Implementing Sustainable Bioenergy Production

A Compilation of Tools and Approaches




Energy, Ecosystems and Livelihoods

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1 Executive Summary

This paper is a compilation of example principles, frameworks and tools already in use in the conservation community which may be applied to bioenergy production to identify and reduce environmental as well as socio-economic risks and promote opportunties. The aim is to provide the range of stakeholders who are engaged in the bioenergy agenda (governments, businesses, communities, land owners, and individuals) the tools to achieve more sustainable outcomes in relation to ecosystems and livelihoods. Key recommendations from this paper are:

1) do not re-invent the wheel
2) think broadly about objectives
3) do not wait
4) expand and adapt existing tools
5) use common sense
6) bioenergy is not just about biofuels

1) Do not re-invent the wheel

Despite serious and legitimate concerns about the risks, it should be noted that bioenergy is not new[1] and is here to stay. Soaring fossil fuel prices and growing concern about climate change recently prompted the IEA to note that "the question is no longer whether bioenergy can play a role in future energy supply, but more the extent, timing and cost of the contribution" (IEA, 2007). Due to the recent rapid growth of the sector, careful planning, and adaptation of existing knowledge is called for that quickly maximises the opportunities of bioenergy whilst minimizing the risks.

2) Think broadly about objectives

While the tools and guidelines presented in this paper can help improve the sustainability of bioenergy developments, assuming that the project is needed and is an optimal use of resources is a flawed starting point – it is worthwhile to question such assumptions before setting out. Project planners should assess the opportunity costs of all viable project options and not assume that bioenergy provides the best synergies between energy, environment and development goals in every context.

3) Do not wait

Numerous tools already exist that may serve various demands, often with minimal adaptation in order to be applicable to bioenergy or biofuel-specific scenarios. Biofuels, after all, are the product of diverting existing biomass production (food crops such as corn and soy, wastes, and cellulosic biomass from grasses, forests etc…) into new processes and products. The challenges of sustainable management of the natural or agricultural resource remain essentially unchanged. What is different from conventional agriculture and forestry is the added complexity of understanding energy pathways, the interplay of agricultural and energy markets, and in some cases, complex industrial processing technologies and standards. Despite this complexity, many potential tools are well suited to addressing a wide range of sustainability challenges. Indeed, due to the large number of potential tools, it should be noted that the ones presented in this paper are indicative of the range of tools available and are not necessarily the "best" or only tools to use in any specific context.

4) Expand and adapt existing tools

We encourage project planners and other stakeholders to adapt the tools in this paper to best fit the specific contexts in which they are to be used. This paper intentionally avoids giving step-by-step guidelines since so many aspects of sustainability are context-specific. There are numerous opportunities to use existing tools and datasets innovatively to feed into decision-making at multiple scales. An example might be to overlay World Heath Organization smoke inhalation data with bioenergy feedstock potential models from the FAO to identify areas of greatest potential to reduce health impacts from traditional fuelwood and dung combustion.

5) Common sense

Many of the tools presented in this paper encourage and facilitate common sense: engaging stakeholders, agreeing on and setting objectives, establishing environmental, economic and social baselines, and monitoring outcomes of project interventions are not new actions that apply only to bioenergy. Indeed, many of the tools are in fact structured and packaged methodologies for applying a common range of skill sets that are the foundation of any successful conservation or development project. These skills, which should underpin any project process, can be summarized as:

- Knowledge of resources
- Knowledge of laws and institutions
- Humility & learning
- Observing and adapting[2]

6) Bioenergy is not just about biofuels

Whilst liquid biofuels produced from agricultural crops currently dominate much of the debate, the potential for production of heat, electricity and second-generation liquid biofuels from a wider range of non-food biomass is perhaps of greater long-term significance. As bioenergy use becomes more widespread and second-generation technologies mature, it is likely that the nature of environmental and social risks will shift and so will the focus of the current sustainability debate.

