting for both qualitative and quantitative C&Is.

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*Appendix 4.1. Questionnaire framework for a focus group meeting*

1. Brief introduction about the project (research team)

2. Participants introduction session:
   2.1. Where do you live, work, areas of interest?
   2.2. How long have you been associated with the organization/group/club or agency you are representing today at this meeting?
   2.3. What are the areas your organization work on?
   2.4. Show on the map your land or radius of regular movements, and land use.
      i. What kind of benefits (economic, spiritual, cultural, and environmental) do you receive from your land?

3. We have divided wood based fuel production system into five components. These components are listed in the table below with examples:

| | **Component I**: Feedstock production | **Component II**: Production plant | **Component III**: Distribution and Energy Use | **Component IV**: Decision making and sustainable management |
|---|---|---|---|---|
| Depending upon the service coverage, these components may be further divided into:<br><br>**Local**<br><br>**Regional**<br><br>**National**<br><br>**International** | • Land owners (public, private, industrial, nonindustrial)<br>• Plantation management<br>• Natural resource managers<br>• Foresters and consultants<br>• Harvesting and Collection<br>• Waste management<br>• Storage<br>• Preprocessing | • Investors/ Venture capitalists<br>• Subsidy/Incentive providers<br>• Biorefineries<br>i. Fermentation<br>ii. Gasification<br>iii. Pyrolysis<br>iv. Blending<br>• Process waste management<br>• Storage of the products | • Biofuel and wood pellet distributors<br>• Local drivers<br>• Local consumers of wood pellet | • Policy making (regarding taxes, subsidy, incentives)<br>• Land (forestland/abandoned agricultural land) management agencies<br>• Land owners<br>• Planning and Monitoring |

Which of these component/s do you think your organization is (most likely to be) a part of? (if a new bio-energy production system is established in your area?)

4. Can you describe for us the ways in which you or your organization benefit from forestland in the region?

5. Are the retired croplands in the region benefitting you or your organization in anyway?
   a. If yes, how?

b. If no, do you see a prospect of these lands benefitting you/your organization in the future?

6. Do you think wood-based fuel production would be a suitable project for the region? If yes/no, why? (Challenges and opportunities, potential impacts)

*Appendix 4.2. Questionnaire framework for a semi-structured interview*

1
- What is your occupation?
- Where do you live? How long have you been living/working in this area?
- In your opinion, what is the most valuable or appealing thing about this area?

2 How do you use the land in the area? (live, agriculture, recreation, businesses etc)

3 What are the common uses of land around your area?

4 How valuable are they for your livelihood?

5 ***Component specific questions***

5.1. Feedstock production: Could you please describe your land properties? (whether they are forest, retired croplands, agricultural lands, or other)
- Who manages your land?
- How have you been using your land? (benefits: rent, agricultural products, lease, any other kind of products, emotional attachments?)
- (if not already involved in feedstock production) Would you be willing to use/lease your land for the feedstock production for fuel production? (e.g. grow plantations)
  - o If yes, what would be your motivation for doing so?
  - o If no,
    - ▪ Why?
    - ▪ What would be the factor/s, if there is/are any, which might change your decision?

5.2. Production plant: Are you involved in any kind of bioenergy production system currently?
- If yes, in what way? (Example: own a land where raw material for bioenergy production is grown, investor/shareholder, bioenergy plant owner, transportation service provider, employee at bioenergy plant.
- If no, do you see yourself being involved in one of the bioenergy production systems in the future?

5.3. Distribution and Energy Use: Do you use any kind of wood-based or crop-based fuels for your business or personal uses? How?
- What do you think about wood-pellet technology in relation to this region?

- What do you think about wood-based transportation fuel production in the area?
- What do you think is/are key factor/s to ensure continuous supply of these products in the market?

5.4. <u>Decision-making and sustainable management</u>: Do you see any way you/your organization could impact development of wood-based energy production in the area?

6 What do you think about bioenergy industry in general?
- Any downfalls or opportunities you can think of?

7 What do you think about using wood or forest residues for fuel production (wood pellet, wood chips, biofuels etc.) in your area?
- Do you see any potential threat to the environment because of this industry?
- How do you think it may benefit or harm your community?
    - Do you think the community will readily accept it?
    - What would cause it to be acceptable?
- What elements of economics do you think are most important for bioenergy industry to grow in this region?

8 How would you look at bioenergy production plant operating at close proximity to your land? Do you see it as opportunity or threat to your land? Why?

9 How do you see government efforts to inform local communities about forest-based bioenergy industry in the area?

10 What do you think will determine longevity of the industry, particularly in this region?

11 How do you want the land area in the region to look in the future?

# CHAPTER V: Use of participatory approach to develop a regional assessment tool for bioenergy production[23]

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***Abstract***

Recent years have witnessed a considerable upsurge in the number of certification schemes and sustainability assessment tools for bioenergy. Indicators used to measure sustainability by these mechanisms are often too generic, numerous and too broad for regional level implementation. Furthermore, these assessments are often weighted toward economic and environmental sustainability with less focus on social, cultural and institutional factors. This study was intended to overcome these limitations. We developed a community-driven regional assessment tool for forest-based bioenergy production in the Upper Peninsula of Michigan (USA). A combination of focus group meetings and individual interviews generated a list of criteria and indicators (C&Is). Participants included local landowners, farmers, township supervisors, timberland management companies, venture capitalists, government organizations and local interest groups. They generated a preliminary list of C&I in a series of focus groups and interviews, and narrowed the list using multiple criteria analysis (MCA) in a workshop. Local stakeholders weighed environmental protection as the most important and relevant sustainability principle. However, sustainability principles including policy and governance, and institutional capacity were weighted as important and relevant. The final set of C&I consisted of 17 criteria and 31 indicators (C&I in parentheses): Economic (3 & 6), Environmental (4 & 7), Social (6 & 8), Policy and regulations (2 & 4) and Institutional capacity (2 & 6). This set reflected the general balance across sustainability dimensions valued by the stakeholders. While expert-developed sustainability assessments are routinely biased toward easily quantifiable indicators, the indicators that were considered important and relevant by the stakeholders in this study included both quantitative as well as qualitative indicators, in almost equal proportions. This participatory MCA method identified criteria and indicators that were reflective of the regional context and the concerns of local stakeholders, and data for many of these C&I are readily available.

**Keywords**: bioenergy, participatory, multiple criteria analysis, sustainability, sustainable assess

# 1. Introduction

To ensure energy security and curb greenhouse gas emissions from fossil fuels, countries are mandating targets for the production and use of renewable energy, particularly since the early 2000s (e.g., US Energy Independence and Security Act of 2007; EU Directive on the Promotion of the use of biofuels and other renewable fuels for transport (2003/30/EC)). This has induced a rapid expansion of the production of bioenergy, particularly biofuels. In response, there has been a sharp increase in the number of initiatives to monitor and standardize the production of bioenergy products (van Dam et al. 2008). Most of the 67 certification schemes reviewed by van Dam et al. (2010) were focused on the environmental sustainability of bioenergy production. These initiatives are generally motivated by the growing interest in international trade obligations and other considerations (Elbehri et al. 2013), with little case-specificity (Florin et al. 2014).

Sustainability is an integrative function of environmental protection, economic viability and social equality (Burton 1987; Dixon & Fallon 1989; UNCED 1992; Gibson 2006; Mayer 2008); therefore, it is not possible to assess sustainability of any system by excluding one or two dimensions. While a few bioenergy certification programs address socio-economic aspects of bioenergy production, most neglect issues such as governance, social impacts, and the linkages among global, national and local contexts (van Dam et al. 2010; Florin et al. 2014). Policy, regulations, and institutional strength are crucial for sustainable bioenergy development (McCormick 2011). Nevertheless, van Dam et al. (2010) suggested that bioenergy assessments of developing countries are generally motivated by socio-economic concerns while assessments in developed countries focus more on economic and environmental dimensions of bioenergy production. Similarly, assessment tools used for micro and meso-scale assessments (e.g., Life Cycle Assessments, Cost-Benefit Analysis, and Environmental Impact Assessment) mostly focus on techno-economic and environmental aspects of bioenergy development, largely

failing to reflect socio-economic and other community concerns (Buytaert et al. 2011). This suggests the need for a comprehensive framework for building sustainability assessments at a variety of scales (Lewandowski & Faaij 2006; van Dam et al. 2010; Scarlat & Dallemand 2011; Florin et al. 2014). A few global-scale sustainability assessments address these shortcomings and incorporate all dimensions of sustainability (such as Roundtable on Sustainable Biomaterials (RSB), Roundtable on Sustainable Palm Oil (RSPO), Global Bioenergy Partnership (GBEP), International Organization for Standardization (ISO) etc.), However, the variety of feedstocks, geographical regions, cultural contexts, logistic requirements, and production processes make existing generic frameworks too broad and ambiguous for practitioners at the grassroots (Lewandowski & Faaij 2006; van Dam & Junginger 2011; Efroymson et al. 2013; Florin et al. 2014; Dale et al. 2015).

Bioenergy production is a complex system with multiple interconnected components. Therefore, an indicators-based sustainability assessment for bioenergy should be holistic and systemic, incorporating the participation of experts and actors from all components of the system (Buchholz et al. 2009; Dale et al. 2015). This is possible only through an inductive, collaborative and reflexive approach that involves all key stakeholders in the development of the framework (Lewandowski & Faaij 2006; Podger et al. *In Press*). There is growing evidence (particularly in forestry and agriculture sectors) that differences in opinions and priorities among stakeholders can be effectively mitigated at regional and local scales, where the number of stakeholders and project objectives are smaller and more manageable (Mendoza & Prabhu 2000; Khadka & Vacik 2012). Participation in decision-making processes by key stakeholders and local experts can enhance credibility, ownership, and context-specificity of the interventions, which are all imperative in the pursuit of sustainable development (Lewandowski & Faaij 2006). When stakeholder participation is perceived to be transparent, inclusive and interactive, it can reinforce trust and credibility, generating a more comprehensive conceptualization of the problem and identification of compromises (Reed 2008; Dietz 2013; Khadka & Vacik 2012). Reed argues that stakeholder participation in decision-making also contributes to better acceptance of emerging interventions in local contexts

(Reed 2008). Stakeholder engagement is also crucial in ensuring that the interventions and technologies cater to the local needs and goals by enhancing the social intelligence of the scientific communities (Dietz 2013; Buytaert et al. 2014).

This paper discusses the participatory development of a regional sustainability assessment, involving stakeholders from all key components of a potential bioenergy production system. In the earlier phase of this study, we identified the interests and values of key stakeholders in relation to regional bioenergy development. These concerns and values were then translated into an extensive list of sustainability criteria and indicators (C&I) using an expert-assisted approach[24] for a bioenergy production system (see Chapter IV). The main objective of this paper is to use the stakeholder workshop and Multiple Criteria Analysis methods to narrow down the long list of C&I into a comprehensive yet manageable set of sustainability C&I. In Section 2, we briefly discuss the methodologies: different phases of the research, and techniques used to collect and analyse data over the course of this study. In Section 3, we discuss our research outcomes and present the final sustainability assessment framework. In Section 4, we discuss the conclusions and limitations of our study.

## 2. Methods

Our study was conducted in the Western Upper Peninsula (WUP) of Michigan. The immense exploitation of the forestlands in the late 1800s and the early 1900s by the logging and mining industries had once left this region almost completely deforested (Hamel et al. 2013). Following the closure of these industries by the 1960s, the subsequent outmigration had a tremendous impact on the regional economy. Over several

[24] An expert-assisted approach is a participatory approach, which involves the elicitation of local knowledge to understand the local socio-ecological context. In this approach, experts only facilitate the process and avoid using pre-defined criteria and indicators to generate a sustainability framework (Vaidya and Mayer 2014).

decades, the forests have regenerated and currently more than 80% of the WUP land is forested (Mayer & Rouleau 2013). The forest industry remains as an important part of the local economy and culture in the WUP. However, the youth population has continued to decline and the WUP remains an aging population (US Census 2010).

We divided the study into three distinct phases: I. Stakeholder selection; II. Qualitative development of C&I; III. Preference elicitation using Multiple Criteria Analysis (MCA) techniques (Fig 5.1). We accomplished stakeholder selection through stakeholder analysis (Reed et al. 2009). We collected data using a combination of three different participatory techniques for the latter two phases: focus groups and interviews for phase II (see Chapter IV) and one workshop to accomplish phase III. Here we will limit our discussion to the outcomes of phase III of this study. The main purpose of phase III was to solicit feedback using MCA techniques on the importance and relevance of criteria and indicators generated from phase two.

**Study Site: Western Upper Peninsula of Michigan**

**Phase I: Stakeholder Analysis**

- Identify key components of the bioenergy production system
- Identify sectors (forestry, landownership, environment, business etc.) that could be impacted by new bioenergy development in the WUP
- Identify individual and organizations (private, public, government, non-government) who could impact or be impacted by bioenergy development decisions
- Prioritize potential participants for involvement in the study based on their association, time availability and willingness to participate

**Outcome: Selection of participants**

**Phase II: Qualitative development of C&I**

- Seven focus group meetings (which involved introduction to the project, open discussion about the challenges and opportunities associated with forest-based bioenergy production in the WUP)
- Twenty-nine individual semi-structured interviews (to understand individual perceptions about the social, environmental and economic cost and benefit of forest-based bioenergy system)
- Literature review on bioenergy sustainability assessments

**Outcome: Preliminary set of C&I supported by literature review and local context**

**Phase III: Preference Elicitation**

- Stakeholders Workshop (MCA techniques were used to understand value, preference of the stakeholders; supplemental materials: glossary, PowerPoint presentation of tutorial on how to do MCA)

**Outcome: Evaluation of C&I based on their relevance and importance to our participants**

**Figure 5.1. Summary of research phases**

### *2.1. Phase I: Stakeholder selection*

We identified stakeholders using a number of sources, including professional networks, snowballing and Internet searches. We invited potential participants through physical mail and/or email, which conveyed a brief description about the project, their role in the study, time commitments required of them, and incentives for their participation in the project.

A total of 31 stakeholders participated in the study, representing four major stakeholder groups as illustrated in Fig 5.2[25].

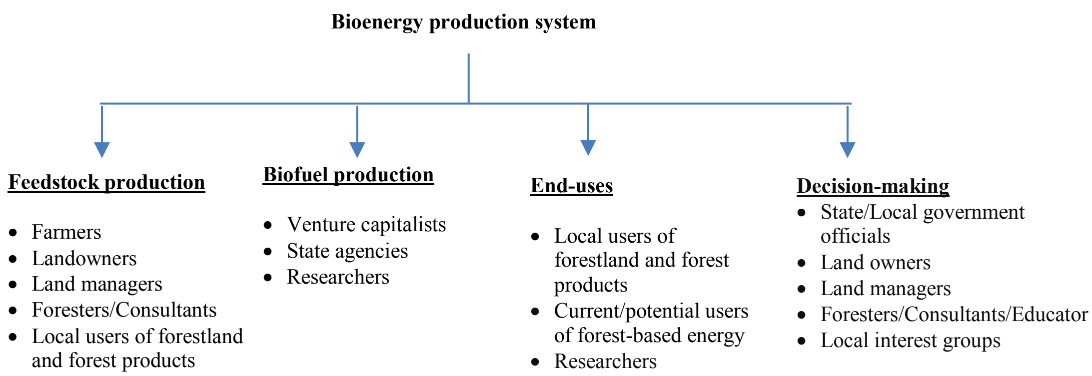


**Figure 5.2. Distribution of different participants over stakeholder groups**

### *2.2. Phase II: Qualitative development of C&Is*

The use of focus group meetings and interviews conducted during this phase revealed the concerns of the stakeholders and their information needs. Participants did not only provide insights and opinions, but also helped us to understand the underlying contexts. This in turn helped us to transform their concerns and values into criteria and

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[25] Some participants have been counted in more than one category, depending upon the number of stakeholder groups they represented.

indicators through appropriate codification, aggregation and categorization. Additionally, the literature review on sustainability assessments allowed us to partially validate the initial set of C&I, and highlighted the influence of the regional context on the sustainability goals of the community. Subsequently, we designed a hierarchical framework consisting of sustainability principles, criteria and indicators similar to the one described in Prabhu et al. (1999), originally designed for sustainable forestry decision-making (Table 5.1).

**Table 5.1. Criteria and indicators derived from focus group and interview data**

| Sustainability Principles | Criteria | Sub-criteria/Indicators |
|---|---|---|
| **Economic** | Contribution to local economy | Employment |
| | | Use of local resources |
| | | Value-addition to forest products |
| | | Infrastructure development (roadways, railways, hospitals, training institutes) |
| | Energy security | Net energy import dependency |
| | | Consistent/Reliable supply of energy products |
| | | Competitive cost of biofuel |
| | Economic viability | Cost of production/operation |
| | | Energy return over investment (EROI) or Energy balance (Efficiency in production and use); Useful energy output /Fossil energy input, mileage per gallon |
| | | Energy from forest-based biomass compared to energy from fossil fuels; British Thermal unit (BTU) per volume |
| | | Travel distance between collection points of feedstock and production and distribution points; Within …. miles |
| | | Return over investment; Net investment/ initial investment |
| | | Resource efficiency of the process; Fuel production per volume of feedstock or hectare |
| | | Scale of production: Local/Regional |
| | Market acceptance & adaptability | Ability to use diverse feedstock |
| | | Ability to produce diverse products |
| | | Return rate; Payback time in years |
| | | Cost of returning to previous land use |
| | | Comparative gain over other investments |
| | | Technology, infrastructure, machineries and equipment; Production of energy, use of energy |
| | Competition for resources | Availability of forest biomass; Price and availability of forest products |
| | | Availability of lands for other purposes; Land price; land availability |
| **Environmental** | Air and greenhouse gases | GHG emissions; $CO_2$ equivalent emissions, change in carbon sequestration properties |
| | | Prevent air pollution (Particulate matter, NOx, SOx, CO) |
| | Ecosystem and wildlife habitat | Biodiversity |
| | | Controlled use of agrochemicals |
| | | Avoid any disturbance to high conservation value areas |

| | | |
|---|---|---|
| | | Controlled use of forestland for bioenergy operations |
| | Invasiveness | Use of non-native species/genetically engineered species for bioenergy production |
| | Water quality | Prevent water contamination (Herbicide concentrations in water, pH, eutrophication) |
| | Land/Soil quality | Productivity/yield, soil organic compounds, soil nutrient, pH, soil compaction |
| | | Land (soil) conservation/management |
| | Waste management | Residue management and utilization |
| | | Waste management; Waste volume; Management plan |
| **Social** | Cultural value | Access to recreational activities in public lands |
| | | Protection of local/tribal heritage and sites |
| | | Access to forest products for local inhabitants |
| | | Aesthetics, change in forest cover, general cover type of the region |
| | Ethical concern | Avoid any disturbance in the livelihood of the local residents; Noise, smell, traffic |
| | | Protection of land rights and access for local residents |
| | | Work conditions; Income (fair wage/benefits); Safety |
| | Food security | Availability of agricultural land; change in agricultural land area |
| | | Food and feed (for livestock) price |
| **Policy & regulations** | Precautionary and support mechanisms | Sustainable harvesting guidelines |
| | | Inventory of accessible forest resources |
| | | Compliance to best management practices |
| | | Subscription to certification schemes |
| | | Subsidies and tax incentives |
| | | Policies to protect the local industry from impact of fluctuating oil prices and foreign competition |
| | Compliance with laws and regulations | Payment of legally prescribed fees, taxes, royalties |
| | | Compliance with local standards, laws and regulations |
| | | Compliance with national and international standards |
| | Regulatory policies | Regulation to prevent the use of agricultural land |
| | | Regulation to control the use of forest |
| | | Traffic controls |
| | | Pollution control mechanisms |
| **Institutional capacity** | Transparency | Participation: involve public and citizen advisory panel in decision-making |
| | | Public availability of management plans |
| | | Involvement of local organization, institutions or companies in the monitoring and control process |
| | Integration and colocation | Mechanism to integrate bioenergy projects into existing developmental projects and programs (e.g. carbon projects, community development) |
| | | Co-location of bioenergy production on or near existing facilities such as paper and pulp industries |
| | | Education and training facilities to produce skilled workforce |
| | | Research and development programs for new technologies and processes |
| | Administration and Management | Documentation and reporting of management and operation plans |
| | | Regular monitoring and evaluation of operational and management systems |
| | | Legal documentation of clearly stated tenure and contracts |
| | Communication and outreach | Hold events and workshops for mutual learning and information sharing among key stakeholders |
| | | Communication of research outcomes and long-term impacts |
| | | Existence of a unit to facilitate communication between different stakeholders |

