Indicators for Assessing Social Sustainability of Fuel Wood Systems

Eng. K J Sirikumara,

Assistant Director, Engineering standardization Division, Sri Lanka Standards Institution, Sri Lanka

jayantha@slsi.lk

Abstract— *There are pressing reasons for developing a better understanding group of indicators to assess social, economic and environmental sustainability of fuel wood systems. Therefore an important current research need is to develop a better accepting of group of indicators for social sustainability. Effective indicators can help to identify and quantify the sustainability attributes of fuel wood options. Therefore, the aim of this paper is to critically review the indicators that assess the social sustainability of fuel wood systems. A comprehensive literature review and a desk study of 16 key research papers written on fuel wood are analyzed in this research study. This research identified a selection of indicators influencing sustainability criteria for fuel wood under social sustainability. Ten social indicators are identified from the literature review for land use change, land use right, social development, energy security, water use right, resource conservation and, social acceptability. Ten indicators identified under seven categories from literature review will be used to identify critical indicators affecting the sustainability criteria for fuel wood during the next phase of the study. These critical indicators are hypothesized to be practical toolset for capturing key social effects of fuel wood across a range of fuel wood system, including different pathways, locations, and management practices. To evaluate the hypothesis that the toolset meet this goal, and also to help measure variability and establish appropriate targets, the toolset should be field tested in systems spanning a wide variety of conditions. If the hypothesis is confirmed, the toolset can be implemented more broadly, modified as necessary for particular situation.*

Keywords— *fuel wood, social indicators, food security, employment, energy security, social acceptability, social well-being.*

I. INTRODUCTION

The production and use of fuel wood have potential roles in mitigating climate change, promoting energy security and fostering economic and social development. Various types of biomass are used for the production of fuel wood through many types and sizes of economic operations. Virtually every country in the world produces and consumes some form of fuel wood. The characteristics of fuel wood production therefore are very heterogeneous, and their production processes depend on several factors, such as geographic location, climatic conditions, level of development, institutional frameworks and technological issues.

In fact still if you ask a direct question how sustainability looks and feels answering can be quite difficult. Big countries and big powers will think quite different to small and less develop countries and those who are about to be submerge due to climate change. For the latter the criteria should be applied to others on how they work and play as they are going under no fault of theirs but more due to excessive consumption and selfishness of some others. Sustainability is often considered to be the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the socioeconomic, environmental and other requirements of present and future generations. A less work has focused on the development of social indicators for sustainable fuel wood system in Sri Lanka. In International Standardization of sustainability criteria for fuel wood system, no consensus has yet emerged regarding which indicator should be assessed and which indicator should be given the highest priority. Therefore a need arise to identify whole set of indicators to assess the sustainability of different types of fuel wood systems. To fulfil above requirement, Set of social sustainability indicators are identified from this literature review study.

This set of indicators may be useful for decision makers, policy makers, Agronomists, Producers, business people, and other stakeholders in all stages of the supply chain from an albeasia (vatamara) grower or waste suppliers to those involved in logistics, conversion facilities such as biomass power plant owners and end users. Now the sustainability criteria should consider all different aspects of these operators and their physical locations and operations. A biomass plant owner can influence across a wider group as they would be influencing long distance farming including where and by whom. How well and comprehensive you address social, environmental linkages and performances will mean the accuracy of your work and the honesty of your purpose. It is important to understand that if we are to grow our food, live our lives and grow our energy too from the same land mass, competition has to come in some day.

The fact is that as yet fuel wood is not mainstream energy in countries. This is true with many developing economies as bioenergies do not operate in the domain of commercial energy. With globalization and with increased demand for reducing Green house gas (GHG) emissions one can grow your energy elsewhere and proceed to source or have carbon accounting and offsetting. Where the energy is grown, if the offer is attractive, one may witness the shift of land for more opportunistic fuel wood than for food or other use.

Indicators provide information about potential or realized effects of human activities on phenomena of concern. Indicators can be used to assess the social, economic and environmental conditions of a system, to monitor trends in conditions over time, or to provide an early warning signal of change. While this review made to be broad enough to apply to fuel wood, generally, the indicators were selected based on biomass production pathways. The review was done to address few objectives. The first objective is to identify a full set of social indicators that can effectively support policy makers, decision makers and planners. The second objective is to identify indicators that apply across the supply chain, including feedstock production and logistics, conversion to biomass, biomass logistics and biomass end uses, as defined by the group of actors at each stage. For example, growers and suppliers are the major players in the feedstock production stage; the conversion stage involves biomass plant and other biomass application; and fuels users (including the public) are at the end-user stage. It is important to consider the components of the supply chain both individually and collectively. The third objective is to identify a full set of indicators of social aspects of sustainable fuel wood systems based on literature review. The lack of consistent application of selection criteria can weaken attempts to promote sustainability indicators by generating well intended but bulky aspiration lists. Too many indicators and data requirements upset effective adoption because of unacceptable technical, administrative or economic burdens. The fourth objective is to help in the implementation of certification programme (ISO Bioenergy standard is under development) that can be applied to either the whole supply chain, parts of a supply chain, or a single process in the supply chain. The fifth objective is to facilitate comparison between various fuel wood process and product. This full set of indicators can also be used to facilitate comparison between fuel wood processes or products and other energy options.