[1] According to the International Energy Agency, bioenergy currently supplies about 10 percent of total primary energy supply worldwide, and in 2005 accounted for 78 percent of all renewable energy. In some developing countries it accounts for up to 80 percent of total primary energy supply, whereas in most industrialised countries it provides less than 5 percent. IEA, 2007. Key World Energy Statistics.
[2] Sayer, J. in ArborVitae 35, 2007.

2 Introduction and Rationale

In recent years, concerns about energy security, climate change and support for rural development have climbed rapidly up political agendas, both in developing and industrialised countries.

Bioenergy occupies a unique position at the nexus of energy, environment, climate change and rural development agendas. Consequently, bioenergy and biofuels in particular, have seen record levels of support in the form of subsidies, mandates and investments as governments seek to maximise the perceived synergies between the various opportunities offered by bioenergy. Whilst it is true that well-planned bioenergy development can reduce greenhouse gas emissions from a range of sources, increase rural incomes, reduce waste, improve access to energy, and improve overall energy security and independence – the reality is that current expansion of production, particularly of first-generation liquid biofuels, is increasingly cause for concern.

Recent research[3] suggests that many of the concerns are at root triggered by demand for additional land for producing bioenergy, which may have a number of direct and indirect impacts on:

- Food prices/security
- Increased GHG emissions
- Loss of biodiversity
- Land rights and other equity issues

Aim of this paper

As a number of sustainability schemes develop principles and critieria for sustainable bioenergy production. This paper aims to outline examples of existing tools and approaches to reduce, manage and mitigate these risks which can be adapted (where necessary) and applied, and indeed, to promote synergies between bioenergy production and biodiversity conservation and livelihood development.

This paper addresses a range of stakeholders (see box 1), including:

- Governments, through agricultural, energy and environment departments
- Agri-businesses and land-owners
- Civil society groups
- Communities and individuals

Section 3 provides a background to the bioenergy debate. Section 4 explores environmental tools. Section 5 explores socio-economic tools.

Further information

Suggestions for further information sources are provided at the end of each of the sections in this paper. More generally, a large and constantly expanding resource is available online in the form of the BioenergyWiki,[4] which covers many of the topics in this paper and also provides links to a wide range of documentation on the subject.

Additional tools not included

The scope of this paper is quite broad and it includes a wide range of principles, frameworks and tools that may be applied to bioenergy. However, it cannot include all possible tools and serves merely to illustrate the types of tools that could be used to implement sustainability criteria. We encourage additional tools to be listed and discussed on the bioenergywiki page.

Guidelines related to legality, mandates, trade, macro-economic subsidies and other fiscal incentives that are generally implemented by national governments at national and international scales are not included in this overview. While such policy measures are often the primary drivers for bioenergy production at the macro scale, this paper aims to promote sustainable bioenergy at the project level by providing principles, frameworks and tools that can be applied by businesses, communities, land owners, and individuals on the ground.

It should also be noted that many of the tools in this paper address more than one potential application and may be of use to more than one group of users, thus the current layout and emphasis is purely indicative.

[3] For more information on the risks of biofuels see: Doornbosch, R. & Steenblik, R. 2007. *Biofuels: Is the cure worse than the disease?* OECD Roundtable on Sustainable Development. OECD: Paris Searchinger, T. et al. (2008). *Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land use changes.* Science 319, 5867, pp. 1238 Fargione, J. et al. (2008). *Land clearing and the biofuel carbon debt.* Science 319, 5867, pp. 1235-1238. The International Risk Governance Council is also drafting a set of Risk Governance Guidelines for the Production and Trade of Bioenergy (www.irgc.org)

[4] BioenergyWiki: http://www.bioenergywiki.net

Box 1 — MATCHING TOOLS WITH PROSPECTIVE USERS

Different stakeholders are likely to find certain tools presented in this paper more relevant to them than others, since the capacity, challenges and priorities of each group are unique. This section addresses different groups of users and makes some suggestions about which of the tools in this paper may be of particular use. This section also attempts to outline what level of assessment each type of tool might require to be suitably employed. Whilst some suggestions are provided, it should not be regarded as a prescription for each type of user.