### *2.3. Preference elicitation: Stakeholder workshop*

Criteria that are widely used in the evaluation of sustainability indicators are importance, relevance, practicality and their sensitivity to the changes caused by the system of concern (Reed et al. 2006; Buchholz et al. 2009; Buytaert et al. 2011; McBride et al. 2011; Hák et al. 2012; Kurka and Blackwood 2013). In our study, participants evaluated the preliminary set of sustainability criteria for their importance (to the participants) and relevance (to the wood-based bioenergy production in the WUP) at the stakeholder workshop. The workshop provided an opportunity for interaction among researchers and local stakeholders, and for researchers to share outcomes and progress with the participants. Although the criteria and indicators were derived from stakeholders' concerns and perceptions, allowing participants to provide feedback on the study outcomes was important to ensure the credibility and validity of our study findings. The evaluation of C&I based on their sensitivity and practicality was beyond the scope of this study. The workshop followed three steps:

#### *2.3.1. Preparation*

*2.3.1.1. Criteria and indicators:* Not all criteria and indicators in the preliminary list were bioenergy-specific, and many of them reflected the general concerns of the participants as a community. On the other hand, some of the bioenergy-specific criteria and indicators were relevant to one group of stakeholders with little relevance to another group. For instance, 'land management opportunities for landowners' and 'professional consulting services for landowners and farmers' are clearly relevant to feedstock producers, while they are of little relevance to the bioenergy producers or potential consumers of the bioenergy products. Therefore, in order to make the assessments comprehensive and easy to work on for all participants, we rearranged the criteria and indicators in the preliminary list into two broad categories: general (for criteria that reflected the concerns of the stakeholders as a community) and bioenergy-specific (for criteria that were reflective of participants' specific concerns as stakeholders of the bioenergy system) (as shown in Fig 5.3).

*2.3.1.2. Participants:* We invited all study participants (36 in total) who had participated in phase II, to the half-day workshop (i.e. phase III). Only 17 participants could attend the workshop, along with five researchers working on different components relevant to forest-based bioenergy development in the WUP. Fifteen of the invited participants expressed interest in participating in the workshop but could not due to time conflicts. We sent a survey package to record their preferences. The data collection package handed over to the participants at the workshop (or the survey package mailed to the survey participants) contained a handout that explained Multi Criteria Analysis (MCA) techniques, an assessment worksheet, and a glossary that briefly described all the criteria listed in the assessment sheet (Appendix 5.1. for a sample of assessment worksheet). Out of those 15 participants to whom the survey package was sent, nine returned the worksheet. Altogether 31 stakeholders participated in this phase.

### *2.3.2. Preference elicitation tools*

Prior to the preference elicitation, we gave a PowerPoint presentation to participants about the research activities conducted up to that point, expected outcomes of the workshop, and a brief overview of MCA techniques that participants would use to evaluate the criteria and indicators. The presentation also included a brief introduction about the project, objectives of the workshop agenda, purpose of the workshop, and the project as a whole.

In our study, we used three different Multiple Criteria Analysis (MCA) techniques i.e. analytical hierarchy process using pairwise comparison[26], ranking and rating method, to elicit preferences from the stakeholders (for procedural details about these methods, refer to Saaty 2000; Mendoza & Prabhu 2000). We used these simple MCA techniques for preference elicitation over other more popular software-based MCA techniques (Myšiak 2006) because: i) no special skill or technology is required to use

[26] Pairwise comparison involves one-to-one comparison between criteria.

them and they are easy to learn and understand, which was important in our case as it involved participants (or 'decision-makers') from diverse backgrounds (i.e. both scientific and non-scientific); ii) it can be used to evaluate both quantitative and qualitative criteria and indicators iii) these methods require relatively less time for decision-making (Mendoza and Prabhu 2000; Saaty 2000; Myšiak  2006). MCA methods such as pairwise comparison, outranking and rating are relatively easier to use than other software-based techniques, which can encourage a greater participation of stakeholders from a wide range of backgrounds to aid decision-making processes (Mendoza & Prabhu 2000; Kurka 2013). For this reason, MCA is often associated with transparency and credibility (Mendoza & Prabhu 2000, 2005; Kurka 2013).

MCA is a decision-making tool used when an evaluation process involves multiple, competing interests and objectives among diverse stakeholders. It has been used extensively in a wide range of resource management and planning projects (Mendoza & Prabhu 2000; Myšiak  2006; Uhde et al. 2015), including sustainable energy development and planning (Pohekar & Ramachandran 2004; Buchholz et al. 2009; Kowalski et al. 2009; Wang et al. 2009; Scott et al. 2012). It has been used for a variety of purposes, such as for choosing between management alternatives or technology options against a set of pre-defined criteria (Doukas et al. 2007; Evans et al. 2010; Scott et al. 2012). In some cases it has been used to identify the optimal criteria or indicators to assess an emerging intervention or technology (Terrados et al. 2007; Buchholz et al. 2009; Kurka & Blackwood 2013). One of the important advantages that MCA has over many other decision-making tools (such as LCA and CBA) is that it can work with both qualitative as well as quantitative data (Mendoza & Prabhu 2000; Uhde et al. 2015).

Our participants used pairwise comparison to make one-on-one comparisons between criteria. Participants also rated criteria and indicators from 1 to 9 based on their relevance and importance[27]. Multiple techniques were used to assess a set of criteria and indicators whenever possible, in order to account for inconsistency in decision-making. Ranking prompted participants to apply an ordinal scale to the criteria based on their

[27] Where 1= weakly important (or relevant when the rating is for relevance) and 9= extremely important.

relative importance or relevance. Aggregate rankings were used to make decisions about the most important and relevant indicators and criteria.

### *2.3.3. Assessments of C&I*

We divided the workshop exercise into three segments: individual assessment, stakeholder group assessment, and mixed-group assessment. We encouraged participants to write down notes on terms and phrases that they found difficult to understand, and to note C&I that they felt were redundant or missing from the list.

*2.3.3.1. Individual assessment:* Participants used pairwise comparison and rating methods to individually assess general criteria representing economic, environmental and social concerns and the corresponding indicators. Participants evaluated these C&I based on their relative importance and relevance to the forest-based bioenergy industry in the context of the WUP. To make the assessment less time-intensive for the participants, use of pairwise comparison (which although is more reliable (Saaty 2000), is relatively more complex and takes longer than simple rating and ranking methods) was limited to individual assessment of general criteria under three primary sustainability principles: environmental, economic and social. Participants also used a rating method to evaluate the criteria based on their relevance and importance. They also rated environmental and socio-economic indicators (most of which were previously validated through a literature review) for their relevance to bioenergy production. We designed this assessment based on the assumption that local stakeholders' knowledge and perceptions would lead to the general C&I that are more reflective of the local context and interests of the community. We used individual assessment for general socio-economic and environmental C&I because of their (large) numbers and relevance to all stakeholders. Running them through group assessments may have entailed longer discussion times, which in turn could have affected the effectiveness and efficiency of the process. Despite the willingness shown by our participants in contributing to the studies, conflicting schedules and travel distance to the workshop made time one of the limiting factors for our study.

*2.3.3.2. Mixed group assessment:* We inter-mixed all participants to create four heterogeneous groups of stakeholders. This group evaluated criteria and indictors under 'Consumers' concerns' and 'Policy and institutional concerns', both under the 'General criteria' category in Fig 5.3. All groups used ranking and rating systems to assess the given list of C&I for their relevance and importance. We structured the group assessment based on the assumption that 'Consumers' concerns' and 'General policy and institutional concerns' were relevant to all stakeholders, because everyone plays the role of consumer and occasionally a decision-maker.

*2.3.3.3. Stakeholder group assessment:* For this assessment, we categorized our participants into three homogenous[28] stakeholders' groups (feedstock production, biofuel production, decision makers) depending on the components of the bioenergy production system that they represented. They worked with the criteria that were specific to the components of bioenergy production system represented by their groups. For example, the 'feedstock production' group evaluated criteria such as 'location of the plantation', 'land management opportunities for landowners', 'professional consulting services for landowners and farmers', and 'long-term contracts between buyers of feedstock and the growers of feedstock'.

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**28** 'Homogeneity' has been stressed on in the structuring of the groups because studies have shown that a homogenous group is more likely to encourage unhindered communication and smooth exchange of information (Prell et al. 2009).

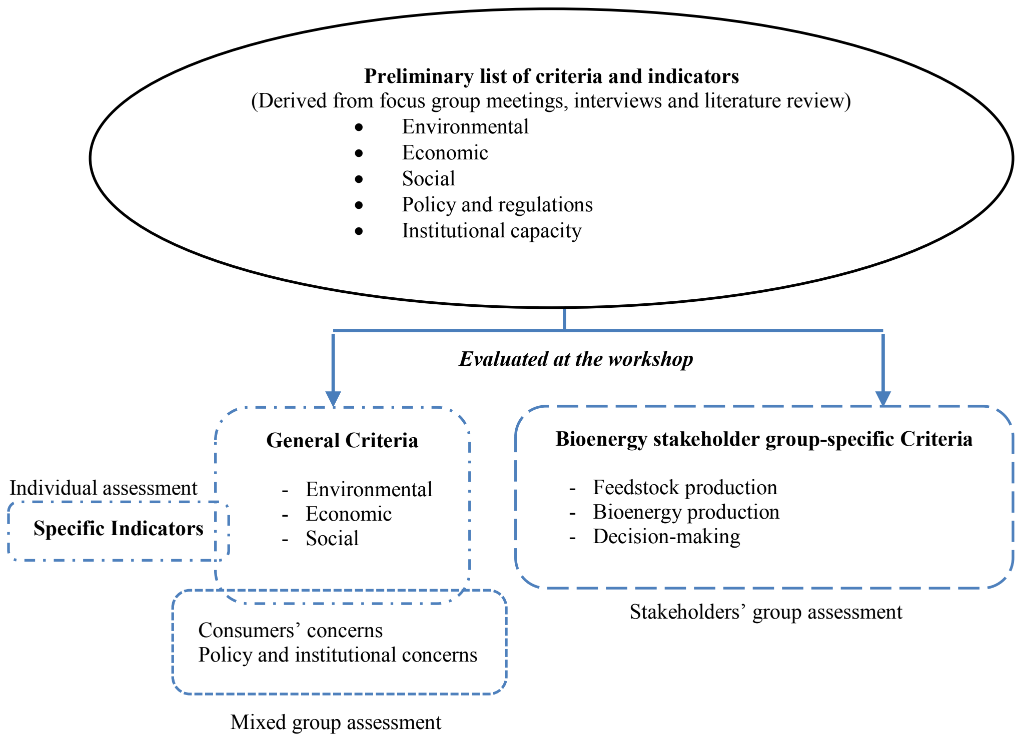


**Figure 5.3. Rearrangement of criteria and indictors**

## 3. Results and Discussion

We calculated pairwise ranks, and aggregate ranks using Microsoft Excel and Analytical Hierarchy Process formulae adapted from *Decision Modelling with Microsoft Excel* (Mendoza and Prabhu 2000; Moore and Weatherford 2001). In pairwise ranking, only the comparisons that had a consistency ratio (CR) $\leq 0.1$ were included in the calculation of the average ranks. For weighted average rank calculation, n (total number of samples) was between 10-13 for each pairwise comparison after eliminating the matrices with CR $> 0.1$. Criteria and sub-criteria with the highest aggregate rankings were listed in the final set. In case of indicators' ratings for relevance, we used a weighted average rating for indicators in each criterion to select the most relevant indicator/s for the assessment framework. Any criteria and indicators with aggregate

rating below 6 (i.e. less than strongly relevant/important) were eliminated. For example in table 5.2, both indicators of the criterion ‘Food security’ and all four indicators of ‘Improved neighbourhood’ were rated equal to 5 or lower. Therefore, ‘Food security’ and ‘Improved neighbourhood’ are not included in the final set of C&I. For the rest of the criteria, indicators with the highest ratings are included in the final set.

**Table 5.2. Results from the individual assessment of specific social indicators (derived from participatory techniques and literature) using rating systems for relevance**

| Social criteria (C.S) | Social indicators (I.S) | Relevance | | |
|---|---|---|---|---|
| | | Average rating | SD of rating | Relative weights |
| **C.S.1. Food security** | I.S.1.1. Change in local agricultural land area | 5.07 | 2.46 | 0.52 |
| | I.S.1.2. Food and feed (for livestock) prices | 4.67 | 2.29 | 0.48 |
| **C.S.2. Education/ Capacity building of the community** | I.S.2.1. Skill transfer and training opportunities | 6.57 | 1.83 | 0.52 |
| | I.S.2.2. No. of educational resources/presence of information resources | 6.10 | 1.77 | 0.48 |
| **C.S.3. Improved neighbourhood** | I.S.3.1. Odour | 5.31 | 2.49 | 0.26 |
| | I.S.3.2. Noise | 5.28 | 2.07 | 0.25 |
| | I.S.3.3. Traffic volumes | 5.20 | 2.07 | 0.25 |
| | I.S.3.4. Crime rate | 4.93 | 2.55 | 0.24 |
| **C.S.4. Work conditions** | I.S.4.1. Safety of workers | 6.90 | 1.90 | 0.28 |
| | I.S.4.2. Health condition of workers | 6.52 | 2.20 | 0.27 |
| | I.S.4.3. Fair wage conditions | 6.37 | 2.17 | 0.26 |
| | I.S.4.4. Gender-based discrimination at work | 4.73 | 2.70 | 0.19 |

Although C&I were evaluated using different methods and in different group structures by our participants at the workshop, the results from all assessments have been combined and rearranged in the final set under five different sustainability principles: economic, environmental, social, governance, and institutional capacity.

One of the benefits of a bottom-up approach to developing sustainability assessment is that the context drives the preferences, rather than a pre-defined set of principles (Gibson 2006). Our findings support this assertion. ‘Policy & regulations’ and ‘Institutional capacity’ were suggested as important and relevant sustainability principles by the stakeholders in our study. They were rated and ranked similarly (in terms of both importance and relevance) to social, economic dimensions, although the environmental

dimension was considered to be the most important (see Fig. 5.4) (for results from preference elicitation exercises, please refer Appendix 5.2).

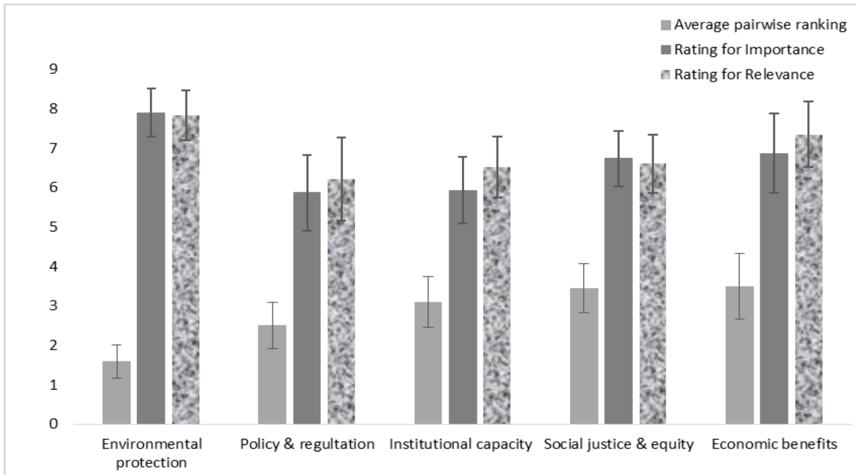


**Figure 5.4. Individual assessment using pairwise comparison and rating methods: Sustainability principles**

### *3.1. Sustainability assessment tool*

Tables 5.3-5.6 introduce the results of the MCA, the final set of C&I for a regional bioenergy industry, based on the stakeholders' preference elicited through ranking and rating exercises. The final set of sustainability criteria, sub-criteria/indicators for different sustainability principles are presented in the following section in separate tables. For each sub-criterion/indicator, we identified relevant aspects of the bioenergy production system (indicated by shaded boxes in the following tables) and the potential source/s of data (also included in tables below).

#### *3.1.1. Economic criteria*

Most of the economic indicators chosen as the most important and relevant by our participants have been widely used and cited as important economic or socio-economic indicators in relation to sustainable energy in the literature (Buytaert et al. 2011; Dale et

al. 2013; Kurka & Blackwood 2013). The use of local resources was heavily emphasized in our study (Table 5.3).

**Table 5.3. Final set of economic C&I[29]**

| Criteria | Sub-criteria/ Indicators | Direction to sustainability | Potential sources of data |
|---|---|---|---|
| Local economy | Unemployment rate | <5.4%[30] | US Bureau of Labor Statistics (US BLS) |
| | Local revenue (per capita personal income in USD) | >34,685[31] | US Bureau of Economic Analysis (US BEA) |
| Resource efficiency | Wood biomass availability/price | = | US Department of Agriculture (USDA)- Forest Inventory and Analysis, MI-Department of Natural Resources |
| | Fossil energy return on investment (EROI) | >1[32] | Michigan Forest Biofuels Research, US Department of Energy (USDoE)-Biomass Program |
| | Use of local resources | ↑ | Survey of bioenergy plant |
| Profitability | Return over investment | ↑ | Survey of energy plants and feedstock producers, Techno-economic assessments |

## *3.1.2. Environmental criteria*

Of all the sustainability indicators used in relation to the sustainability assessment of bioenergy systems, environmental indicators are probably the most generalizable and widely recognized. Although our participants rated environmental sustainability as the most important of all criteria, many were not able to identify or recommend environmental indicators. Many participants expressed difficulty in understanding terminologies related to environmental indicators, and some did not provide ratings for some environmental indicators. Under such circumstances, non-responses were not

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[29] Current data have been included for selected indicators to suggest sources for a baseline analysis and the direction toward sustainability. When data were not available, the direction has been indicated as ↑ or ↓ or = signs to indicate whether they should increase/improve, decrease/decline or remain intact/balanced, as compared to the baseline. For qualitative indicators, directions have been indicated as √ (for 'Yes' or affirmative) and X (for 'No' or negative) measurements.
[30] Estimate from September US BLS 2015
[31] Estimate from US BEA 2014
[32] Estimate varies depending on boundaries, subsidies, externalities, and fuel versus biofuel production system (Townsend et al. 2014)

counted into the calculation of average ratings. The resulting list of environmental criteria and indicators are presented below in the Table 5.4.