II. AIM AND SCOPE

This paper performs a review of a large portion of the existing scientific literature on effective indicators that is used to identify and quantify the sustainability attributes of fuel wood options. Author of this paper assume that the reader already has a basic knowledge of social effect of the full supply chain for fuel wood, including feedstock production and logistics, conversion to fuel wood, fuel wood logistics and fuel wood end uses, so that general information on these aspect is not provided here.

The main purpose of this work is to discuss the key direct and indirect indicators of social and striking features emerged from a review process of the wide scientific literature available and analyzing the approaches used by the different authors to face these issues, thus reporting the current state of the art.

In addition, only papers written in English and with good and reliable supporting data and references were selected. Selection of indicators was based on research in the disciplines related to each category of indicators. The diversity of indicators needed to broadly assess environmental sustainability may not allow for a uniform, well defined indicator selection process. Therefore, expert judgment is an important part of the selection process.

III. Categories of Indicators

3.1 Land use change and land use right

3.1.1Food Security

The use of cropland to grow fuel wood feed stocks has generated concern that the energy benefits of fuel wood may come at the expense of food security. The majority of current ethanol and biodiesel production uses industrial feed grain, sugar, and oil crops as feedstock, including maize in the US, sugarcane in Brazil, oil seeds in Europe, and palm oil in Asia. Food security became a concern in 2007 and 2008 when global food prices rose rapidly. Initially, those price increases were largely attributed to bioenergy production (Runge and Senauer, 2008; Rosegrant, 2008). From the dawn of civilization, food security has been a major human goal. Historically, food production in the overall Asian context increased at the same rate as that of human population (FAO, 2002a). However, population growth has outmaneuvered the food production trends in the past decade, implying the need to augment food production. According to (FAO, 2002b), there are about 800 million people in the developing world who suffer from hunger.

Studies' Authors / Indicators	Geetha M 2013	Krishnal S 2012	Jayaweera M 2012	Smeet E 2008	Leiby P N 2008	ISO 26000 : 2010	FAO 2009	Bandaragoda D. J 2006	ECOLOGIA 2011	Runge C 2008	Rosegrant M 2008	Perera TGUP	IEA 2010	Thornley 2008	Aleklett K 2010	Visscher V H M 2011
Land use change																
Food security																
Land use right																
Land use right																
Social Development																
Job in the fuel wood																
Change in income																
Energy security																
Self sufficient in																
Water use right																
Water use right																
Resource																
Depletion of fossil																
Social acceptability																
Public opinion																
Transparency																
Stakeholder participation																

Table 1: List of recommended social indicators for fuel wood sustainability - Different studies, Authors and the indicator identified by them

And most of this (60%) is in Asia with South Asia accounting for about 36%. Well-developed home garden with different annuals and perennials can play a crucial role in providing household of high-nutrient food items, in low input costs, through producing diversity of food items that is consumed on a daily basis. The results of this investigation indicate that if a considerable array of plant species is nurtured in home gardens, these will become as an essential resource on which families, communities, nations, and future generations depend. (Krishnal S et al., 2012) Information on populations that are food insecure at national and regional level, and changes in food security over time, are important in formulating policy and development interventions for food security. Sri Lankan's food security assessments have been based on composite indices constructed using variables that are direct or indirect determinants of food security. Such composite indices help compare relative food insecurity across geographic areas, and over time, but limit the assessment of the magnitude of the prevalence food insecurity.

In line with the literature an individual was defined food insecure if the food energy intake fell below a nutritionally recommended minimum level. Applying a method available in the international literature to nationally and periodically available National household income and expenditure surveys (HIES) data food insecure population proportions were estimated for two time periods 2006-2007 and 2009-2010. Based on 2006-2007 data and under both Minimum Dietary energy requirement (MDER) levels (1810 Kcal and 2030 Kcal), Nuwara Eliya District turned out to be the least food insecure and Gampaha District the highest food insecure; by 2009-2010 Colombo turned out to be the most food insecure District, while Nuwara Eliya remained least food insecure. The results point out that, based on per capita food energy intake for identification of food insecure populations, the western province (consisting of Colombo, Gampaha and Kalutara Districts) which is also the most populated and urbanized province in the country contains the largest number of food insecure individuals - an important matter to be considered in food policy formulation. (Geetha M and Romeshun K, 2013) (Table 1).

Indeed, recent studies suggest that food price trends follow oil prices, and short-term volatility is linked to weather and local import/export polices. Nevertheless, this issue will persist as long as there are hungry people in the world and land is used to produce fuel wood. Thus, an effective indicator for food security is more complex than simply tracking changes in food prices and land use that may be attributable to fuel wood. Based on the state of scientific data and analysis discussed here, we propose that the percent change in price volatility of food crops attributable to fuel wood be developed as an indicator of food security (Table 1). Sudden price falls can put producers out of business while sudden increases affect consumers.

Our proposed food security indicator requires further work to implement because there is no agreed upon way to measure how food price volatility can be attributed to fuel wood. Development of this indicator requires an approach that controls for major influences on changing food prices and distinguishes effects due to fuel wood projects or policies. FAO (2011b) provides a starting point with its indicator for changes in real prices of staple crops attributable to fuel wood. FAO (2011b) proposed indicators aimed at (1) measuring the domestic availability of staple foods and (2) determining whether use of staple foods for fuel wood is met by additional production or replacement of existing production. Their estimation requires detailed data on the availability of staple foods and effects of fuel wood production on land and food supplies.