BUSINESS PROJECT DEVELOPERS

When setting up a bioenergy project, the needs of industry are often quite specific – identifying suitable partnerships, locations, markets and contractors; ensuring product quality and compliance; remaining competitive in the market. Whilst many businesses have highly developed tools for assessing a number of risks and streamlining operations, there are a range of other ways in which industry can contribute to improving the sustainability of bioenergy that go beyond following mandatory legislation directly related to sustainability. Elements from life cycle assessments, site impact assessments, resource management tools such as the WBCSD Global Water Tool, and planning frameworks can all be used to maximise the efficiency and sustainability of operations. Adherence to future bioenergy certification systems, and labelling of certified products may also give businesses a competitive advantage in the marketplace. Lastly, the issue of economic sustainability is crucial to ensure that operations remain viable in the long term. Thus, there are long term gains to be made from ensuring that capital investments and technology choices do not lock industries into current production methods and allow the adoption of future technologies, and that projects contribute to the economic and social development of local communities. Large scales of production mean that adequate assessment of impacts and planning to minimise them is crucial.

- Stakeholder engagement tools to address land tenure and free, prior and informed consent such as those developed by the Roundtable on Sustainable Palm Oil (see section 5.2)
- Economic tools such as Payments for Ecosystem Services (PES) and biodiversity offsets that allow project planners to develop socially and economically sustainable projects which balance the market values of bioenergy and biofuels with the value of sustainable ecosystems and livelihoods (see 5.5).

SMALL-SCALE BIOENERGY PROJECT DEVELOPERS

Small-scale bioenergy projects tend to focus on development opportunities for local communities and on maximising synergies between local resources and economic development. To achieve these goals, project developers may derive particular benefits from the following tools:

- Gender tools such as the UNDP toolkit that help to ensure women's needs are mainstreamed into bioenergy projects (see 5.2).
- Economic resources such as green investment funds that may provide the necessary capital for equipment and start-up costs (see 5.5).
- Community decision-making tools such as CRiSTAL that help communities prioritize based on their needs and plan projects coherently (see 4.3).
- Agricultural approaches such as ecoagriculture and organic farming that improve the overall productivity and sustainability of bioenergy at field level through better use of water and nutrients, and by providing co-benefits to wild flora and fauna (see 4.2).

GOVERNMENT MINISTRIES RESPONSIBLE FOR VARIOUS ASPECTS OF BIOENERGY

Whilst governments operate at multiple scales, they are usually responsible for national level land use planning and for regulation of natural resources such as water and air. Governments also tend to control protected areas, transport infrastructures and have the power to set laws related to bioenergy such as trade and investment regulations. Whilst the level of government intervention varies a great deal between countries there remains a good deal of common ground. To date, governments have mostly focused on promoting bioenergy for rural development, GHG emission reductions and energy security opportunities. To help ensure bioenergy contributes to these goals, relevant government bodies may benefit in particular by adopting or adapting tools including:

- Certification and standards to ensure the sustainability of the whole bioenergy industry can be verified (see 5.4).
- Life cycle assessments to ensure that bioenergy pathways are quantified and to enable fair comparisons between different options (see 4.1).
- Land use planning tools, including general frameworks for protected areas (see 4.4), forests and agricultural land, as well as more focused tools such as Pest Risk Analysis (see 4.8) or the use of GIS software to improve planning oversight (see 4.6).
- Resource management tools such as DRIFT and STELLA for assessing the impact of bioenergy developments on water resources or forests (see 4.3).
- Economic tools such as payments for ecosystem services to provide incentives for sustainable production across whole sectors (see 5.5).
- Tools for analysing and modelling the impact of bioenergy on food security such as BEFS (see 5.1).