**Table 5.4. Final set of environmental C&I**

| Criteria | Sub-criteria /Indicators | Direction to sustainability | Potential sources of data |
|---|---|---|---|
| Water quality | Nutrient concentration (N, P) | ↓ | United States Geological Survey (USGS), Michigan State University (MSU) Extension |
| | Herbicide/pesticide concentration | ↓ | United States Geological Survey (USGS), MSU Extension |
| Air quality | Particulate matters (PM), CO, SOx, NOx | ↓ | United States Environmental Protection Agency (US-EPA), EPA (National Emissions Inventory, Monitoring services) |
| | Greenhouse gases ($CO_2$, $CH_4$, $N_2O$, $O_3$) | ↓ | EPA (National Emissions Inventory, Monitoring services) |
| Soil quality | Soil erosion/soil compaction | ↓ | USGS, United States Department of Agriculture (USDA) |
| | Nutrient (Soil organic compound/ Nitrate/ Phosphate) | = | USGS, USDA |
| Ecosystem | Avoid invasive species/ Use native species | √ | Michigan Department of Natural Resources, USDA |

### *3.1.3. Social criteria*

The social criteria had a balance of quantitative and qualitative indicators (Table 5.5). All social indicators have been incorporated into a single set, regardless of how they were evaluated (individually or in groups). Although social indicators in general have been largely overlooked in the majority of sustainability assessments, social indicators for criteria such as food security, transparency and participation are increasingly being integrated into sustainability assessments for energy systems (Buytaert et al. 2011; Kurka & Blackwood 2013; Florin et al. 2014). Indicators related to participation and transparency were also weighted highly in our study; however, 'food security' indicators were not weighted as highly for relevance.

**Table 5.5. Final set of social C&Is**

| Criteria | Sub-criteria /Indicators | Direction to sustainability | Potential sources of data |
|---|---|---|---|
| Participation | Key stakeholders' participation in decision making | √ | Survey of stakeholders |
| Transparency | Public availability of management plan | √ | Survey of stakeholders, Monitoring reports |
| | Communication of research outcomes and long-term impacts | √ | Survey of stakeholders |
| Work condition | Workers safety | √ | Survey, Project plan |
| Recreational values | Recreational activities/areas | = | DNR, WUPPDR, Survey |
| Educational/capacity building | Skill transfer and training opportunities | ↑ | Survey, Project plan |
| Consumer concerns | Reliability/consistent supply of the product | √ | Market survey |
| | Environment-friendly | ↑ | Market survey, Techno-economic assessments |

### *3.1.4. Criteria for governance and institutional capacity*

This set represents policy, institutional building and management concerns of the participants (Table 5.6). Unlike in the earlier three sets, all the indicators in this set are qualitative, and data for these indicators would need to be collected.

**Table 5.6. Final set of policy & regulation, and institutional capacity related C&Is**

| Sustainability Principles | Criteria | Sub-criteria /Indicators | Direction to sustainability | Potential sources of data |
|---|---|---|---|---|
| Policy & Regulations | Regulatory policies | Pay all legally prescribed fees/royalties/taxes | √ | *ex post* survey of stakeholders |
| | | Compliance to state standards and regulations | √ | Monitoring agencies |
| | Precautionary policies and support mechanisms | Compliance to sustainable harvesting practices | √ | *ex post* survey of stakeholders, Government monitoring agency |
| | | Protection of landowners' rights | √ | Ex post survey of the landowners |
| Institutional capacity | Logistics | Water source | √ | Baseline study |
| | | Technical expertise | √ | Baseline study |
| | | Consistent supply of feedstock/products | √ | Baseline study, *ex post* market survey |

| | | | | |
|---|---|---|---|---|
| | Management & monitoring | Regular monitoring | √ | Monitoring agencies |
| | | Residue management and utilization | √ | Project plan, Monitoring reports |
| | | Colocation of biorefineries in existing facilities | √ | Project plan, Monitoring reports |

### *3.2. Measurable sub-criteria/indicators and eliminations*

From the final list of C&Is, the indicators that were rated lower were eliminated, particularly if the variance for the calculated means were also smaller (Mendoza & Prabhu 2000). For those indicators with no available data, we chose the indicator rated and/or ranked next highest.

While some C&Is preferred by the stakeholders are clearly measurable and are supported by existing databases, others (mostly concerning social, policy and management issues) were inherently qualitative and their measurement would require additional data collection through qualitative research methods (such as a survey-based approach). For such criteria rated and ranked highly important and relevant (such as 'Compliance to sustainable harvesting practice', 'Pay all applicable and legally prescribed fees/royalties/taxes'), existing databases were not helpful. Therefore for these, an *ex post* monitoring and evaluation by the state agencies will be necessary.

### *3.3. Difficult indicators*

A few participants expressed confusion in understanding terms such as 'Institutional capacity', 'Transparency' and 'Compliance'. Participants particularly struggled with rating indicators under environmental criteria; at least 6 out of 22 workshop participants expressed difficulty in understanding or assessing the environmental indicators, despite the assistance of the facilitators and the glossary provided to each participant at the workshop. Environmental indicators are the most extensively used sustainability indicators in the literature for assessing sustainability of bioenergy production (van Dam et al. 2010). At the focus groups and interviews, however, most participants hesitated to provide specific indicators for environmental

criteria that they perceived as important, citing their lack of awareness about the potential impacts of bioenergy production on the environment. The difficulty among the participants in evaluating environmental indicators may be explained by the fact that these were expert-driven, and mostly included technical terminologies for environmental indicators.

In a similar study to evaluate sustainable development indicators for Marine Protected Areas, Marques et al. (2013) attributed unanswered questions in their survey by stakeholders to two possible reasons: either lack of knowledge about the matter, or a lack of interest in the given issue. Interaction with participants at the workshop suggested that the former may be the case in this study. When a criterion or an indicator was not ranked/rated, the response/ non-response was not taken into account for the calculation of the average rank/rate.

### *3.4. Interesting criteria/indicators*

Interestingly, some of the sustainability indicators ('benefits from external trade', 'infrastructure development in the region', 'youth population in the region' and indicators related to food security) that were frequently discussed in focus groups and interviews, when evaluated based on their relevance and importance at the workshop, were rated significantly lower. Although 'food security' was rated as important and relevant at the criteria-level (see Appendix 5.2), pertinent indicators (i.e. food price, change in local agricultural land area, restrict use of agricultural land for biofuel production, availability of agricultural land) were rated significantly lower for their relevance to wood-based bioenergy production. During the focus group and interviews, participants associated forest-based bioenergy more with residues and wastes from forest-based industries, than with plantations and food crops. This may explain the lower ratings for relevance of food security indicators despite 'food security' being rated highly for importance.

External trade was brought up as an important concern by venture capitalists in focus groups and interviews. However, at the workshop it received the lowest aggregate weighting for relevance and importance as an economic criterion. Indicators related to

employment, energy security, resource efficiency and use of local resources were rated and ranked higher in the assessment (in both criteria as well as indicator level assessments) than those related to external trade. This may suggest that stakeholders were more concerned about ensuring economic benefits to the community through self-reliance in energy and local employment, than through expansion of external trade.

Similarly, in focus groups and interviews, the loss of the youth population for jobs elsewhere was frequently cited as an effect of the shrinking economy. However, relative weightings suggested that participants on average considered youth population to be the least relevant indicator of ‘local economy’. The fact that ‘employment’ was rated the highest in the given criteria suggests that participants may have viewed ‘youth population’ as redundant indicator in the list, hence rated lower. Participants often associated a lack of employment with the dwindling youth population in the region in focus groups and interviews.

### *3.5. Variability in judgments*

Participants were allowed to choose their own methods to reach consensus and provide a collective judgment in the given worksheet. The judgments made among the groups usually involved averaging out the individually assigned rankings and ratings within the group. Some (but not all) groups made decisions collectively, preceded by intense discussions.

The large variance (standard error) across almost all criteria and indicators could originate from two sources. First, some of the participants struggled with the data collection tool, and the large standard errors could reflect some confusion over the tool itself. Based on the consistency index, participants were found to be less comfortable and consistent in making judgments using pairwise comparison methods. Our results also suggest that on the whole, our participants saw little difference between importance and relevance, and perhaps one of the two can be omitted in the future. Second, there could be wide disagreement among stakeholders (or even within stakeholder groups) regarding

the relative utility of criteria and indicators; in this case, the standard error provides a measure of the diversity within our sample group.

Finally, in the case of a few criteria and indicators (such as 'Subsidies and taxes'), the high priority may reflect a diversity of opinion and possible interpretations; in these cases, one must go back to the conversations in the focus groups and interviews. Rating and ranking for 'Subsidies/tax incentives' by a stakeholder (biofuel production) group were not consistent with the assessment done by the mixed groups and another stakeholder (feedstock production) group. While the stakeholder (biofuel production) group ranked and rated it the lowest for relevance as well as importance, mixed groups ranked it higher in importance but lower in relevance, and lastly, stakeholder (feedstock production) group rated financial/government incentives as one of the most important and relevant indicators. On the other hand, survey participants rated 'Subsidies/tax incentives' the lowest in importance. 'Subsidies/tax incentives' was one of the most contentious issues in the focus groups and interviews: some participants expressed that bioenergy production would need to be subsidized in order to be successful, while others felt that a bioenergy industry should not receive subsidies to be considered "sustainable" (in the sense of persisting in the long term). Still other participants considered subsidies to the fossil industry to be an important issue in bioenergy sustainability, but were arguing for the elimination of all subsidies. All of these positions consider subsidies to be an important issue, but for different reasons. Therefore, the high priority of "subsidies and taxes" should not be interpreted as uniform support for subsidizing the bioenergy industry, for example. This indicator was omitted from the final list of C&I due to a lack of consistency in the relevant judgments.

### *3.6. Sustainability assessment and its policy implications*

The Upper Peninsula (UP) of Michigan is well positioned to benefit from wood-based bioenergy production, with forest industry being one of the top industries in the region (Froese et al. 2007). Although renewable energy standards in Michigan have mainly concentrated on local electricity generation (Quackenbush et al. 2015), research

on innovative ways to efficiently use wood-biomass to produce transportation fuel is also ongoing (Shonnard et al. 2008; Jenkins & Sutherland 2014). A stakeholder-driven regional sustainability assessment tool can play an important role in informing policy-makers about the key areas that may require intervention for the sustainable development of this industry.

The Michigan Public Act 295 (2008) stipulated that electric providers in the state have ten percent of electricity produced from qualified renewable energy sources by 2015 (Quackenbush et al. 2015). Until 2012, wood-based biomass was the primary contributor to the Michigan renewable energy portfolio (RPS). In 2014, biomass contributed 35% of the Michigan RPS compliance target (EIA 2015). Although the utility companies with renewable energy contracts in Michigan claim that they have met the 2015 compliance target, they have supported removing the mandates (VanHulle 2015). Similarly, the Renewable Energy Amendment (2012) that proposed an increased renewable energy target of 25% to be met by 2025 (Proposal 3) was defeated at the state's electorate. Nevertheless, Li et al. (2014) suggest that renewable energy is widely supported by the Michigan public and the defeat of Proposal 3 does not reflect public opinion regarding renewable energy. While this claim requires further research, most of our participants were interested in local energy production using renewable resources and in learning about the potential for wood-based bioenergy. Many participants did mention a need for more research, outreach programs and unbiased information about wood-based bioenergy production. These concerns were frequently brought up by the participants over the course of this research (Chapter IV), and are also reflected on the final set of C&Is. Communication about research progress and policy interventions also address another key concern of the stakeholders i.e. participation and transparency. With reference to a bioenergy production, Becker et al. (2009) suggest that not only benefits and promises, but trade-offs and local constraints should also be effectively communicated. Conversely, public outreach and research are generally the least-used policy interventions by states for the development of bioenergy industry (Aguilar & Saunders 2010).

In the UP, of the three renewable energy projects under the Michigan RPS, only one project uses biomass as a source of renewable energy (Quackenbush et al. 2015).

However, wood-based bioenergy production in the UP has not been very encouraging so far. The only biomass-driven energy plant in the WUP has recently come under public scrutiny for the use of environmentally hazardous feedstock (Roblee 2015) and for its lack of compliance with air quality regulations (Associated Press 2015). Similarly, a demonstration facility located in Northeast Michigan halted its wood-based ethanol production due to "the low ethanol price environment, the small size of the pre-commercial facility, and the limited feedstock supply" (see http://www.alpenabiorefinery.com/). These situations could be mitigated by using a comprehensive, stakeholder-driven, context-specific sustainability assessment framework like the one we have developed here, for the *ex-ante* and *ex-post* monitoring and evaluation of this industry.

## 4. Study limitations

A number of studies have used the participatory approach to develop sustainability assessments for different socio-ecological systems. Few of them have identified context-specific sustainability criteria for the assessment of a regional bioenergy production system. However, most of these studies have relied exclusively on interdisciplinary suites of experts, and very few studies have involved all of the key stakeholders including those from non-scientific backgrounds (Buchholz et al. 2009; Adams et al. 2011; Kurka and Blackwood 2013). We endeavoured to assemble a representative set of key stakeholders from each component of a bioenergy production system, as well as diverse backgrounds. While such participation largely enhanced our understanding about regional contexts and concerns, it also made the resulting sustainability C&I highly specific to the WUP. This process therefore limits our ability to use the resulting framework elsewhere, and hence it lacks generalizability. Furthermore, the viability of this framework in this region is yet to be demonstrated, and it may be

confirmed (through the careful observation of changes in indicators over time) only when the industry develops in the region[33].

Sustainability assessment is a tool that can contribute to a better understanding of the importance of context, and can influence actions, which impact the attainment of sustainability objectives of the key stakeholders (Dale et al. 2015). More generic sustainability assessments often fail to provide direction and thresholds that are imperative for the measurement and interpretation of sustainability indicators (Lewandowski & Faaij 2006). Efroymson et al. (2013) argue that general sustainability assessment should be treated as a starting point, but historical data, trends, local concerns and objectives should guide the selection, measurement and interpretation of sustainability indicators for biofuel systems (p. 302). We selected sustainability indicators based on local concerns and stakeholders' values, and we are able to provide a direction for improvement based on the characteristics and function of each indicator (Table 2-5). However, setting thresholds (which is necessary for the use of sustainability indicators for operating systems) is beyond the scope of this study. It should be noted that our study does not establish a causal relationship between the sustainability indicators presented here, and the sustainability of the bioenergy industry in the region.

# 5. Conclusion

Bioenergy is a multidimensional and complex system (Buchholz et al. 2009; Buytaert et al. 2011; Florin et al. 2014), as is the concept of sustainability (Morse et al. 2001; Buytaert et al. 2011). Failing to account for all dimensions of it can affect the sustainability of bioenergy systems (Karekezi 2002, Upreti & van der Horst 2004, Buchholz et al. 2007). Generally, social, environmental and economic aspects are

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[33] The region lacks a commercial bioenergy production system, and bioenergy industry is yet to be established in this region.

considered as key dimensions of sustainable bioenergy system. Our results suggest that criteria and indicators related to governance and institutional capacity are as important as social, economic and environmental dimensions in the regional context for bioenergy development. Additionally, while most SAFs rely mainly on quantitative indicators to measure sustainability, our participants weighted qualitative indicators (mostly related to governance and institutional criteria) as almost equally important.

Stakeholders' participation was the keystone of this study; it provided multiple opportunities to the researchers involved to interact with stakeholders and to define sustainability in relation to bioenergy production. Involving stakeholders and local experts in the project (from planning and design to evaluation of the C&I) allowed us (the researchers) to familiarize ourselves with the local terms, contexts and, stakeholders' interests and values. This is important to improve the likelihood that the framework will be adopted and implemented by local practitioners and policy makers as the bioenergy industry develops in the region. Stakeholders' participation is not only important in the development of sustainability assessment framework, it is also important in the implementation and revision of this framework to ensure its viability and relevance in the long run. In addition to highlighting a need for policy and other important interventions, context-driven comprehensive framework like the one presented here provides a monitoring and evaluation tool for State and County-level agencies to ensure that a bioenergy production system remains sustainable as it develops in the region. It may be difficult to collect data for the qualitative indicators that we recommend, particularly those related to governance and institutional capacity. Further work may be necessary to identify methodological requirements for the collection of relevant data. Furthermore, it may be difficult to monitor these qualitative data over time if no one agency is responsible for collecting and monitoring these data.

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*Appendix 5.1. Data collection package*

## Session A

1. Research updates: Potential list of sustainability criteria and indicators (C&I) derived from focus group discussions and telephone interviews.
2. Hands-on overview on Pairwise comparison, ranking, and rating methods for decision-making.