However at the global level, Gasparatos et al. (2011) estimated that fuel wood account for less than 2% of the total harvested land area. It is also not clear what a change in the proportion of arable land represents in terms of food security, because if fuel wood generate more income than other land uses, food security could increase with higher proportions of land dedicated to fuel wood. Hence, this indicator has to be considered in the context of land suitability for various purposes and variable market opportunities. And if a region has limited capacity to grow food efficiently but extensive ability to produce fuel wood feedstock, increasing the portion of land in fuel wood feedstock may lose food security. Selected indicators should be able to provide representative, unambiguous and unbiased measurements of change in sustainability. The inherent complexity of establishing and measuring an indicator of food security implies that significant time, cost and analytical effort will be needed to reach agreement on its definition, methodology, and application.

3.1.2 Land use right

Land registration systems that define and identify the land rights, making it commercially and financially visible to the market are one key for the development of the country. However in developing countries the administrative framework for the registration of lands seems to be inefficient and ineffective in coping with the dynamics of the land markets. In Sri Lanka too as per the issues that can be experienced with regard to the land tenure, it could be presumed that the land registration system has not been effective in dealing with the development requirements of the country. Accordingly this study investigates and evaluates the land registration systems in Sri Lanka and has attempted to propose certain strategies in order to improve its effective implementation. In this regard one of the strongest claim made by the study is that the land registration system should enforce pragmatic decisions and strategies rather than relying on too standardized, bureaucratic and costly approaches.(Perera TGUP, 2006) Selected indicator, land use right, should be able to provide representative, unambiguous and unbiased measurements of change in sustainability. The economic operator provides information on how land use rights are addressed. Where traditional land use rights are applicable, is there documented evidence of a process for consulting and gaining free, prior and informed consent for the right to use the land, and documented evidence of outcomes? (Table 1).where there are direct effect on local food security resulting from land use change, is there documented evidence of free, prior and informed consent from local stake holders? Where local stake holder consent has been sought under above indicator, the economic operator has clearly documented the process to determine the area considered to be local.

3.2 Indicator of Social Development

Development refers to the condition of the people and social systems with regard to prosperity, safety, and health. This category focuses on two indicators of social development: job in the fuel wood sector and Change in household income. Other services and health issues that affect social well-being are covered by environmental indicators (e.g., potential for disease can be related to measures of air quality while the provision of food and other services is related to indicators of productivity, soil quality, and water).

3.2.1 Job in the fuel wood sector

Job in the fuel wood sector has been considered in all known and proposed sustainability standards that incorporate social issues. Policy makers have highlighted employment as a prime motivator of national policies supporting fuel wood research, development, and use. For local economies, the driving force behind the push for fuel wood is often job creation and economic growth, while other potential benefits such as environmental protection and energy security may be considered bonuses (Domac et al., 2005).
Rural areas of Sri Lanka are expected to benefit from the establishment of fuel wood industries through job creation related to biomass conversion facilities established near production sites and the extensive supply chains involved in feed-stock production. However, as with any industry, employment projections are contingent on assumptions about the configuration of the industry (e.g., feedstock choices and distribution and number of conversion facilities) and vary based on profitability of the production site and management choices across the supply chain (e.g., manual or mechanical harvesting).

One indicator, full time equivalent (FTE) employment generated (including both direct and indirect), is recommended to capture the number of jobs provided by the industry (Table 1). The selection of this indicator was motivated, in part, by the importance of measuring employment in both local and national economies and by the availability of data and methods for measuring direct and indirect employment (e.g., Thornley et al., 2008). There are many ways that employment could be interpreted with respect to other variables (e.g., FTE positions/unit of energy, total employment in person-years/ha of land devoted). When sufficient data on pre- and post-industry employment are available for the appropriate scale, comparing total employment in the energy sector before and after fuel wood systems development can be used to estimate the industry's net effect on overall employment.

It is imperative that Sri Lanka grasps the concepts of green jobs to meet the most vital but intricate challenge of the 21st Century, which is the transformation to a sustainable and a low-carbon economy. Such a transformation or a paradigm shift, which can be gradual or rapid depending on the circumstances, will undoubtedly have a considerable positive effect on the way we produce and/or consume goods and services. The speed at which this transformation would occur is likely to accelerate in the near future as there is a trend of global transition from a traditional to a low-carbon economy, in order to attain sustainable economies. Such trends will help create an array of different forms of green jobs across many sectors, and most probably can become a catalyst for further development. The International Labour Organization (ILO) has defined green jobs as "Jobs created when they help in reducing the negative environmental impacts ultimately leading to environmentally, economically and socially sustainable enterprises and economies". Green jobs, in general, stand on two pillars: decent work and environmental sustainability. Thus, green jobs can be defined as decent work that contributes to environmental sustainability. In a broader sense decent work needs to address the core of international labour standards such as freedom of association and effective recognition of the right to collective bargaining, elimination of all forms of forced or compulsory labour, effective abolition of child labour, elimination of discrimination in respect of employment and occupation, occupational health and safety, etc. whilst aligning to laws applicable to Sri Lanka. Environmental sustainability addresses issues such as effectively combating climate change, pollution prevention and control, conservation of eco-systems and biodiversity etc. (ILO, 2007).