## Session B

**I. Individual Assessment (pairwise comparison and rated for relevance and importance): Criteria level**

| |
|---|
| ***Broad sustainability concerns*** |
| Economic benefits |
| Environmental protection |
| Socio-economic benefits |
| Policy and regulations |
| Institutional capacity and strength |
| ***Social criteria*** |
| Improved neighborhood |
| Aesthetics |
| Recreational values (hunting, hiking, snow mobiling etc) |
| Cultural products (herbs, fruits, firewood etc) |
| Food security |
| Educational/capacity building |
| ***Environmental criteria*** |
| Ecosystem services |
| Biodiversity |
| Air Quality |
| Water quality and quantity |
| Soil quality |
| Climate change |
| Land productivity |
| ***Economic criteria*** |
| Employment |
| Infrastructure development |
| Energy security |
| Benefit from external trade |
| Resource efficiency |

## II. Individual Assessment (rated for relevance): Criteria level

| ***Environmental criteria*** | ***Potential indicators*** |
|---|---|
| Ecosystem | Native forest cover |
| | Land fragmentation |
| | Natural grasslands area |
| | State of areas with high conservation value |
| | No. of wetlands/Peatlands |
| | Population and habitat changes of species of concern |
| | Wildlife population |
| | Invasiveness of species being used or introduced as feedstock |
| Air Quality | Tropospheric ozone |
| | CO emissions |
| | SO2 emissions |
| | Particulate matter (PM2.5, PM10) |
| | Nitrogen Oxides emission |
| | Odor |
| Water Quality & Quantity | Biological Oxygen Demand level (eutrophication) |
| | Dissolved Oxygen (DO) |
| | Total suspended solids |
| | Nutrient level in water sources |
| | Herbicide concentration |
| | pH (Acidification) |
| | Depth of water table |
| Soil Quality | pH |
| | Bulk density of the soil (Soil moisture) |
| | Total organic carbon |
| | Nitrate and phosphate concentration |
| | Total exchangeable cations (causes change in pH) |
| | Amount of soil washed away |
| | Soil compaction |
| Climate change | GHG emissions |
| ***Economic criteria*** | ***Potential indicators*** |
| Resource efficiency & use | Price of wood ($) |
| | Availability of wood |
| | Land price |
| | Land availability |
| | Stress on water resource |
| | Availability of agricultural land |
| | Use of local resources versus imports |
| Local economy | Employment rate (Number of full time equivalent jobs) |
| | Displacement of existing jobs |
| | Job types (direct versus indirect, service type versus other etc) |
| | Youth population in the region |
| | State revenue (Local economy) |
| | Diverse local economy |

| | |
|---|---|
| | Expansion of road networks |
| | New industries |
| | Infrastructures for public services (hospital, educational institutions) |
| Energy security | Fossil Energy Return On Investment (Fossil EROI) |
| | Local distribution of energy |
| | External input/total input |
| Benefit from external trade | Terms of trade (Price of exports/price of imports) |
| | Trade volume (in terms of income) |
| | Consumption of resources versus production |
| ***Social criteria*** | ***Potential indicators*** |
| Work conditions | Gender-based discrimination at work |
| | Safety of workers |
| | Health condition of workers |
| | Fair wage conditions |
| Food security | Change in local agricultural land area |
| | Food and feed (livestock) price |
| Education/Capacity building of the community | Skill transfer and training opportunities |
| | No. of educational resources, and presence of information resources |
| Improved neighborhood | Traffic volumes |
| | Access to roadways |
| | Crime rate |
| | Odor |
| | Noise |

## Session C

### I. Stakeholder group (Feedstock production) assessment: rated and ranked for relevance and importance

| |
|---|
| ***Participation and acceptance*** |
| Key stakeholders participation in decision-making |
| Professional consulting services for landowners |
| Presence of landowners cooperatives |
| Protect landowners rights |
| Ability to be integrated into current use of lands |
| Low cost of returning to previous land use |
| Long-term contracts with the buyers of feedstock |
| ***Profitability and benefits*** |
| Return over investment |
| Return over time |
| Financial incentives/government incentives |
| Maintain land productivity |
| Comparative gain over other investment |
| Carbon emission reduction |
| Resource conservation |
| Land management opportunity |
| Infrastructure development |
| ***Logistics*** |
| Location of the plantation |
| Transportation facilities |
| Machineries and equipment (harvesting, collection, hauling) |
| Infrastructure (storage, processing) |
| Water source |
| Expertise in feedstock production |
| ***Management and Monitoring*** |
| Avoid use of chemical herbicides and fertilizers |
| Avoid clear-cutting |
| Avoid using heavy equipment for harvesting and collection |
| Avoid plantations in agricultural land |
| Protect ethical and cultural concerns of the local inhabitants |
| Residue management and utilization |
| Third party audit or assessment program (e.g., certification) |

## II. Stakeholder group (Biofuel production) assessment: rated and ranked for relevance and importance)

| |
|---|
| ***Acceptability*** |
| Adaptability to changing market |
| Distance between plant and the market |
| Ability to use diverse feedstock |
| Ability to produce diverse products/co-products |
| Competitive price |
| Use of local resource |
| Cost of setting up a supply chain |
| ***Profitability and benefits*** |
| Return over investment |
| Return over time |
| Value addition to the wood products |
| Upfront cost requirement |
| Scale of production/operation (local versus regional) |
| Cost of production /operation |
| ***Logistics*** |
| Location of the plant |
| Expertise (training facilities) |
| Energy balance |
| Consistent supply of feedstock/products |
| Technology for efficient production |
| Transportation for distribution |
| ***Management and Monitoring*** |
| Pollution control mechanisms |
| Residue management and utilization plan |
| Waste management plans |
| Continuous research and pilot projects |
| Transparency about management and operation plans |
| Collaboration with existing forest-based industries |
| Local third party institutions' involvement in audit or assessment program |
| Local stakeholders' participation in decision-making |

## III. Stakeholder group (Decision makers) assessment (rated and ranked for relevance and importance)

| |
|---|
| ***Regulatory policies*** |
| Pay all applicable and legally prescribed fees, royalties, taxes should be paid |
| Compliance with state standards and regulations |
| Compliance with national and international standards and regulations |
| Restrict use of agricultural land |
| Restrict use of forests, wetlands and water courses |
| Restrict use of high conservation value areas |
| Protection of unique and significant tribal sites |
| ***Transparency*** |
| Involve citizen advisory panel in decision making |
| Public availability of management plan |
| A unit to facilitate communication between different stakeholders |
| Involvement of local organization/institutions/companies in the management/control processes |
| Communication of research outcomes and long-term impacts |
| ***Precautionary policies and support mechanisms*** |
| Management prescription for sustainable harvesting |
| Compliance to best management practices |
| Subsidies/tax incentives |
| Subscription to certification schemes |
| Policies to protect the local industry from impact of falling oil prices/foreign competitions |
| Integration of bioenergy projects into existing developmental projects & programs |
| ***Management and Monitoring*** |
| Reporting of management and operational activities. |
| Events and workshops for mutual learning/information sharing |
| Regular revision of management/operation decisions |
| Legal documentation of clearly stated tenure and use rights |
| Colocation of biorefineries on or near existing sites such as paper and pulp mills |
| Comprehensive R&D programs for new technologies/processes |

## Session D

## Mixed group assessment (rated and ranked for relevance and importance)

| |
|---|
| ***Policy and institutional framework for wood-based bioenergy industry*** |
| Subsidies/tax incentives |
| Public participation in decision-making |
| Compliance with sustainable harvesting practices |
| Compliance with state and national regulations |
| Communication and reporting of management and operational decisions and plans |
| Continuous research |
| Regular monitoring |
| Maintain transparency in management/operation decisions |
| Collaborative learning, education, public awareness |
| ***Consumers' concerns regarding bioenergy products*** |
| Competitive cost |
| Compatibility with existing vehicle/technology |
| Convenience |
| Reliability (consistent supply of product) |
| Environment friendly |
| Efficiency |
| Renewable energy alternative |

## Appendix 5.2. Results from the workshop data

### 1. Sustainability principles

One of the benefits of a bottom-up approach to developing sustainability assessment is that the context drives the preferences, rather than a pre-defined set of principles (Gibson 2006). Our findings support this assertion. ‘Policy & regulations’ and ‘Institutional capacity’ were suggested as important and relevant sustainability principles by the stakeholders in our study. They were rated and ranked similarly (in terms of both importance and relevance) to social, economic dimensions, although the environmental dimension was considered to be the most important (Fig. 1).

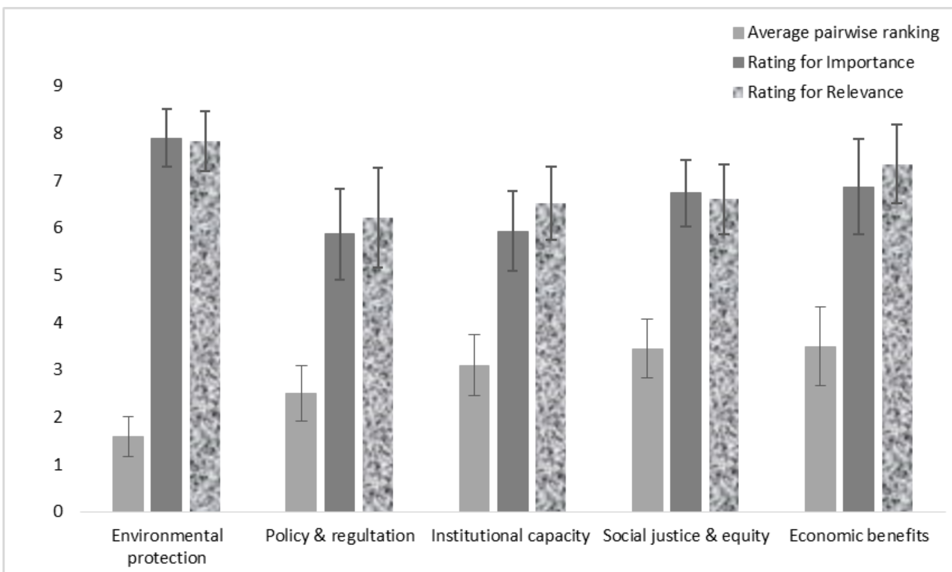



**Fig 1. Individual assessment using pairwise comparison and rating methods: Sustainability principles**[34]

‘Environmental protection’ was ranked and rated the highest with very small standard error (*s.e.*), suggesting a greater degree of agreement among the participants about the judgment in both methods. Although ‘Economic benefits’ was ranked the lowest in the pairwise comparison, it was rated highly for importance (6.87) as well as

[34] For pairwise ranking: 1= implies the most important among all choices, and higher numbers indicate lower relative importance. For rating: 1= weakly important; 3= less important; 5= moderately important; 7= strongly important; 9= extremely important. Even numbers denote intermediate scales between two adjacent judgments

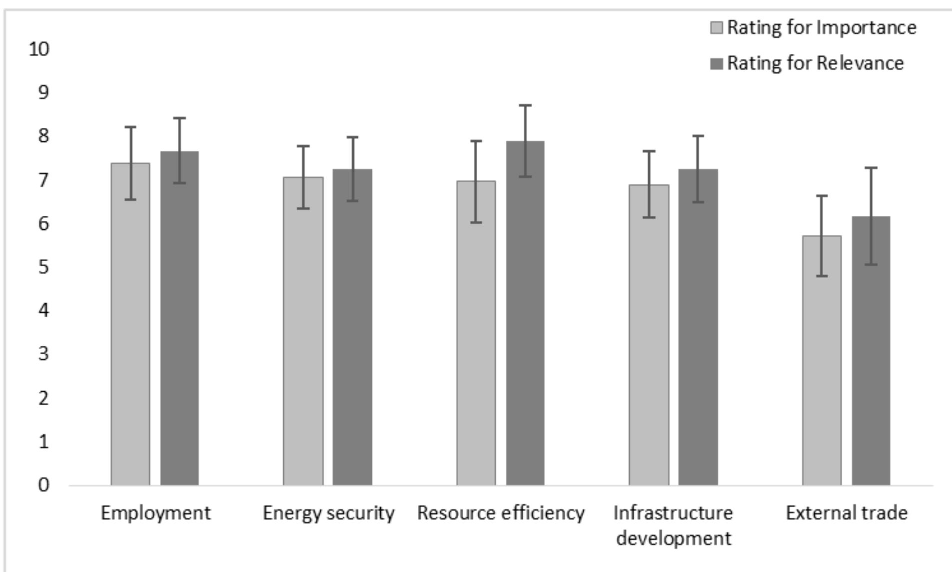
relevance (7.35). Overall, all the sustainability principles were rated between moderately to extremely important and relevant.

## 2. *General sustainable energy criteria*

### *2.1. Economic criteria*

Of the five criteria presented to the participants (shown in Fig 2), four of the criteria were rated more or less evenly while ‘External trade’ was clearly rated the lowest (Fig 2.a). Consistent with this was the results from rating system (Fig 2.b). All criteria except ‘External trade’ were rated ≥7. ‘Employment’ and ‘Resource efficiency’ received the highest ranking in the list of economic criteria.

a)



b)

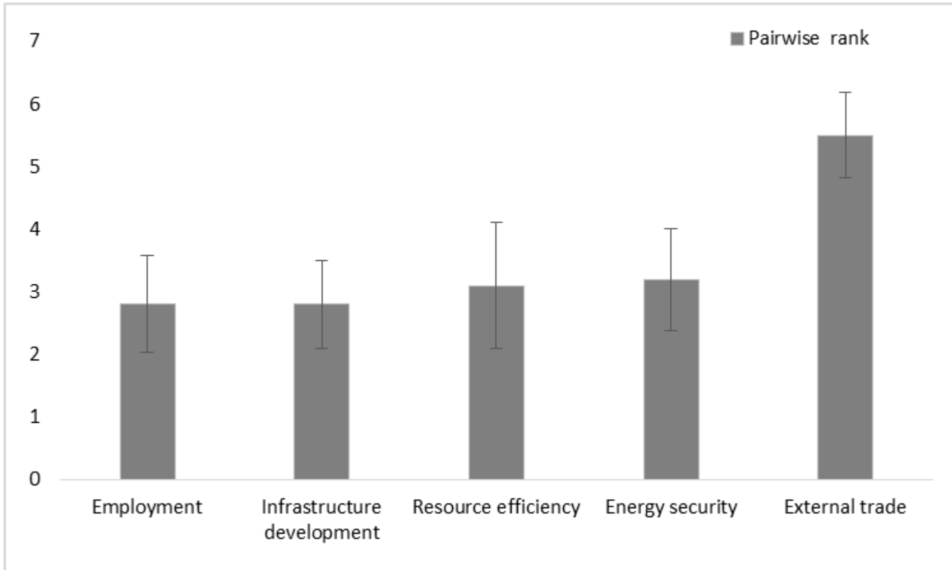
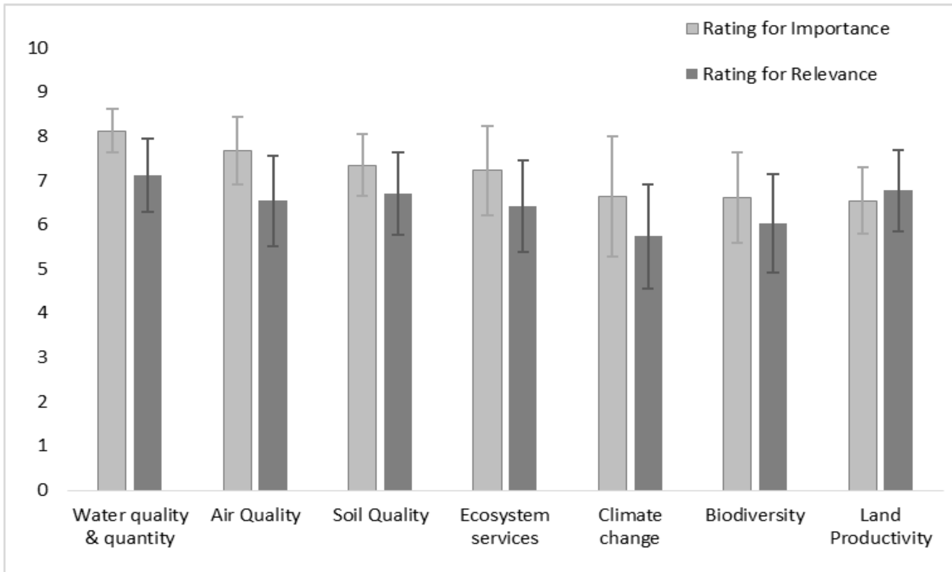



**Fig 2. Individual assessment economic criteria using: a) rating b) pairwise ranking**

## *2.2. Environmental criteria*

Participants rated all the environmental criteria 6 or above for importance as well as relevance with one exception: 'Climate change' (rated 5.74 for relevance). Within the environmental criteria, they rated 'Water quality & quantity', 'Soil quality' and 'Air quality' as the most important and relevant (Fig 3.a). The result of pairwise ranking was fairly consistent with that of the rating method. Participants' judgments were found to be the most divisive for their judgments about 'Climate change' and 'Biodiversity' as may be inferred from the relatively higher *s.e.* for the two (i.e. >2). The two criteria received the lowest aggregate ranking.

a)




b)

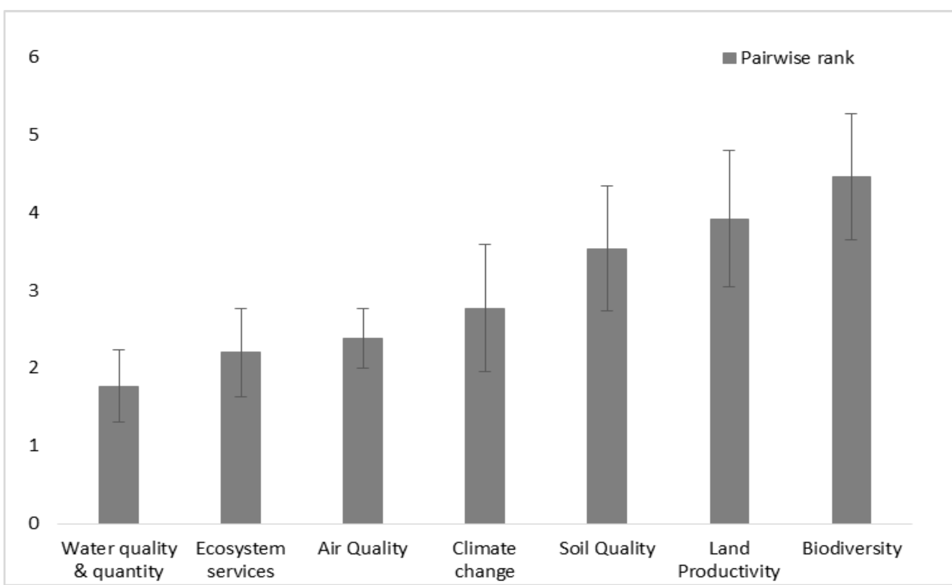


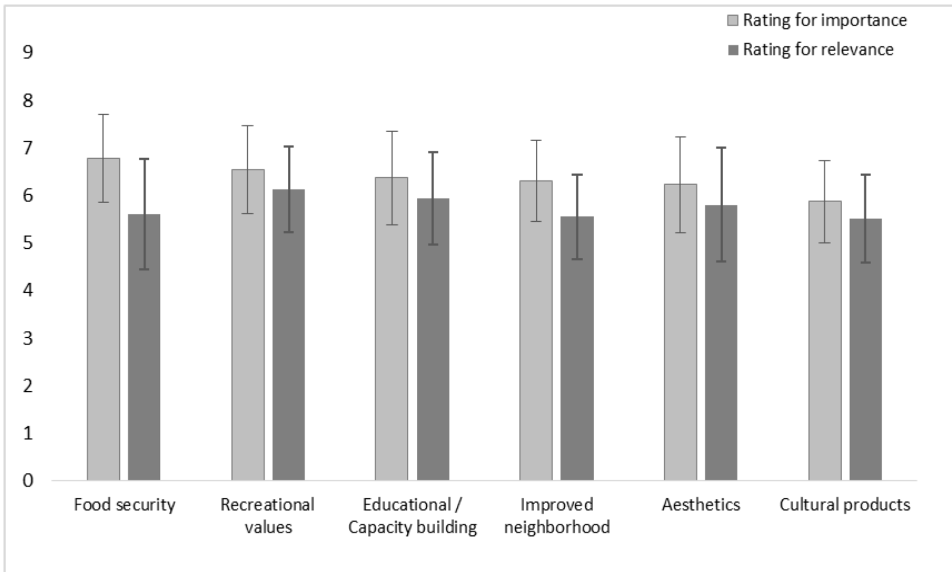

**Fig 3. Individual assessment of environmental criteria using: a) Rating b) Pairwise ranking**

## *2.3. Social criteria*

As shown in Fig 4.a, 'Food security', 'Recreational values' and 'Educational/Capacity building' were rated the highest for importance. This result was consistent with the pairwise ranking of the social criteria (Fig 4.b). The criteria were rated

almost evenly for relevance as well as importance. The pairwise ranking also suggested a huge overlap in the degree of importance among all criteria. The participants' judgment was found to be the most divisive for 'Food security', particularly in the case of pairwise ranking (Fig 4.b). Cultural products were rated the lowest for importance as well as relevance in rating system, which was consistent with the result from pairwise ranking.

a)




b)

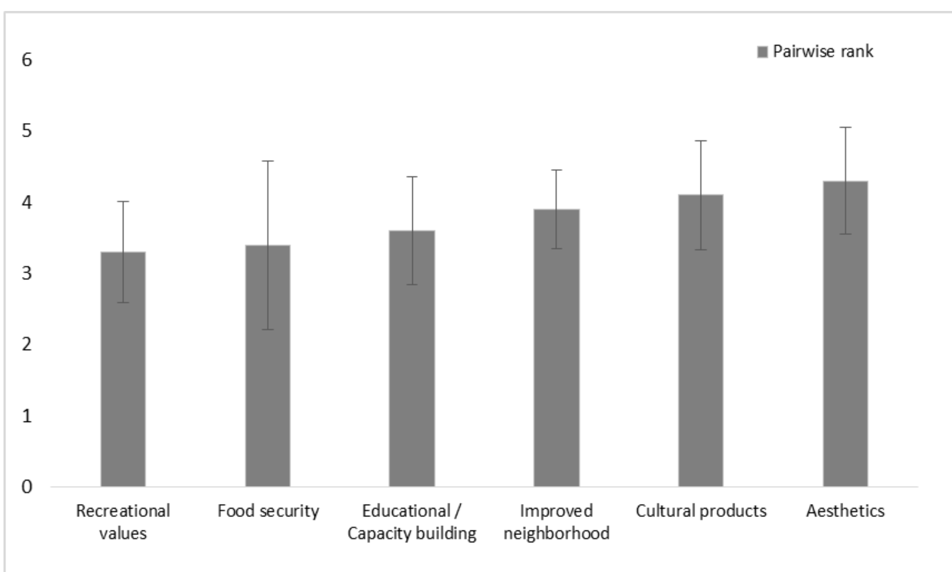



**Fig 4. Individual assessment of social criteria using: a) rating b) pairwise ranking**

## 3. General sustainable energy indicators

Indicators were presented to the participants in two separate lists of environmental and socio-economic concerns. Participants rated the indicators between 1-9 with respect to their relevance to industry[35]. For clarity, we will present the result from this section of the assessment under three separate sub-headings: economic indicators, environmental indicators and social indicators.