The decent work component seems to be relatively strong in terms of statutory attributes such as
EPF/ETF, health and safety issues, maternity and overtime provisions. In addition, some other benefits such as transport, insurance and bonus schemes are also provided for employees though they are not statutory requirements. It is interesting to note that career development is considered important by almost all organizations. However,

some essential attributes pertaining to decent work such as having a policy for HIV.AIDS, gender equity are still lacking.
In order to see a positive growth in green jobs, organizations must foresee the benefits of green jobs and they should explore the possibility of moving towards becoming greener businesses by catering to green needs and opportunities. In summary it is apparent that most of the organizations stick to the mandatory attributes with great success but other attributes that are of paramount for green jobs are yet to be embraced at large. At least a few of these organizations have perceived the importance of green jobs in the context of retention of good work force among them. In future what remains within the sustainable economy reflects a large number of green jobs creations through practices of more and more environmental sustainable initiatives with decent work embedded in them. (Jayaweera et al 2012).

3.2.2 Change in income

Change in income of those employed in the fuel wood industry is a useful indicator of well-being and is measured as financial compensation received by workers for their labor. As with other indicators, the income should be attributable to fuel wood and distinct from other non- fuel wood -related income. While wage rates are influenced by market forces, tradition, social structure, seniority, and other factors, they can be a useful way to compare welfare received from the fuel wood industry to welfare received from other industries. For example, Sydorovych and Wossink (2008) consider income stability and predictability to be important aspects of agricultural sustainability. Also, (Smeets et al. 2008) found that wages were higher for sugarcane harvesting and ethanol refining than for comparable employment in other sectors. Careful thought will be required to define what sources of household income are attributable to the fuel wood industry or project being analyzed. Methods consistent with those applied to the employment indicator should be used to identify activities that are clearly linked via the supply chain, such as biomass storage and management, trucking and transportation, and other agricultural or forestry-based employment associated with biomass production, harvesting and logistics. At a minimum, data should be collected to estimate the average income of employees in the industry. Our proposed indicator is Rupees per day of household income (Table 1). However, collecting data to generate the distribution of income would allow better comparison to other industries and among alternative fuel wood production pathways.

3.3 Indicators of energy security

3.3.1 Self sufficient in energy

For fuel wood to enhance energy security, they must lead to reduced imports of non-competitively supplied fuels and a shift in consumption toward more stably supplied fuels. For fuel wood, energy security also requires reliability and security of resources and activities that support the fuel wood supply chain, including water, nutrients, and production operations, in spite of highly variable commodity and product prices. Three key factors promote biofuel energy and social security: stability of energy feedstock supply, stability of product and co-product supply and demand, and flexibility of the feedstock and fuel system. Each of these influences is discussed briefly. The stability of primary feedstock supply for biofuel depends on the volatility of biofuel feedstock production and the diversity of bio feedstock supply sources for the biofuel system. Historical data on crop yield and price volatility indicate that supply stability (FAO, 2008) could be an issue for biofuel feedstocks. Yield fluctuations in response to some stressors (such as cyclic drought or pests) can be accommodated in the supply chain, especially if there is substantial diversity in that supply chain and the opportunity to adjust operations. Biofuel feedstock systems may be less resilient when faced with fluctuations due to unexpected disturbances such as drought, floods, or disease. Feedstock supply stability is affected by the availability, choice, and engineering of crop varieties to achieve specific goals (e.g., drought and pest resistance) as well as management practices (Leiby P N, 2008).

There may be additional uncertainty regarding the stability of feedstock supply from new sources such as algae that may be susceptible to pond crashes and grazing pressure as well as sudden fluctuations in temperature or water chemistry that are out of operators' control. Feedstock supply stability, from the perspective of the biorefinery owner, can be increased by planned and regionally integrated logistics (advanced preprocessing such as pelletizing) and infrastructure (access to railroad) such that they can draw feedstock over large areas. The stability of product supply and demand (and prices) depends on management of product inventories, availability of a stable market for biofuel co-products, long-term policies and subsidies, reliable production/conversion processes, transportation logistics, and the stability and level of oil prices. The relationship between agricultural commodity price volatility and inventory levels is widely reported (e.g., Munier, 2010). Feedstock and product inventory management may be as important to biofuel cost stability as it has been for petroleum fuels. Diversifying markets and production lines (e.g., for food, fuel, fiber, fodder, chemicals) for a given feedstock supports larger and more widespread production that may help absorb temporary or localized shocks to supply and demand. Access to a reliable market for biorefinery co-products is important for producers to weather shocks in feedstock or product prices. Flexibility of the biofuel feedstock and fuel system enhances energy and economic security by allowing substitutions during short-run supply or demand fluctuations. Supply flexibility follows when feedstock producers and logistical systems can respond to multiple markets through, for example, greater feedstock uniformity and enhanced transportation systems. System flexibility also is increased by biorefinery technologies that can use multiple feedstocks and produce a range of products, in varying proportions. Petroleum product pipelines have the potential to expand the range of long-distance transport methods for drop-in, biologically produced fuels. Demand flexibility depends on the types of fuels produced, with a distinct advantage anticipated from drop-in-replacement fuels compared to fuels that are incompatible, or blend-limited, with fossil fuels and their infrastructure. The flexibility of end-use biofuel demand increases with the availability of biofuel refueling infrastructure and the extent to which the vehicle stock includes vehicles with capability for fuel switching or fuel flexibility. With respect to fuel flexibility, jet aircraft can use bio-based fuels in their fuel mix, but current refining processes do not produce fuels with the required aromatic compounds or density specification, and so fossil fuels need to be blended with the bioenergy (Agusdinata et al., 2011).

3.4 Water use right

The demand for water has increased over the years in Sri Lanka and will continue to increase in view of the accelerating tempo of urbanization, population growth, industrialization and agricultural intensification. The general objective of integrated water resources management (IWRM), as it is applied in Sri Lanka, is to make certain that adequate supplies of good quality water are maintained for the entire population of the Island, while preserving the hydrological, biological, and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases.

Sri Lanka's challenges in water resources management include seasonal shortages of water for irrigation, domestic use and hydropower generation as well as degradation of the quality of surface waters through domestic and industrial effluents and agricultural runoff. Hence during the past several decades, the Government of Sri Lanka (GOSL) has made several attempts to institutionalize a coordinating mechanism amongst the plethora of sectoral agencies in the water domain to resolve the water allocation issues. The competitive user agencies fell within the purview of a number of separate Ministries in charge of the subjects of Irrigation, Land, Mahaweli Development, Energy and Urban Utilities.

Currently, there is a "free-for-all" situation where the contending sectoral interests are resolved by means of the greater "political" clout. Formulation of appropriate legislation setting out the principles of "priority water allocations" needs be based on socio-economic, financial, environmental, technical and political considerations. Case studies, which illustrate the competing rights for limited water, must be documented and analyzed in order to formulate policies and procedures.

A system of "water entitlements" is likely to fail if the categories of "reasonable use" are not defined in the legal enactment. Rights to extract and use surface and ground water are based on two principles which should be modified to suit Sri Lanka's situation. These are the doctrines of riparian rights and prior appropriation. The riparian doctrine gives the occupier of land bordering a stream a right to make a reasonable use of water and imposes liabilities on upper riparian that unreasonably interfere with that use. The reasonable use should be defined to include only withdrawals by manual means to protect "chena" cultivations and not commercial farms, hotels or industry. What about underground water? Can a landowner be regarded as owning the water underneath his land and permitted to take, whatever quantity he could capture? An occupier's use of groundwater must be reasonable. This "reasonable use" must exclude mechanical means of pumping, for which purpose an "entitlement certificate" should be obtained specifying the conditions, limiting the quantities that can be drawn. These doctrines must be discussed and agreed upon, if the new policy is to make any headway. (Bandaragoda D. J et al, 2006).

The current water-related issues lead to the identification of some emerging water management constraints. There are four key problems in river basin contexts in Sri Lanka: (a) non-availability of reliable data related to extraction of water from river basins, (b) inadequate planning, (c) absence of well-defined water rights, and (d) lack of mechanisms for integrated development and management of water resources. The intensity of these problems tends to vary from site to site, and country to country, depending on the degree of their water resources development.

The need for water allocation and clear water rights—The principle is accepted by all, but some countries such as Indonesia and Sri Lanka seem to hesitate to introduce the regime fully; all countries acknowledge the justification for allocation that water as a scarce resource must be equitably distributed among competing uses in a way that will maximize the value of the public good, and that an institutionalized allocative mechanism is necessary as market forces do not come into play readily as the ownership of water is not seen as that of an ordinary commodity.(Bandaragoda D. J et al, 2006).

Introduction of participatory management at the lower end of the service provision spectrum, leaving secondary or tertiary segments of irrigation schemes to be managed by farmer organizations and small rural water supply schemes to be managed by community based organizations—Sri Lanka has achieved some positive results in this regard. .(Bandaragoda D. J et al, 2006). Selected indicators should be able to provide representative, unambiguous and unbiased measurements of change in sustainability. Our proposed water use right indicator requires further work to implement. Development of this indicator requires an approach that controls for major influences on changing water demand and distinguishes effects due to fuel wood projects or policies. The economic operator in water-scarce countries provides information on how water availability for human consumption and food production are addressed.