### *3.1. Economic indicators*

Participants rated economic indicators for five economic criteria, the results of which are shown in Table 1. For most of the criteria, indicators were somewhat evenly weighted varying within the range of 2-6% as shown in Table 1.

In Table 1, I.Ec.1.1., I.Ec.1.2. and I.Ec.2.1. were the most highly rated (between 7.5-8) indicators in the entire list. Relatively smaller *s.e.* for all three indicators suggest that most participants agreed with the higher ratings for these indicators. In addition to the three aforementioned indicators, I.Ec.3.1. and I.Ec.4.1. were the most highly rated for their respective criteria with reasonably smaller *s.e*s. Consistent with the criteria-level assessment for economic sustainability, indicators of 'benefit from external trade' were rated evenly but lowly for relevance. Availability of agricultural land, stress on water resources and youth population in the region were rated the least relevant indicators in this assessment.

**Table 1. Individual assessment of specific economic indicators (derived from participatory techniques and literature), using rating systems for relevance**

| Economic criteria (C.Ec) | Economic indicators (I.Ec) | Relevance | | |
|---|---|---|---|---|
| | | Average rating | SD of rating | Relative weights[36] |
| **C.Ec.1. Resource efficiency and use** | I.Ec.1.1. Availability of wood | 7.83 | 1.53 | 0.17 |
| | I.Ec.1.2. Price of wood ($) | 7.73 | 1.53 | 0.17 |
| | I.Ec.1.3. Use of local resources versus imports | 6.67 | 2.06 | 0.15 |
| | I.Ec.1.4. Land availability | 6.38 | 2.18 | 0.14 |
| | I.Ec.1.5. Land price | 5.66 | 2.33 | 0.13 |
| | I.Ec.1.6. Stress on water resource | 5.43 | 2.10 | 0.12 |
| | I.Ec.1.7. Availability of agricultural land | 5.28 | 2.36 | 0.12 |
| **C.Ec.2. Local economy** | I.Ec.2.1. Employment rate | 7.50 | 1.93 | 0.12 |
| | I.Ec.2.2. State revenue | 6.77 | 1.94 | 0.11 |
| | I.Ec.2.3. Diverse local economy | 6.60 | 2.08 | 0.11 |

[35]Where, 1= weakly relevant; 3= less relevant; 5= moderately relevant; 7= strongly relevant; 9= extremely relevant; Even numbers denote intermediate scales between two adjacent judgments
[36]Weight of each indicator vis-à-vis other indicators under any criterion.

| | | | | |
|---|---|---|---|---|
| | I.Ec.2.4. New industries | 6.53 | 2.10 | 0.10 |
| | I.Ec.2.5. Infrastructures for public services (hospital, educational institutions, roadways) | 6.07 | 2.03 | 0.10 |
| | I.Ec.2.6. Number of job displacements | 5.77 | 2.53 | 0.09 |
| | I.Ec.2.7. Expansion of road networks | 5.73 | 2.23 | 0.09 |
| | I.Ec.2.8. Job types (direct versus indirect, service type versus other etc) | 5.70 | 2.09 | 0.09 |
| | I.Ec.2.9. Youth population in the region | 5.62 | 2.47 | 0.09 |
| **C.Ec.3. Energy security** | I.Ec.3.1. Fossil energy return on investment (Fossil EROI) | 6.52 | 1.82 | 0.34 |
| | I.Ec.3.2. Local distribution of energy | 6.47 | 1.78 | 0.34 |
| | I.Ec.3.3. External input/total input | 6.07 | 1.89 | 0.32 |
| **C.Ec.4. Benefit from external trade** | I.Ec.4.1. Consumption of resources versus production | 6.29 | 2.00 | 0.35 |
| | I.Ec.4.2. Terms of trade (Price of exports/price of imports) | 6.00 | 1.77 | 0.33 |
| | I.Ec.4.3. Trade volume (in terms of income) | 5.79 | 2.06 | 0.32 |

## *3.2. Environmental indicators*

Based on relative weights, I.En.1.1., I.En.2.1., I.En.3.1. and I.En.3.2., I.En.4.1. and I.En.5. (see Table 2) were weighted the highest for relevance under their corresponding criteria. Of these, participants seemed fairly polarized in their judgments about I.En.1.2. (native forest cover) and I.En.5. (GHG emissions) as may be inferred from the higher *s.e.* values (i.e. >2) for their average ratings. Based on the number of questions received by participants and the number of blank spaces in the data collection sheets, environmental indicators were found to be the most difficult indicators for participants to evaluate.

**Table 2. Individual assessment of specific environmental indicators (derived from participatory techniques and literature), using rating systems for relevance**

| Environmental criteria (C.En) | Environmental indicators (I.En) | Relevance | | |
|---|---|---|---|---|
| | | Average rating | SD of rating | Relative weights |
| **C.En.1. Ecosystem** | I.En.1.1. Invasiveness of species being used or introduced as feedstock | 6.40 | 1.92 | 0.14 |
| | I.En.1.2. Native forest cover | 6.37 | 2.19 | 0.14 |
| | I.En.1.3. Population and habitat changes of species of concern | 5.63 | 2.11 | 0.13 |
| | I.En.1.4. Wildlife population | 5.63 | 1.88 | 0.13 |
| | I.En.1.5. Land fragmentation | 5.57 | 2.31 | 0.12 |
| | I.En.1.6. State of areas with high conservation value | 5.53 | 2.40 | 0.12 |
| | I.En.1.7. No. of wetlands/Peatlands | 5.00 | 2.39 | 0.11 |
| | I.En.1.8. Natural grasslands area | 4.73 | 2.46 | 0.11 |
| **C.En.2. Air Quality** | I.En.2.1. Particulate matter (PM2.5, PM10) | 6.15 | 1.94 | 0.18 |
| | I.En.2.2. $SO_2$ emissions | 6.00 | 2.09 | 0.17 |
| | I.En.2.3. Nitrogen Oxides emission | 5.89 | 1.80 | 0.17 |
| | I.En.2.4. CO emissions | 5.86 | 2.10 | 0.17 |
| | I.En.2.5. Odor | 5.71 | 2.42 | 0.16 |

| | | | | |
|---|---|---|---|---|
| | I.En.2.6. Tropospheric ozone | 5.50 | 1.95 | 0.16 |
| **C.En.3. Water Quality & Quantity** | I.En.3.1. Nutrient level in water sources | 6.48 | 1.81 | 0.13 |
| | I.En.3.2. Herbicide/pesticide concentration | 6.46 | 2.12 | 0.13 |
| | I.En.3.3. pH (Acidification) | 6.22 | 1.83 | 0.12 |
| | I.En.3.4. Depth of water table | 6.19 | 2.18 | 0.12 |
| | I.En.3.5. Biological Oxygen Demand level (eutrophication) | 5.89 | 2.26 | 0.12 |
| | I.En.3.6. Total suspended solids | 5.85 | 2.23 | 0.12 |
| | I.En.3.7. Dissolved Oxygen (DO) | 5.70 | 2.38 | 0.11 |
| **C.En.4. Soil Quality** | I.En.4.1. Amount of soil washed away | 7.07 | 1.59 | 0.16 |
| | I.En.4.2. Soil compaction | 6.61 | 1.47 | 0.15 |
| | I.En.4.3. Nitrate and phosphate concentration | 6.19 | 1.67 | 0.14 |
| | I.En.4.4. Total organic carbon | 6.00 | 2.20 | 0.14 |
| | I.En.4.5. pH | 5.88 | 2.25 | 0.14 |
| | I.En.4.6. Total exchangeable cations (causes change in pH) | 5.81 | 1.74 | 0.13 |
| | I.En.4.7. Bulk density of the soil (Soil moisture) | 5.70 | 2.09 | 0.13 |
| **C.En.5. Climate change implications** | I.En.5. GHG emissions | 6.41 | 2.27 | 1.00 |

## *3.3. Social indicators*

All the indicators were weighted somewhat evenly across their respective criteria except for I.S.4.4. (gender-based discrimination at work; see Table 3) which received a very low weight, and hence was omitted from the final C&I set. Participants were highly polarized in their judgments regarding relevance of indicators under food security and improved neighborhood where all the indicators' ratings had *s.e.* values of >2. Indicators of food security, crime rate and gender-based discrimination at work were rated the least relevant in this assessment.

**Table 3. Individual assessment of specific social indicators (derived from participatory techniques and literature), using rating systems for relevance**

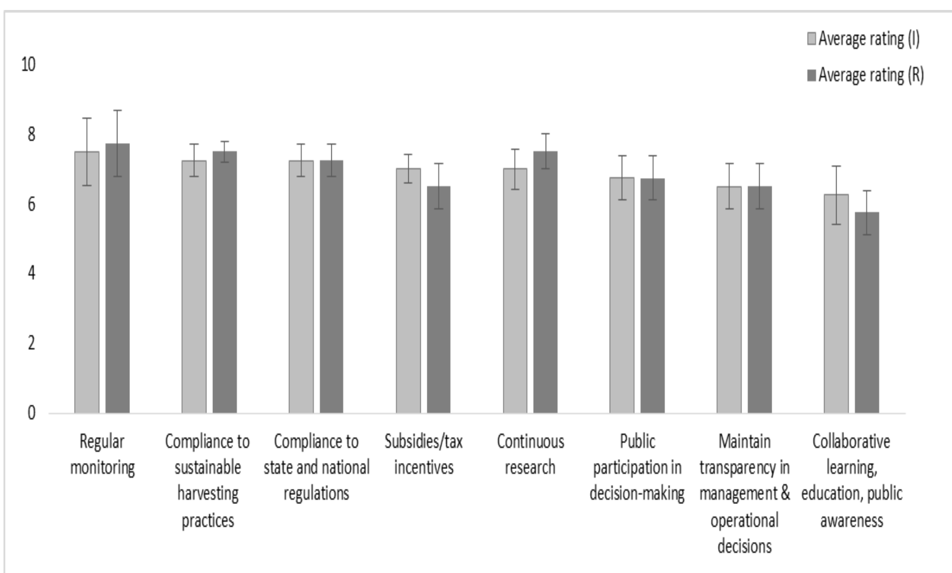
| Social criteria (C.S) | Social indicators (I.S) | Relevance | | |
|---|---|---|---|---|
| | | Average rating | SD of rating | Relative weights |
| **C.S.1. Food security** | I.S.1.1. Change in local agricultural land area | 5.07 | 2.46 | 0.52 |
| | I.S.1.2. Food price | 4.67 | 2.29 | 0.48 |
| **C.S.2. Education/ Capacity building of the community** | I.S.2.1. Skill transfer and training opportunities | 6.57 | 1.83 | 0.52 |
| | I.S.2.2. No. of educational resources/presence of information resources | 6.10 | 1.77 | 0.48 |
| **C.S.3. Improved neighborhood** | I.S.3.1. Odor | 5.31 | 2.49 | 0.26 |
| | I.S.3.2. Noise | 5.28 | 2.07 | 0.25 |
| | I.S.3.3. Traffic volumes | 5.20 | 2.07 | 0.25 |
| | I.S.3.4. Crime rate | 4.93 | 2.55 | 0.24 |
| **C.S.4. Work conditions** | I.S.4.1. Safety of workers | 6.90 | 1.90 | 0.28 |
| | I.S.4.2. Health condition of workers | 6.52 | 2.20 | 0.27 |
| | I.S.4.3. Fair wage conditions | 6.37 | 2.17 | 0.26 |
| | I.S.4.4. Gender-based discrimination at work | 4.73 | 2.70 | 0.19 |

### *3.4. Policy and institutional framework*

While the indicators under this theme were mostly rated more or less evenly, those related to compliance, regular monitoring and continuous research were weighted relatively higher (>7) for importance as well as relevance (Fig. 5.a). This was consistent with the results from ranking for relevance. However, ranking for importance suggested 'Subsidies/tax incentives' to be the most important followed by compliance to sustainable harvesting practices and existing laws (Fig. 5.b).

One of the groups had difficulty reaching consensus on the 'Subsidies/tax incentive' indicator. The s.e. values suggest that the groups were also highly polarized in their judgments about the ranking of 'Compliance to state and national regulations' and 'Regular monitoring'. The average ranking completed by participants through the mailed survey did not vary much from the assessment done by participants in groups. However, contrary to the group assessment, survey participants ranked 'Subsidies/tax incentives' the lowest in importance.

a)



b)

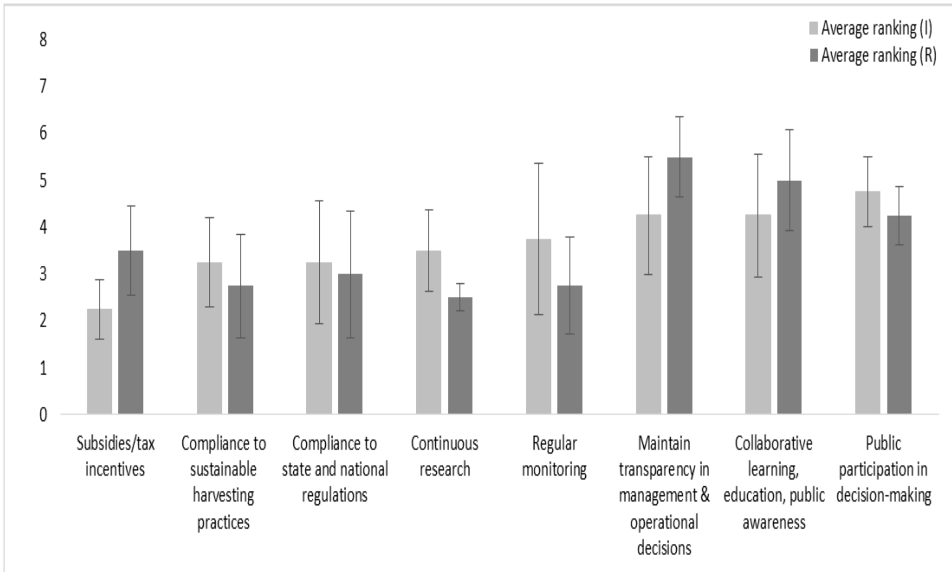


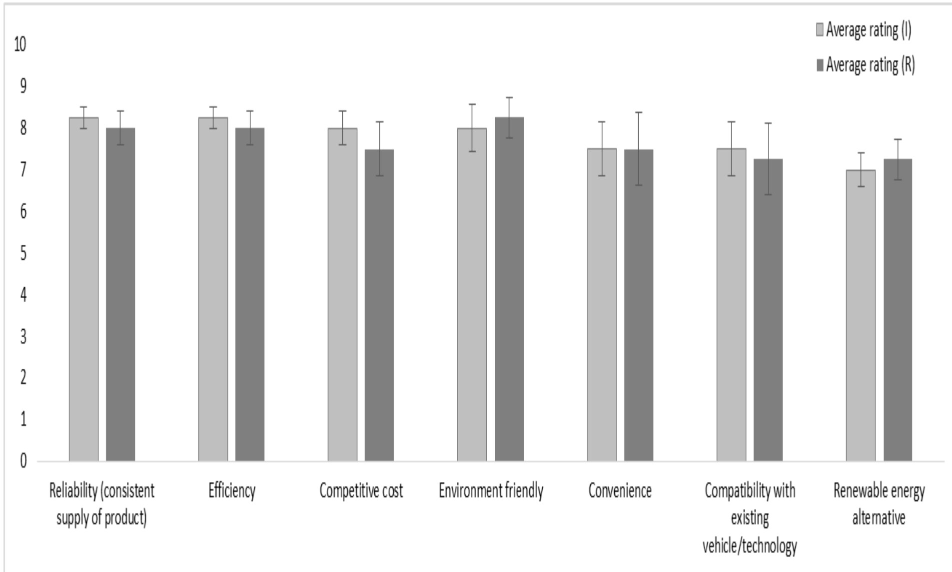

**Fig 5. Mixed group assessment of Policy and institutional framework using: a) rating b) pairwise ranking (where, I=Importance, R=Relevance)**

### *3.5. Attributes of biofuel important in decision-making for consumers*

While all criteria were rated more or less evenly between *7-9 for* important and relevant, 'Reliability/Consistent supply of product' was ranked the highest in importance with a minimal *s.e.* of 0.58, and was followed by 'Environment-friendly' and 'Efficiency' (see Fig 6). 'Reliability/Consistent supply of product' and 'Competitive cost' were ranked the highest also for relevance. Based on the aggregate ranking, 'Reliability/Consistent supply of product' and 'Environmental friendly' were ranked the highest.