3.5 Indicator of resource conservation

3.5.1 Depletion of fossil fuel

A resource conservation indicator specifically proposed for fuel wood is the amount of crude oil stock extracted each year. Unlike water and soil, non-renewable energy minerals are not typically considered among environmental indicators for fuel wood. Yet they represent valuable natural capital for a region, state or nation, the global community, and future generations. Some minerals can be conserved through efficient use and, with additional energy inputs, recycled to serve similar functions as the source mineral. But fossil fuels that are oxidized with use cannot be recycled. At current rates, over four billion tons of oil consumed annually (IEA, 2010) will never be available for future use. There is growing recognition that industrial societies have rapidly depleted a majority of the most accessible petroleum reserves (Aleklett et al., 2010; IEA, 2010), along with their option value for future use. Given that bioenergy provide a liquid fuel alternative to petroleum products, the conservation of crude oil stocks is of special interest. The proposed indicator, metric tons of petroleum extracted per year, is relatively easy to track at multiple scales, provides a simple measure of future options lost, and uniquely complements other sustainability indicators to reflect the interests of future generations. Data on petroleum removals are available [e.g., via the International Energy Agency (IEA), Energy Information Agency, and US Geological Survey]. The removal of petroleum stocks can be measured using standard units, definitions, and data sets. For example, the IEA releases annual reports on metric tons of crude oil, natural-gas-liquids, and refinery feedstocks extracted, by country. Petroleum fuels can also be monitored in terms of metric tons per unit of equivalent liquid fuel (MJ) supplied, and this information may be applicable for comparisons of pathways (as reflected in the indicator below). For smaller scale analyses and comparisons, the total use of petroleum associated with different energy production pathways is of strategic value. We considered but rejected the use of value and price as indicators for natural resource scarcity and conservation. While a monetary value provides an important perspective on resource consumption, we focus on actual volumes of resources consumed or exported that are no longer available for future use within a defined geographic area or system boundary under analysis. Substitutability is important because, as prices rise to reflect scarce resources, “unconventional” resource extraction (for example, hydraulic fracturing and tar sands) becomes economically attractive and leads to potentially higher marginal social and economic costs.

3.6 Indicator of Social acceptability

3.6.1 Public opinion

Public opinion (% favorable opinion) can be determined using a standard survey instrument to gather data on public perceptions of the bioenergy project under assessment. This indicator provides a direct measure of social acceptability. Surveys of public opinion regarding the social acceptability of a project or technology are measures that integrate variables across sectors and categories. These surveys are common for energy technologies (e.g., nuclear energy in Visschers et al., 2011) and measure the percentage of the surveyed community that rates the project as acceptable. Surveys may also include measures that categorize respondents as favorable, neutral or unfavorable. Surveys can be helpful but need to be crafted and interpreted carefully. Surveys should be designed to measure the public’s reaction to high probability and low impact events in contrast to focusing on risk of catastrophe. However, it can be unclear whether factors that are correlated to social acceptability are determinants or consequences of social sustainability. Research is sometimes needed to distinguish between these possibilities, as was done in a study of how public trust relates to the social acceptability of genetically modified food (Poortinga and Pidgeon, 2005). Standard protocols need to be validated and applied consistently over time to track changes in public opinion. However, the public opinion on producing biofuels from edible sources is not favorable.

3.6.2 Transparency

Transparency can be demonstrated through periodic public reporting on social and environmental performance indicators. All interested parties should be provided free access to data reflecting sustainability indicators such as those described here. The extent to which timely and accurate information is made available, and the degree to which this information addresses issues of interest to stakeholders, reflect measures of transparency supporting sustainability. The proposed unit of measurement, the percentage of indicators for which performance is reported in a timely manner (ISO 26000:2010; Table 1), is context-specific. This public reporting should provide relevant baseline, target and performance data for all environmental, social and economic indicators identified. The suite of indicators may be adapted and prioritized for a given project or situation based on stakeholder participation (discussed below). Furthermore, annual reporting should meet an established standard (e.g., such as that proposed by the Global Reporting Initiative: www.globalreporting.org).

3.6.3 Stakeholder participation

Stakeholder participation is a key component of social acceptability. Many aspects of stakeholder identification and participation are reflected in sustainability literature and proposed certification schemes. Stakeholder participation can contribute to more effective and enduring progress toward other environmental and socioeconomic goals. This process involves providing stakeholders with the necessary understanding of the technologies employed and building a sense of control, trust, and ownership in the project and its benefits. Stakeholder participation can be more effectively achieved when there is meaningful two way dialogue with the industry, if concerns are acknowledged and addressed in a timely manner (ISO 26000, 2010), and if documentation reflecting performance of the full suite of environmental and socioeconomic sustainability indicators is complete, trustworthy, and readily accessible (see Transparency indicator above). Mechanisms that permit effective exchange of ideas and concerns among stakeholders with different viewpoints are also important. Stakeholders should be involved in early stages of a process to define concerns, needs and priorities. Ongoing stake-holder involvement is key to achieving continual improvement in sustainability measures. Many practical approaches can be employed to provide stake holders with relevant information and access to decision makers. For example, social media and web based software, regular public meetings, participation in community events and organizations, and other communication strategies appropriate for the project and specific sub groups of stakeholders can be used. Descriptions, options and guidance for working with stakeholders can be obtained by reading the documentation supporting the International Organization of Standards (ISO 26000), a voluntary Guidance Standard for corporate social responsibility. ISO 26000 and the companion handbook published by ECOLOGIA (2011) provide specific recommendations for identifying and reaching out to stakeholders and for building accountability and sustainability into core business practices. We propose a simple unit to reflect stakeholder participation, the percentage of stakeholder concerns and suggestions addressed in documented responses, reported on an annual basis. This indicator can provide a vehicle to express commitment to, and document progress toward, what are often difficult to measure sustainability values. However, for this indicator unit to be reliable, consistent and transparent reporting mechanisms should ensure that documented responses legitimately address the concerns and suggestions related to sustainability criteria and indicators and that the mechanisms for dialogue remain open to all without fear of reprisal. Other potential indicators of stakeholder participation were considered but not selected. A relevant component of social acceptability that emerges from the literature is equity or fair distribution of costs and benefits.