Consistent with the results of the group assessment, 'Environmental friendly' and 'Reliability/Consistent supply of product' were also ranked and rated highly (> 8) for importance by the survey participants. All three of these indicators were also rated highly (> 7.5) for relevance.

a)




b)

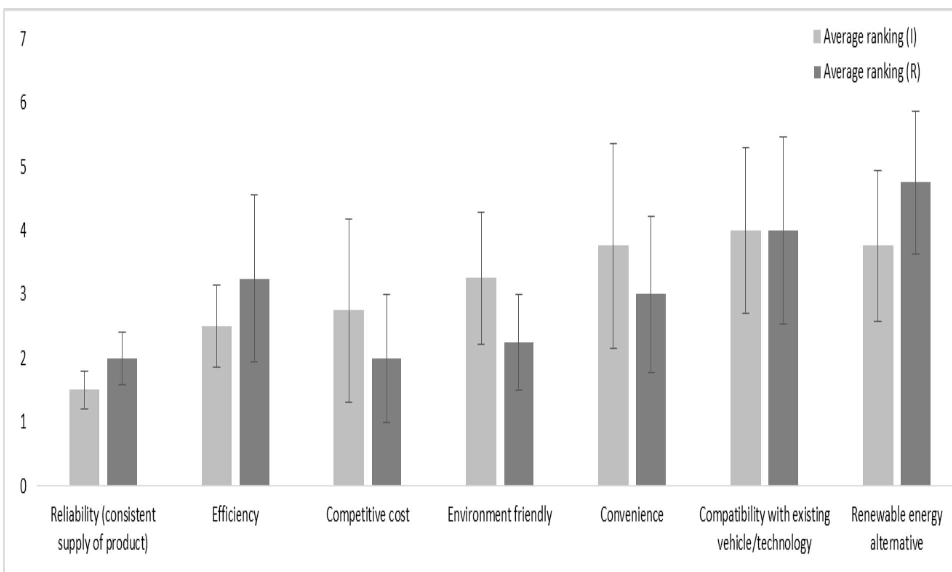



Fig 6. Mixed group assessment of Consumers' concerns using: a) rating b) ranking (where, I=Importance, R=Relevance)

## 4. Bioenergy stakeholder group-specific criteria

This section of the paper will concentrate on the outcome of the stakeholders' group assessment. Many of these sub-criteria and bioenergy-specific indicators had

greater relevance to one group of stakeholders than the other. Therefore, a separate set of assessments was prepared for each stakeholder group.

### *4.1. Feedstock production*

Participants assessed the sub-criteria and indicators under four different broad criteria: a) Participation and acceptance, b) Profitability and benefits, c) Logistics and d) Management and monitoring. This group mainly included potential feedstock producers such as farmers and landowners (Fig 7 & 8).

#### *4.1.1. Participation and acceptance*

Judgments did not vary much between importance and relevance (see Fig. 7.a) particularly for the top three sub-criteria: ‘Protect landowners’ rights’, ‘Key stakeholders’ participation in decision-making’ and ‘Professional consulting services for landowners’. All three sub-criteria were evenly rated as extremely important and relevant. According to the rankings though, ‘Protect landowners’ rights’ was ranked the highest in importance as well as relevance (Fig 8.a).

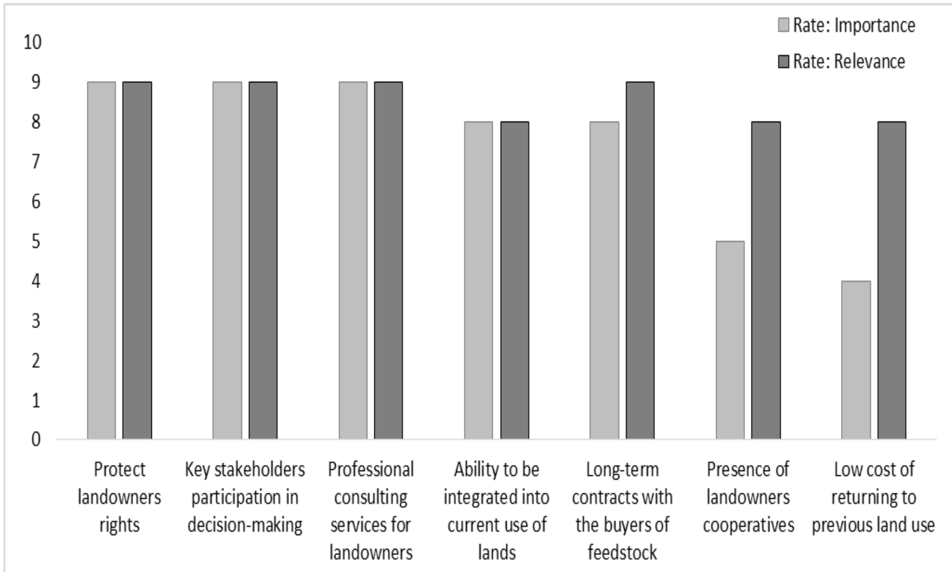
#### *4.1.2. Profitability and benefits*

Interestingly, this group rated all the sub-criteria under this criterion evenly as extremely important and relevant (Fig 7.b). However, they ranked them differently for both importance and relevance, suggesting preferences. Of the 9 total indicators, this stakeholder group ranked ‘Return over investment’ as the most important and relevant indicators for the ‘Profitability and benefits’ criterion (Fig. 8.b). Environment-related benefits such as ‘Carbon emission reduction’ and ‘Resource conservation’ were ranked the lowest for relevance as well as importance.

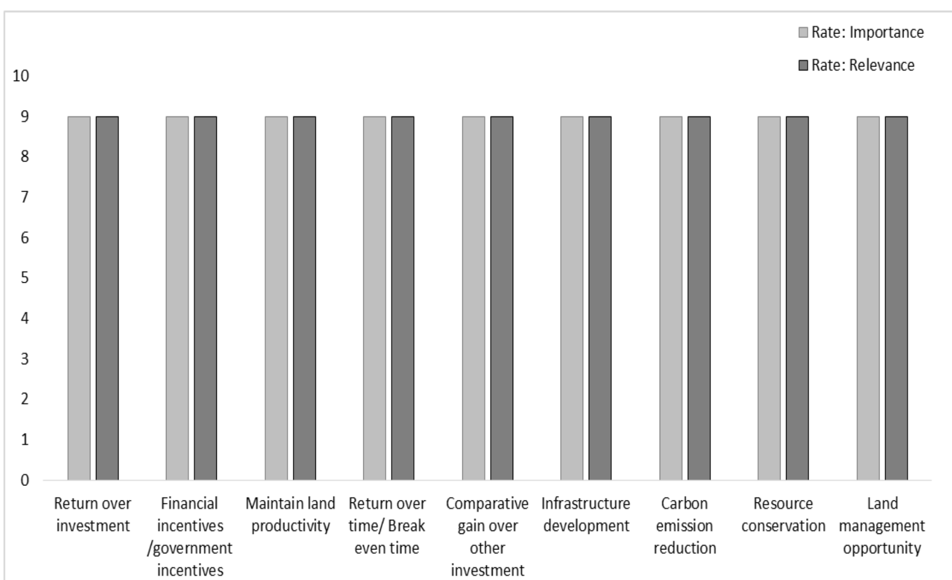
#### *4.1.3. Logistics*

Ratings did not vary much for the sub-criteria/indicators under this category. According to the rankings, ‘Water source’ and ‘Technical expertise’ were ranked higher in important as well as relevant (Fig 7.c). A note provided by the group indicated that ‘Transportation’ and ‘Location of the plantation’ could essentially mean the same thing or are closely related, however these two indicators were rated and ranked very differently (see Fig 7.c and Fig 8.c).

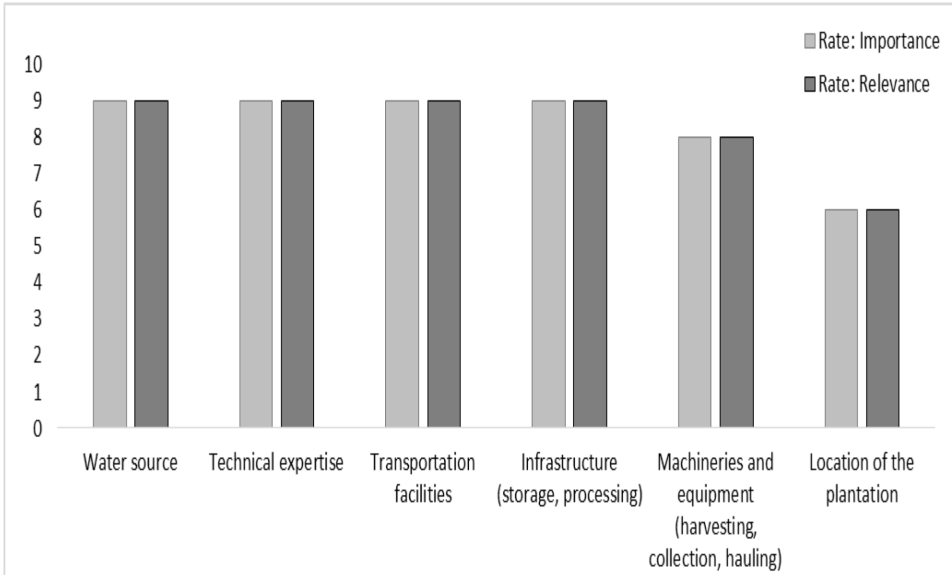
a) Participation and acceptance




b) Profitability and benefits



c) Logistics




d) Management and monitoring

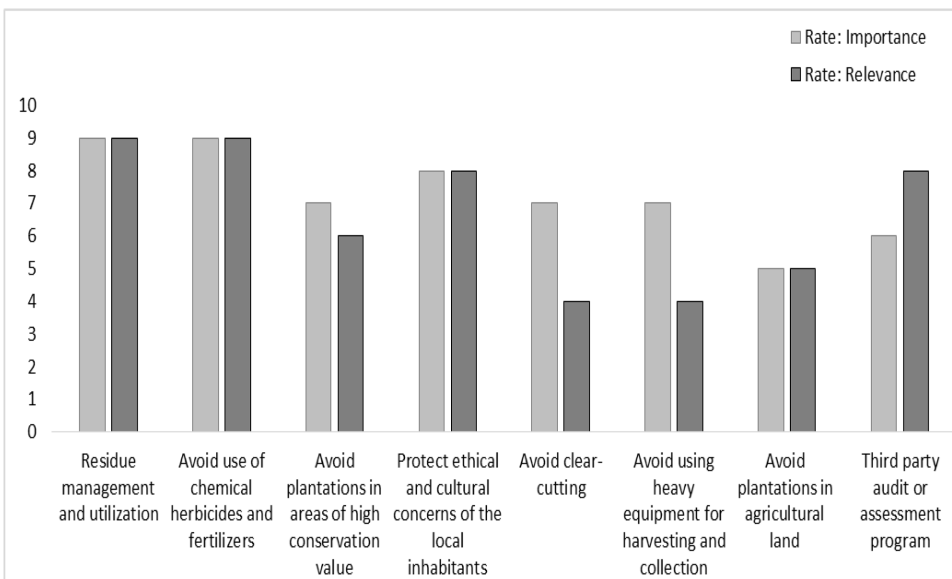
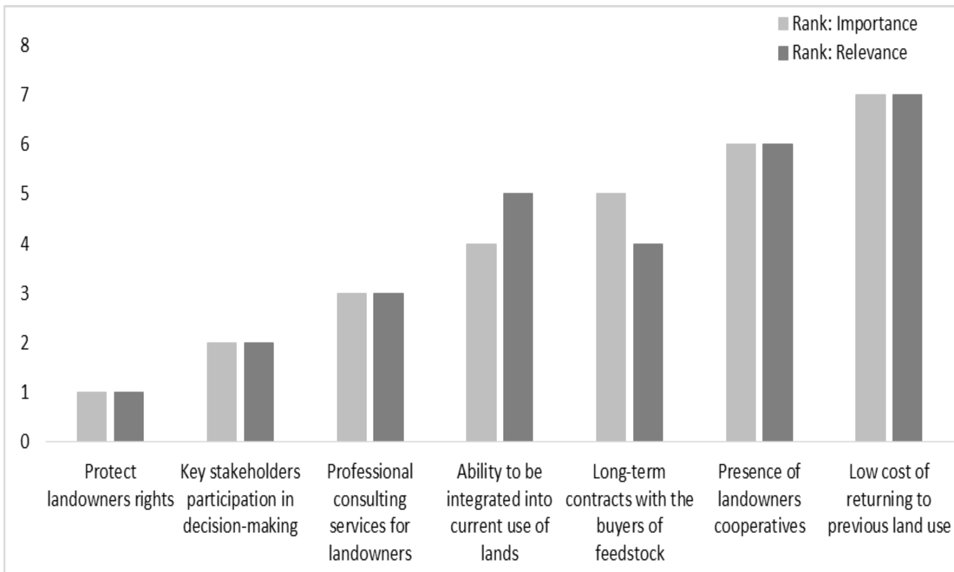



**Fig 7. Stakeholder group (Feedstock production) assessment of criteria using rating method (n=1 because each group considered only one category)**

*4.1.4. Management and monitoring*

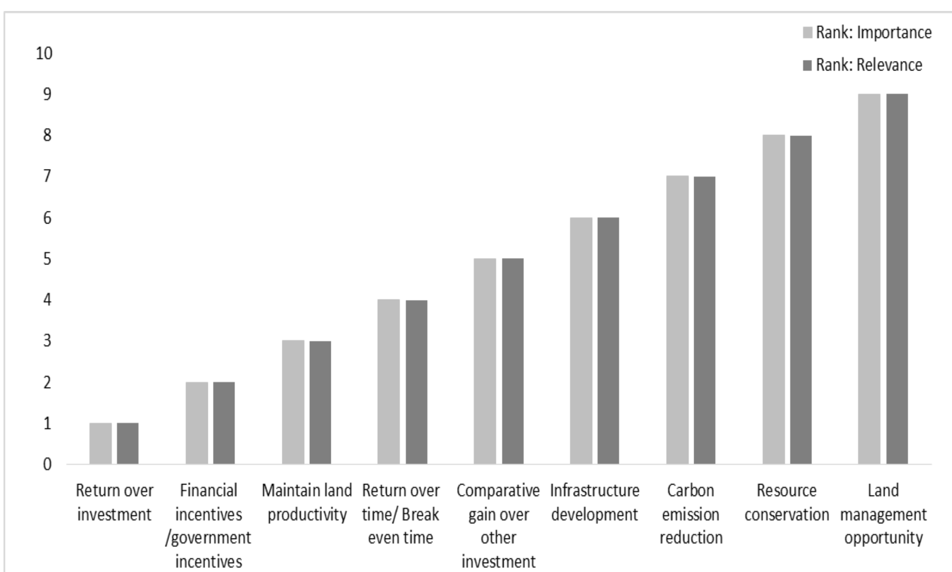
Under this criterion, 'Residue management and utilization' and 'Avoid use of chemical herbicides and fertilizers' were ranked the highest for both importance as well as relevance. Although ranked and rated the lowest in importance, 'Third party audit/assessment program' was rated highly for relevance (see Fig 8.d and 7.d).

a) Participation and acceptance

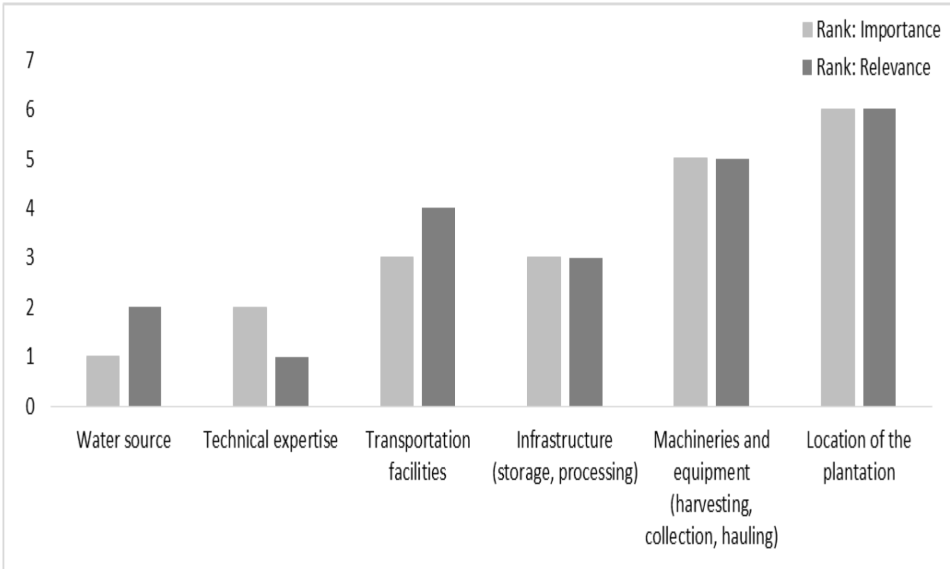



`

b) Profitability and benefits



c) Logistics




d) Management and monitoring

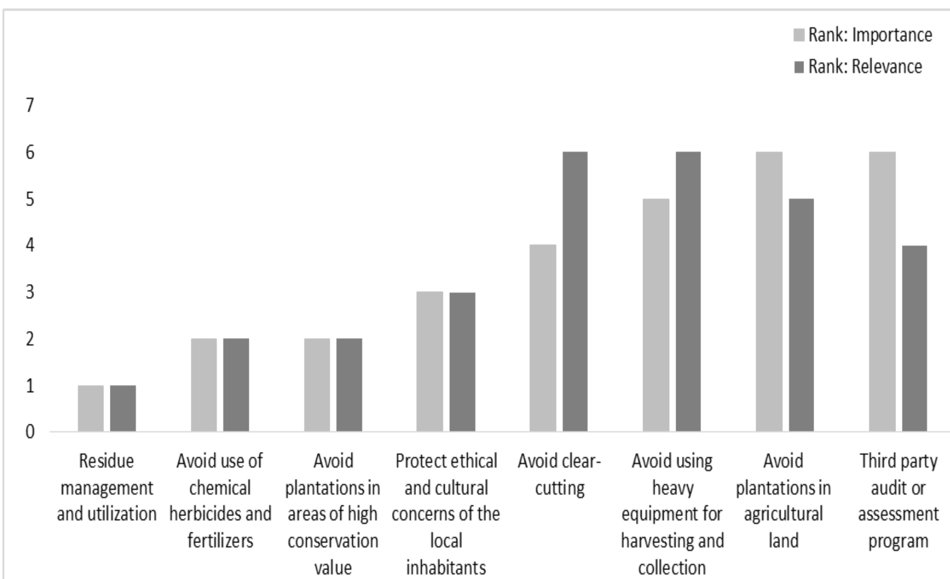



**Fig 8. Stakeholder group (Feedstock production) assessment of criteria using ranking method (n=1 because each group considered only one category)**

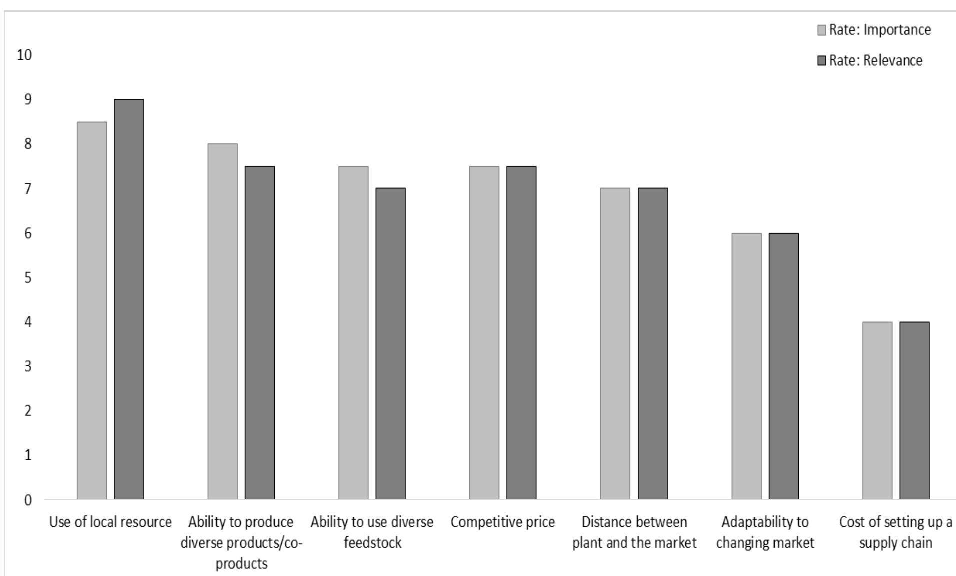
## 4.2. Biofuel Production

This assessment was done by the stakeholder group mainly consisting of venture capitalists, business representatives and individuals with diverse experience in the forest industry. This stakeholder group assessed the sub-criteria or indicators under four different criteria just as in the case of feedstock production: a) Acceptance, b) Profitability and benefits, c) Logistics and d) Management and monitoring.

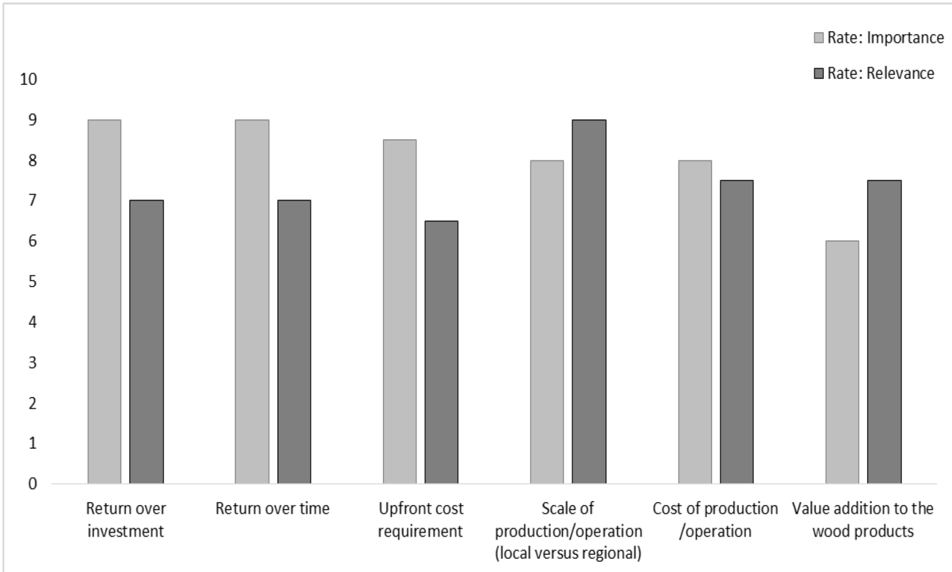
### *4.2.1. Acceptance*

The group rated ‘Use of local resource’ to be extremely important and extremely relevant (Fig. 9.a). ‘Competitive cost’ and ‘Ability to produce diverse products/co-products’ followed the ‘Use of local resources’ in rating with respect to importance as well as relevance. Ranking did not vary much from rating results suggesting consistency in the two methods. ‘Cost of setting up a supply chain’ and ‘Adaptability to changing market’ were both ranked and rated significantly lower (Fig 10. a). Furthermore, obvious difficulty in measuring these two sub-criteria make them a reasonable candidates for exclusion from the C&I framework.

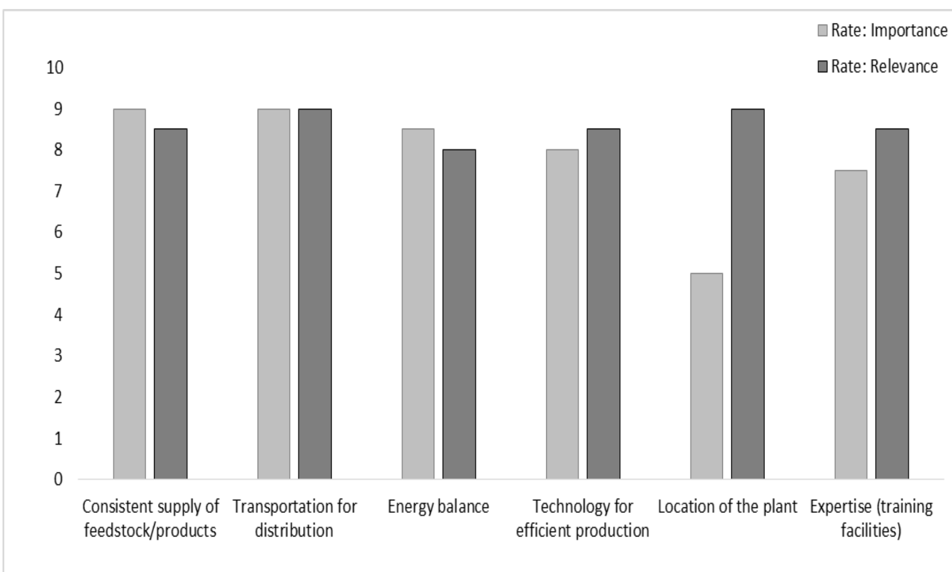
a) Acceptance



b) Profitability and benefits




c) Logistics



d) Management and monitoring

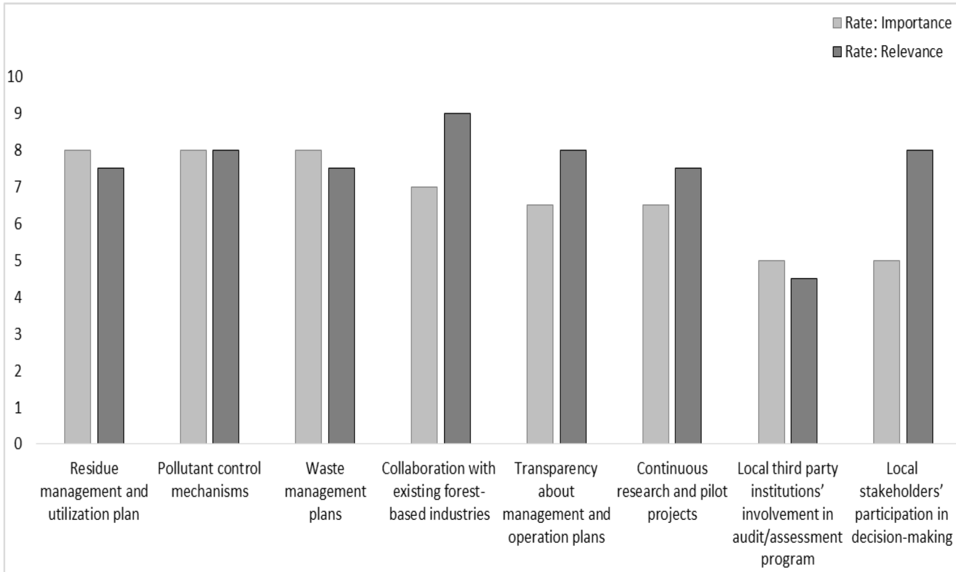



**Fig 9. Stakeholder group (Biofuel production) assessment of criteria using rating method (n=1 because each group considered only one category)**

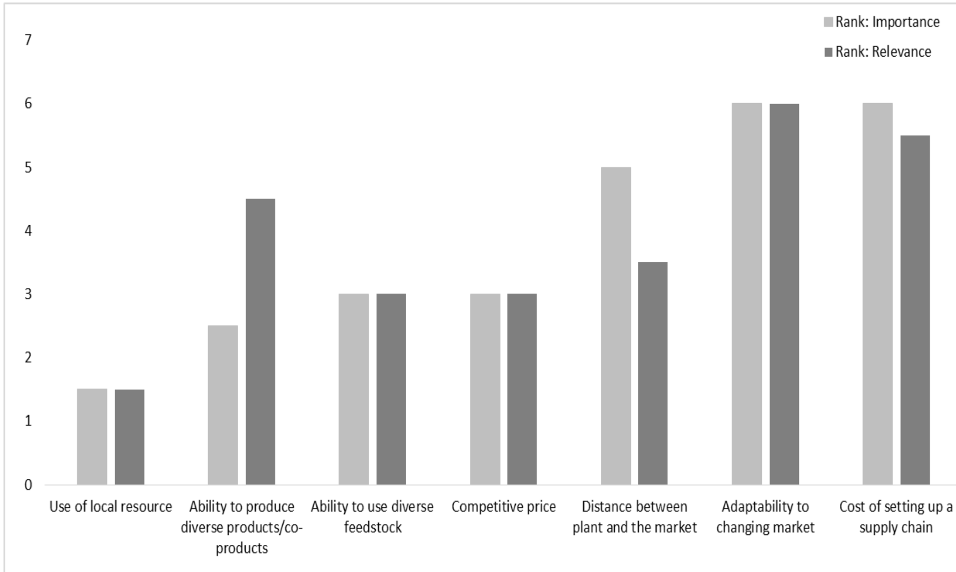
### *4.2.2. Profitability and benefits*

Stakeholders highlighted a lack of independence between two sets of indicators: 'Return over investment' versus 'Return over time/break-even time'; and 'Scale of production/operation' and 'Cost of production/operation'. We therefore use only (highly ranked and rated) one from each pair in our analysis. The group rated 'Return over investment' and 'Cost of production/operation' as the most important (Fig 9.b). This result is consistent with the rankings for importance (Fig 10.b). 'Scale of production' was however, ranked and rated the highest for relevance.

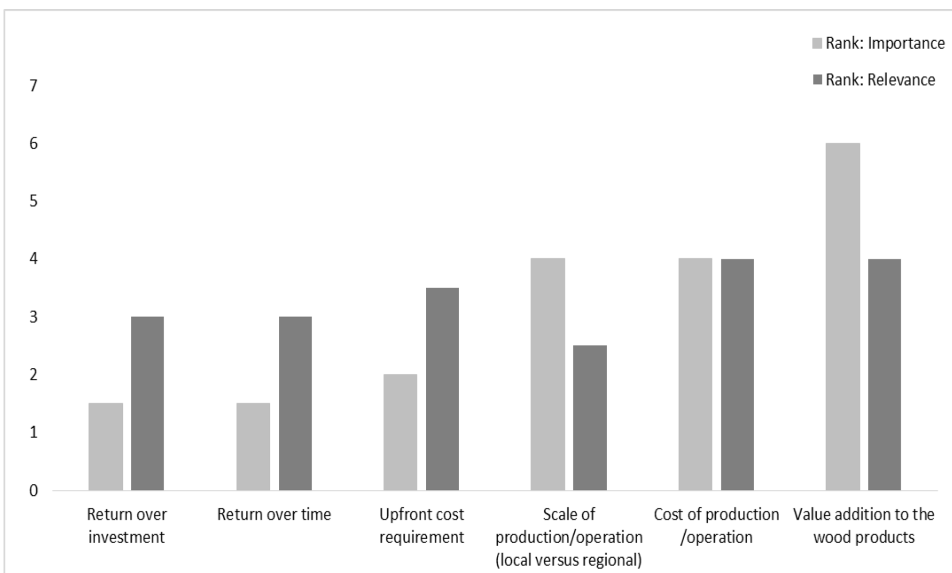
### *4.2.3. Logistics*

'Consistent supply of feedstocks/product' and 'Transportation for distribution' were ranked and rated the highest in terms of importance as well as relevance (Fig. 9.c & 10.c). Although need for experts were brought up as important concern in focus groups and interviews, this group rated and ranked 'Expertise (training facilities)' relatively lower in importance.

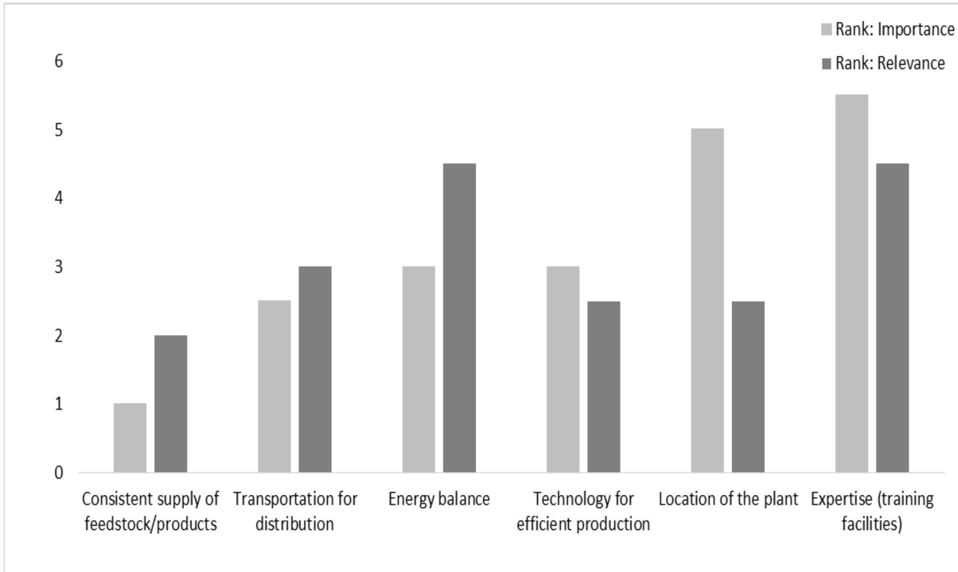
a) Acceptance




b) Profitability and benefits



c) Logistics




d) Management and monitoring

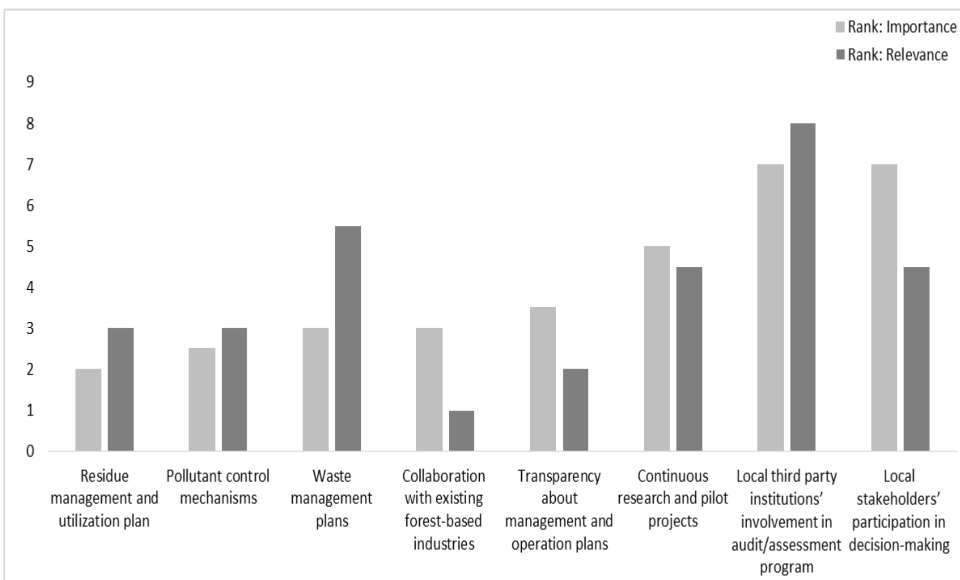



**Fig 10. Stakeholder group (Biofuel production) assessment of criteria using ranking method (n=1 because each group considered only one category)**

#### *4.2.4. Management and monitoring*

Consistent with the assessment done by the 'feedstock production' group, this group also ranked and rated the indicators related to waste management as the highest in importance (Fig. 9.d & 10.d). In terms of relevance, 'Collaboration with existing forest-based industries' was ranked and rated the highest for importance. It also received the highest aggregate ranking. 'Third party audit/assessment program' was assigned the lowest rank and rating by this as well as the 'Feedstock production' groups. On the other hand, while the 'Stakeholders' participation in decision-making' was ranked and rated the lowest in importance by this group, it was rated extremely important and extremely relevant by the 'Feedstock production' group (see Fig. 7.a).

### ***4.3. Decision-making***

This group of stakeholders included participants like township supervisors, interest groups, and government organizations' representatives, and assessed the sub-criteria and indicators under four different criteria: a) Regulatory policies b) Transparency c) Precautionary policies and support mechanisms d) Management and monitoring (Fig 11 & 12). These sub-criteria were evenly ranked by the group, which made the preference elicitation task difficult (see Fig 12.b-d).

#### *4.3.1. Regulatory policies*

On average, the group rated sub-criteria suggesting compliance with existing standards as relatively more important and relevant than those suggesting the need for new restrictive policies. This may reflect participants' trust in the existing policies and regulations. 'Pay all applicable and legally prescribed fees, royalties' and 'Compliance with state standards/regulations' were rated higher for importance as well as relevance (Fig 11.a). This was consistent with the rankings assigned (Fig 12.a). 'Restrict use of agricultural land' and 'Protection of unique and significant tribal sites' were rated and ranked lower for relevance as well as importance.

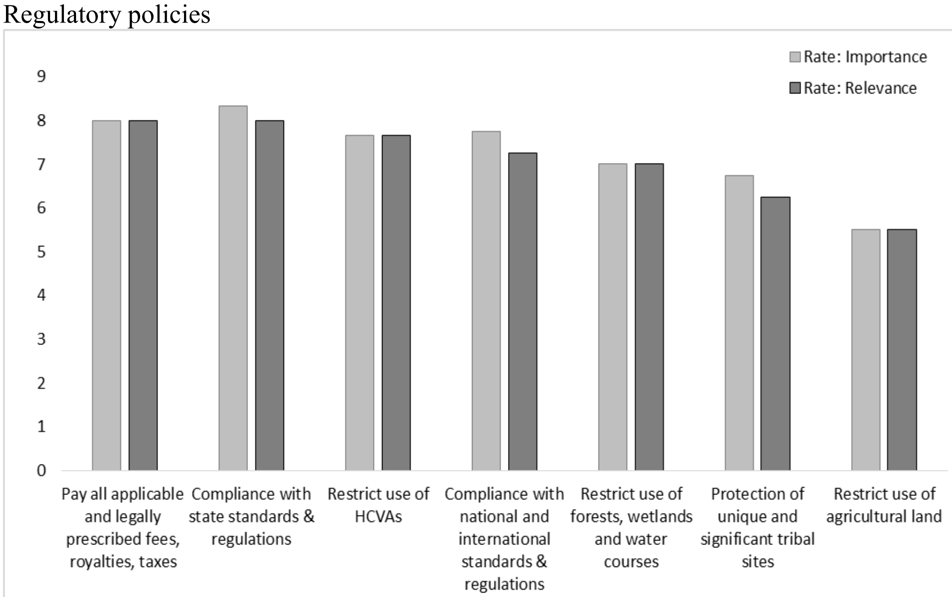
#### *4.3.2. Transparency*

The group ranked most of the sub-criteria evenly for relevance. According to the rating, 'Public availability of management plan' and 'Communication of research outcomes/long-term impacts' were regarded as the most important and the most relevant. The two were also ranked the highest for importance.