IV. DISCUSSION: RECENT TRENDS AND FUTURE CHALLENGES

For the purposes of this manuscript, we focus on social aspects of sustainability that are most relevant to fuel wood production pathways and energy alternatives. This paper identifies a set of 10 indicators that can be used to characterize the social attributes of sustainable fuel wood systems. These 10 indicators collectively represent how fuel wood systems may affect social sustainability with respect to land use change, land use right, social development, energy security, water use right, resource conservation and, social acceptability.

The toolset is not as detailed or comprehensive as other proposed approaches but may be more practical to apply. Even so, 10 measures is a large number for which information needs to be obtained across the supply chain for any industry. To improve future analysis and communication to decision makers, it is important to develop agreement around a manageable set of clearly specified sustainability indicators.

We highlight 10 indicators in Table 1 that could be tested to meet this goal in the near future. Proposed indicators were selected based on criteria of being practical, unambiguous, resistant to bias, sensitive to changes, related to those changes, predictive, estimable with known variability, and sufficient when considered collectively. For a few of the indicators, inadequate data and methodologies are available to meet all of those criteria. We believe that each proposed indicator reflects an important aspect of social sustainability. We envision that this set of indicators can be used as a reference to ensure that the major sustainability attributes of fuel wood systems are considered and relevant indicators measured.

Extensive reporting and documentation requirements can be counterproductive to sustainability by consuming material and energy without providing any real improvement to the sustainability of a process. Extensive and detailed reporting does not in itself assure a standardized or calibrated measure of change in sustainability.

The context of any particular application strongly affects the choice, measurement and interpretation of sustainability indicators. Context considerations include the purpose of the analysis, the specific fuel production and distribution system, policy influences, stakeholders and their values, baseline attributes, available information, and spatial and temporal scales of interest. Knowing the context is essential for setting priorities for assessment, defining the purpose, setting the temporal and spatial boundaries for consideration, and determining practicality and utility of measures.

In the recent years, numerous studies using a life-cycle approach to estimate social, economic and environmental performances of fuel wood systems have been undertaken. An increasing number of papers dealing with lignocelluloses' biomass, sugarcane or palm oil and located in developing countries was observed, especially in South-Eastern Asia. By contrast, few studies are currently available on promising feedstock like algae and jatropha oil as well as papers based on advanced biomass processing. In Sri Lanka "Gliricidia Sepium" is used extensively. The various names include Makulatha, Albizzia, Sevana, Kola Pohora, Nanchi, Wetahiriya, Ladappa, Wetamara and Giniciria. This tree has been named as fourth plantation crop by the government of Sri Lanka.

In particular, different approaches are used to deal with the indirect effects which have a large influence on final figures, and the way by which they should be estimated is still under discussion. The inclusion of these indirect effects in ISO standard represents the next research challenges for fuel wood practitioners.

On one hand, these simplifications can make the overall assessment and interpretation of final results easier, but on the other hand approximation and fixed approaches may have the drawback of misleading and inaccurate conclusions. Therefore, the formulation of regulatory standards in the presence of scientific uncertainty may lead to inefficient or counterproductive methodologies. Finding a compromise is challenging, because a certain degree of simplicity and standardization in sustainability assessment of fuel wood systems is highly desirable nowadays, especially at a governmental and political level, where the best strategies for climate change mitigation should be put into practice as soon as possible.

V. CONCLUSIONS

This review identifies a group of 10 indicators in seven categories to measure the social sustainability of fuel wood systems. It focuses on indicators that are useful to diverse stakeholders, including resource managers, policymakers, planners and designers of proposed certification schemes. While one small set of indicators cannot characterize social sustainability of fuel wood systems under all possible situations, these indicators provide a starting point that could be sufficient in many cases. However, selecting a small set of specific indicators requires compromise. Some contexts demand unique indicators and some desirable indicators require information that is either not available or too expensive to obtain.

The group of indicator is intended to be a handy toolset for capturing key social effects of fuel wood across a range of fuel wood systems, including different pathways, locations, and management practices. To evaluate the hypothesis that the group meets this goal, and also to help measure variability and establish appropriate targets, the group should be field tested in systems spanning a wide variety of conditions. If the hypothesis is confirmed, the group can be implemented more broadly, modified as necessary for particular contexts. This broader implementation will have further two goals. First, it will help stakeholders judge the relative social sustainability of different fuel wood systems, including the question of which feedstock, management practices, and post production processes are appropriate for different locations as well as the question of how fuel wood systems compare with alternative energy systems. Second, it will help provide an empirical foundation for indicators designed to assess social sustainability based on the predicted effects of management practices, such as many of the indicators proposed for use in certifying sustainable fuel wood systems.

Next steps for the use of the proposed indicators of the social aspects of fuel wood sustainability are reaching consensus on measurement protocols, selecting baselines and targets, testing the proposed set of indicators in diverse situations, exploring and documenting the variability in indicators, soliciting feedback and recommendations based on field testing, and jointly considering social, economic and environmental indicators. All of these steps require communication among stakeholders. It is important to consider social, economic and environmental aspects of fuel wood sustainability together. For example, multiple environmental and economic objectives can be pursued through product design, manufacturing process design, recycling, and other techniques with full consideration of economic and environmental tradeoffs. Joint analysis of these issues requires attention to prioritizing indicators in a legitimate process that involves all relevant stakeholders. It also requires a focus on the priorities for the particular situation. A critical next step in sustainability analysis is evaluation of the availability of supporting data and implementation of standard protocols to acquire, evaluate and archive needed information. Testing the proposed indicators via application to a diverse set of sample cases will help evaluate the availability of necessary data, prioritize data and methodological efforts, and generate ideas for improvement.

References

Aleklett, K., Höök, M., Jakobsson, K., Lardelli, M., Snowden, S., Söderbergh, B., 2010. The peak of the Oil Age – analyzing the world oil production reference scenario in world energy outlook 2008. Energy Policy 38, 1398–1414.

Agusdinata, D.B., Zhao, F., Ileleji, K., DeLaurentis, D., 2011. Life cycle assessment of potential biojet fuel production in the United States. Environ. Sci. Technol. 45, 9133–9143.

Bandaragoda, D. J. 2006. Status of institutional reforms for integrated water resources management in Asia: Indications from policy reviews in five countries. Working Paper 108. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Domac, J., Richards, K., Risovic, S., 2005. Socio-economic drivers in implementing bioenergy projects. Biomass Bioenergy 28, 97–106.

ECOLOGIA, 2011. Handbook for Implementers of ISO 26000, version Two. www.ecologia.org

Food and Agriculture Organization (2002a). Measurement and assessment of food deprivation and under nutrition: Proceedings of the International Scientific Symposium, FAO, Rome. At http://www.fivims.net/EN/ISS.htm

Food and Agriculture Organization (2002b), State of Food Insecurity in the World 2002. Available at www.fao.org

Food and Agricultural Organization (FAO), 2009. Hunger in the Face of Crisis: Global Economic Slowdown Underscores Urgency of Addressing Long-Term Challenges. http://www.fao.org/economic/es-policybriefs/briefs-detail/en/?no cache=1&uid=35540, Economic and Social Perspectives, Policy Brief #6. September 2009 (this and other policy briefs at http://www.fao.org/economic/ es-policybriefs).

Geetha M., Romeshun K., 2013. Estimation of Prevalence of Food Insecurity in Sri Lanka. Sri Lankan Journal of Applied Statistics, Vol (14-1)

Gasparatos, A., Stromberg, P., Takeuchi, K., 2011. Biofuels, ecosystem services and human wellbeing: putting biofuels in the ecosystem services narrative. Agric. Ecosyst. Environ. 142, 111–128.

International Energy Agency (IEA), 2010. World Energy Outlook – 2010. OECD/IEA, Paris, France www.worldenergyoutlook.org

ISO, 2010. International Standard 26000: Guidance on Social Responsibility. International Organization for Standardization, Geneva, Switzerland http://www.iso.org/iso/iso catalogue/management and leadership standards/ social responsibility.htm

Jayaweera M, J. Manatunge and A. Witharana 2012 Are Green Jobs Sustainable for Sri Lankan Economy? Journal of Tropical Forestry and Environment Vol. 2, No. 02 (2012) 1-12

Krishnal S., J. Weerahewa and L. H. P. Gunaratne 2012. Role of Homegardens In Achieving Food Security In

Batticaloa District, Sri Lanka International Conference on Economics and Finance Research, IPEDR Vol.32 (2012) © (2012) IACSIT Press, Singapore

Leiby, P.N., 2008. Estimating the Energy Security Benefits of Reduced U.S. Oil Imports. Oak Ridge National Laboratory Report ORNL TM-2007/028.

Munier, B., 2010. Commodity Price Volatility: Causes and Impact on the EU Agricultural Markets. Note for Directorate-General for Internal Policies Ag and Rural Dev, European Parliament, Jun 07. At http://www.momagri.org/UK/ momagri-model/Commodity-Price-Volatility-Causes-and-Impact-on-the-EU-Agricultural-Markets 695.html

Poortinga, W., Pidgeon, N.F., 2005. Trust in risk regulation: cause or consequence of the acceptability of GM food? Risk Anal. 25, 199–209.

Perera TGUP, Implementing Land Registration Systems in Sri Lanka: Being Pragmatic; Sri Lankan Journal of Real Estate

Runge, C., Senauer, B., May 2008. How ethanol fuels the food crisis. Foreign Aff. http://www.foreignaffairs.com/articles/64915/c-ford-runge-and-benjamin-senauer/how-ethanol-fuels-the-food-crisis (Web. 30 Nov. 2011).

Rosegrant, M., 2008. Biofuels and Grain Prices – Impacts and Policy Responses. Inter-national Food Policy Research Institute http://www.ifpri.org/sites/default/files/ publications/rosegrant20080507.pdf

Smeets, E., Junginger, M., Faaij, A., Walter, A., Dolzan, P., 2008. The sustainability of Brazilian ethanol – an assessment of the possibilities of certified production. Biomass Bioenergy 32, 781–813.

Sydorovych, O., Wossink, A., 2008. The meaning of agricultural sustainability: evidence from a conjoint choice survey. Agric. Syst. 98 (10–20), 1191–1202.

Thornley, P., Rogers, J., Huang, Y., 2008. Quantification of employment from biomass power plants. Renewable Energy 33, 1922–1927.

Visschers, V.H.M., Keller, C., Siegrist, M., 2011. Climate change benefits and energy supply benefits as determinants of acceptance of nuclear power stations: inves-tigating an explanatory model. Energy Policy 39, 3621–3629.