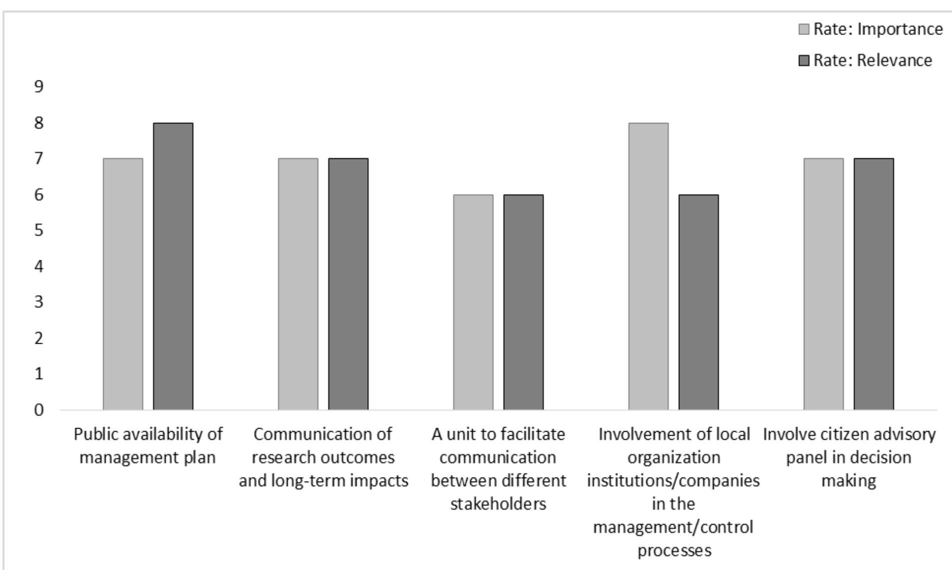
### *4.3.3. Precautionary policies and support mechanisms*

‘Compliance to best management practices’ was rated and ranked the highest for relevance and importance (Fig 11.c; Fig. 12.c). ‘Subscription to certification schemes’ and ‘Subsidies/tax incentives’ were ranked and rated lowest for importance as well as relevance.

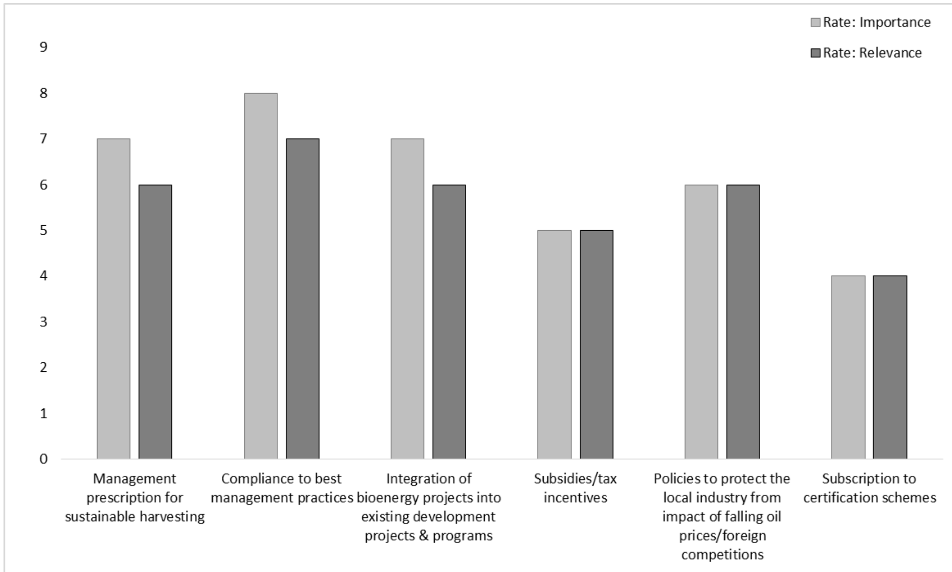
a) Regulatory policies




b) Transparency



c) Precautionary policies and support mechanisms




d) Management and monitoring

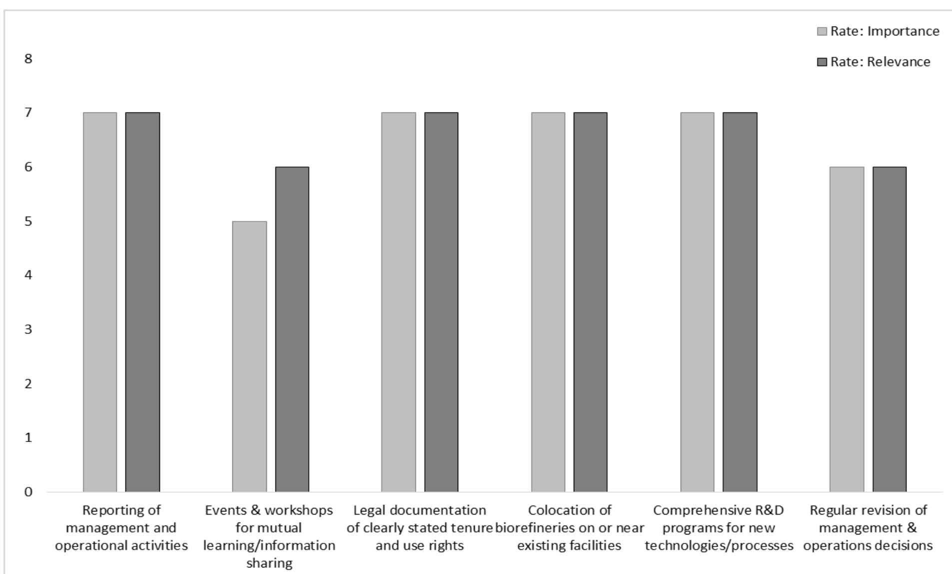


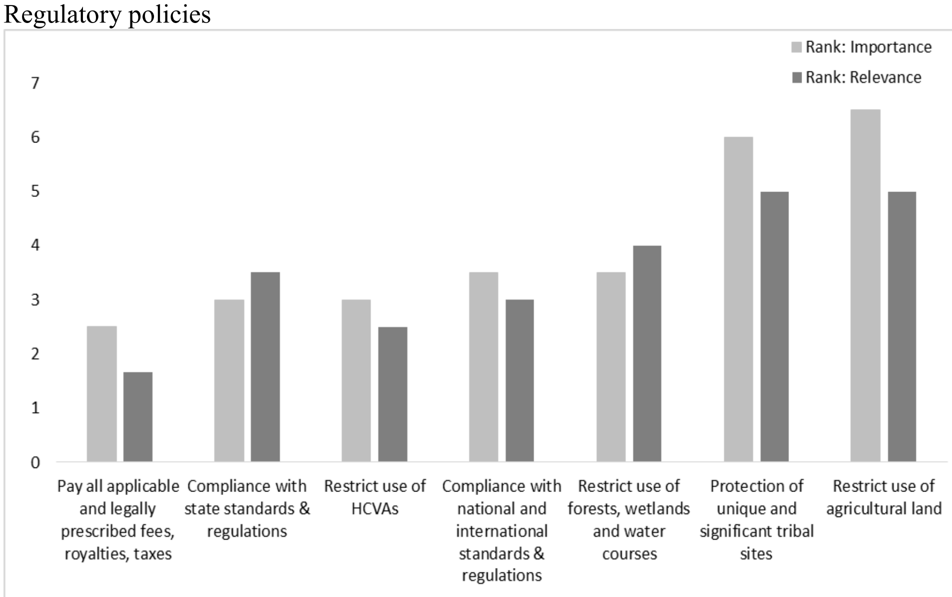

**Fig 11. Stakeholder group (Decision making) assessment of criteria using rating method (n=1 because each group considered only one category)**

### *4.3.4. Management and monitoring*

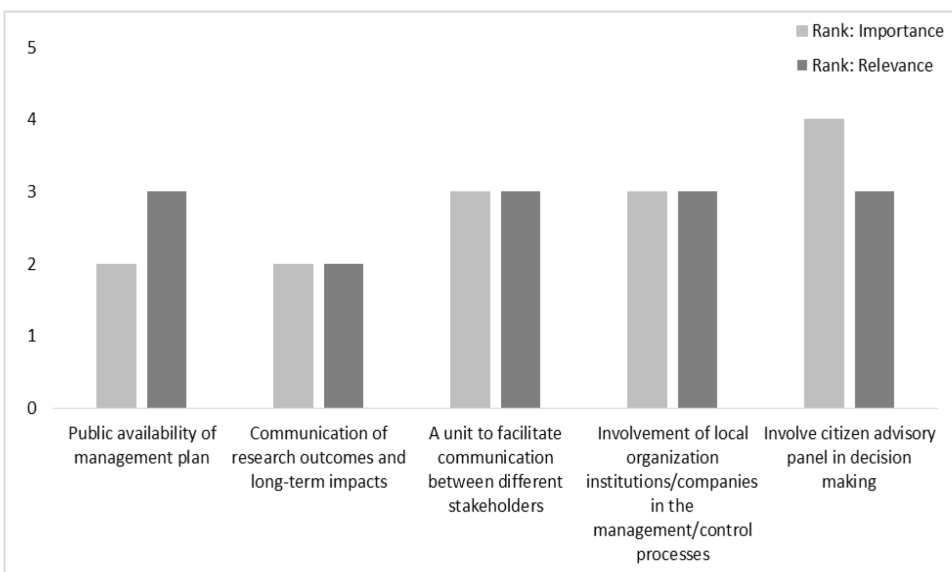
Most of the sub-criteria or indicators were evenly rated as strongly important and strongly relevant in relation to the forest-based bioenergy production (see Fig 11. d).

‘Colocation of biorefineries in existing facilities’ and ‘Legal documentation of clearly stated tenure/use rights’ were also ranked the highest for relevance and evenly for importance (see Fig 12. d).

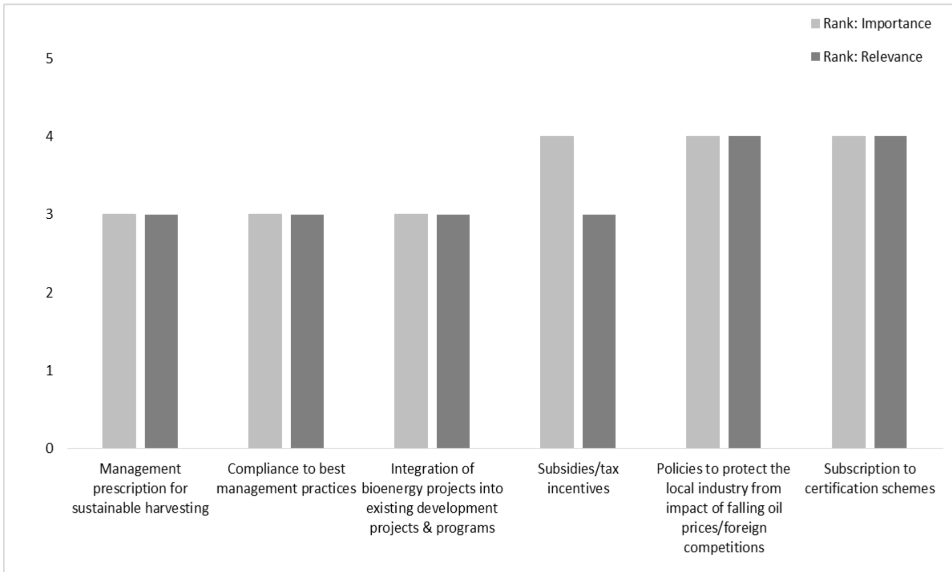
a) Regulatory policies




b) Transparency



c) Precautionary policies and support mechanisms




d) Management and monitoring

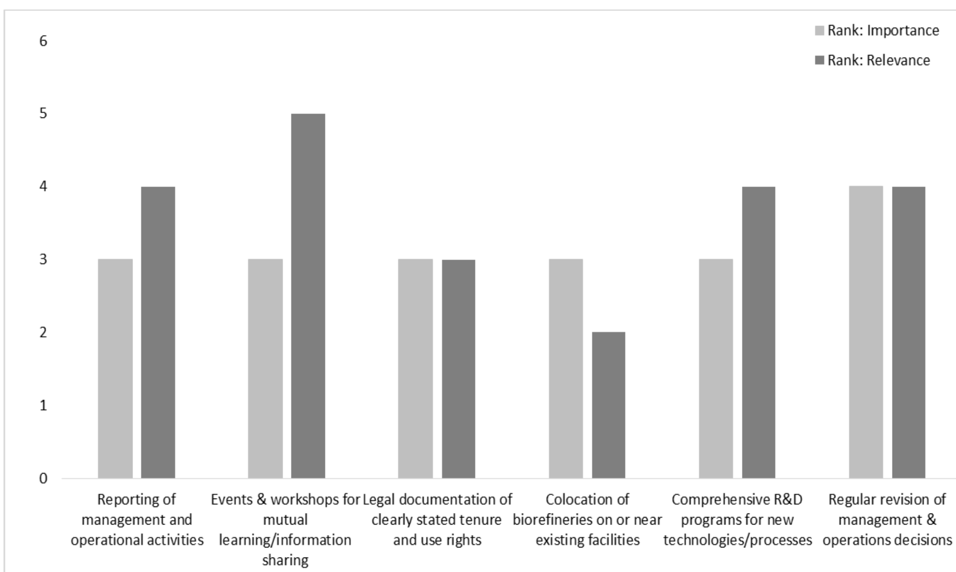



**Fig 12. Stakeholder group (Decision making) assessment of criteria using ranking method (n=1 because each group considered only one category)**

# CHAPTER VI: Conclusion

Sustainable development is a global agenda and entails collaboration among all levels of governance, interest groups and stakeholders. It promotes intergenerational and intra-generational equity in the use and management of socio-economic and environmental resources. Since the 1992 Rio Declaration, sustainability criteria and indicators are increasingly employed to monitor the progress of a human society towards sustainable development goals. Of particular interest in this dissertation were sustainability criteria and indicators, and top-down versus bottom-up (participatory) approaches to develop them.

Through our work, we argue that top-down and one-size-fits-all frameworks (constituting generic criteria and indicators) for all nations or for all levels of governance are not the best approach to pursue it (Colfer 2005; Redclift 2005; Brodhag and Taliére 2006; Ostrom 2009). Certification schemes and international development goals are the most common examples of one-size-fits-all sustainable development assessments. The use of such generic and top-down sustainability assessment frameworks gives the advantage of standardization or harmonization (Buytaert et al. 2011), but the disadvantages of a lack of context-specific relevance, inclusiveness, or procedural legitimacy or transparency (Redclift 2005; Stringer et al. 2006; Keohane 2011; Partzsch 2011; Schouten et al. 2012). Our study of Millennium Development Goals in the Nepalese context (discussed in Chapter II) exemplifies this observation. In Nepal, although top-down sustainable development policies and agreements have injected sustainability thinking into national development frameworks, top-down monitoring tools suffer from a lack of relevance, practicality and completeness. The study makes a case for a bottom-up participative understanding of sustainability issues to develop comprehensive sustainability criteria and indicators.

Agenda 21, a set of guiding principles for sustainable development and sustainable management of resources, promotes stakeholders' involvement and participatory decision-making as imperative for sustainable development (UNCED

1992). Stringer et al (2006) identified two important motivations for the use of the participatory approach for sustainable management of socio-ecological systems: i) improved understanding of diverse perspectives and values to support a holistic understanding of the system and ii) to ensure transparency and equity as recommended by deliberative democracy literature (which recognizes the participation of stakeholders in decision-making as a basic human right). Although local stakeholders generally perceive opportunities for them to participate positively, the contribution of stakeholders' participation to the decision-making process may not always yield anticipated outcomes (Schusler et al. 2003; Jalilova et al. 2012; Vaidya and Mayer 2014). Stakeholder participation falls short particularly when their participation does not include a mechanism for multilateral communication or to alleviate perceived prejudices among participants about relevant issues and the value of others' perspectives (Schusler et al. 2003).

Interestingly, 'participation' has been used widely in sustainable development discourse, but there is a little consensus regarding its meaning and procedural requirements (Stringer et al. 2006). Nevertheless, throughout this dissertation, we use the term 'participation' or 'participatory approach' to broadly mean the involvement of more than one stakeholder group in any decision-making processes. Based on our review of thirteen case studies (discussed in Chapter III), we categorized participative development into: i) expert-initiated and ii) expert-assisted approaches. Expert-initiated approach uses participatory techniques for a consultative purpose or preference elicitation (for a pre-defined or expert-driven sustainability criteria and indicators). It provides limited opportunity for stakeholders from non-scientific backgrounds to share their values, contribute to collaborative learning and to define sustainability goals and criteria. On the other hand, expert-assisted approach allows stakeholders (from scientific and non-scientific backgrounds) to define sustainability goals for their socio-ecological system. An expert-assisted approach uses a greater degree of stakeholder participation, from the development to the implementation of sustainability criteria and indicators, and uses researchers' input to facilitate collaborative learning and interaction among stakeholders.

In Chapter IV and V, we discuss our application of an expert-assisted approach to develop a regional sustainability assessment for a bioenergy industry in the Upper Peninsula (UP) of Michigan. These chapters in particular, helped us further to answer the overall question of this dissertation i.e. what is the utility of participatory approach for sustainable development assessments? The use of bottom-up approach (using multiple qualitative research techniques) in our study allowed participants to interact and share local knowledge with the researchers, ask questions and voice their concerns and values. This knowledge was crucial for identifying relevant, practical and meaningful sustainability criteria and indicators for the target system. This approach improved our understanding of local context, needs, capacities and resources, thereby enabling us to generate, aggregate, comprehensively define, and partially validate sustainability criteria and indicators. However, it is important to note that sustainability criteria and indicators generated in this case still need to be further examined for their viability and practicality in the given context. While historical trends and change of the indicators over time against the baseline (i.e. before the development of a bioenergy industry) may be used to verify the majority of the quantitative indicators, ex-post collection of data will be necessary to verify the viability of qualitative indicators (particularly those related to policy and institutional capacity).

Through this dissertation, we make a case for not just a participatory approach, but a collaborative or expert-assisted participatory approach to generate sustainability assessment tools and to define sustainable development goals for regional systems. The opportunity for collaborative learning and context-based understanding of socio-ecological systems contributes to ensuring the efficiency and effectiveness of the participatory approach (Stringer et al. 2006). It is also important to ensure that all sub-components of the target system are adequately represented in the process. Collaborative learning among stakeholders from scientific and non-scientific backgrounds, representing different dimensions and sectors of a system, contributes to a holistic understanding of the system, which in turn can encourage sustainable thinking and decision-making.

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