3 Background

Bioenergy is a generic term for energy (whether for heat, power, transport) that is derived from non-fossil organic matter (biomass). It generally encompasses a wide range of potential biomass feedstocks, conversion processes, and fuels that can be developed at a number of scales.

1) Bioenergy feedstocks may be derived from:

- Agricultural crops
- Forest biomass
- Residues and wastes from a range of sources (e.g. agricultural, forestry, sewage, municipal solid wastes)
- Perennial crops such as willow coppice and miscanthus
- Biomass harvested from managed natural or semi-natural areas

This collection of tools primarily focuses on feedstocks derived through agricultural, forestry and agro-forestry production methods.

2) Feedstocks may be produced at a range of scales:

- Large scale industrial production for national and international markets
- Regional scales
- Local/community/subsistence scales

3) Feedstocks can be converted to useful energy carriers in a number of ways, including by:

- Biochemical processes such as pressing and transesterification of algae or oilseeds for biodiesel, anaerobic digestion of biomass into gases, and fermentation and distillation of starch and sugar crops into ethanol
- Thermochemical processes such as direct combustion, gasification, and pyrolysis
- Mechanical processes such as compressing wood waste into pellets

Because of the large number of direct and indirect variables along the entire production chain, determining the environmental impact of bioenergy – and biofuels in particular – is extremely complex. These variables include the feedstock species, the scale and location of feedstock production, the feedstock conversion process employed, and the context in which the end product is transported and used.

4) Economic and social sustainability issues further complicate the picture, these include:

- The state of the global economy in general and the price of fossil fuels in particular
- Food price effects of diverting edible crops and land to bioenergy feedstock production
- Trade issues such as tariffs, standards and access to markets for producers and exporters

Box 2 — KEY DEFINITIONS

BIOENERGY	**Energy produced from biomass whether for heat, electricity or transport**
BIOFUELS	**Liquid or gaseous fuels produced from biomass that can be used to replace petrol, diesel and other transport fuels**
BIOETHANOL	**Petrol replacement produced from sugar or starch crops such as sugarcane, sugarbeet, corn and wheat**
BIODIESEL	**Diesel replacement composed of methyl (or ethyl) esters of long chain fatty acids derived from plant oils such as rapeseed, palm oil and soy**
FIRST GENERATION	**Biofuels produced from existing food and feed crops using simple and well established processing technologies (nearly all biofuels are currently first-generation)**
SECOND GENERATION	**Biofuels produced from a wider range of cellulosic biomass including agricultural wastes and plant species grown specifically for their biomass such as switchgrass and willow and converted using more advanced thermo-chemical or bio-chemical processes.**
THIRD GENERATION	**Potential future biofuels produced from "energy-designed" feedstocks with much higher production and conversion efficiencies than current biofuels.**
BIOGAS	**Gas produced from anaerobic digestion or fermentation of biomass and composed mainly of methane and carbon dioxide. Biogas can be burnt to produce heat and/or electricity or upgraded for use in vehicles that run on Compressed Natural Gas (CNG) or Liquid Petroleum Gas (LPG).**

- Health issues such as urban and indoor air pollution concerns
- Equity issues such as land rights, tenure and gender
- Lock-ins from inflexible policies and investments

Thus, the choice of appropriate tools and decision frameworks will be influenced by factors such as land type, feedstock, scale of production and end use, the socioeconomic context of the producer region, and the objectives that are prioritised (improved rural livelihoods, reduced GHG emissions, ecosystem rehabilitation etc...).

Perhaps as a result of the complexity and relatively recent expansion of biofuel production – most of the current debate and assessment of bioenergy and biofuels has focused upon broader policy and economic issues and equity concerns such as trade barriers and subsidies. When environmental concerns have been addressed, most of the discussions to date have focused on issues of global or regional concern such as deforestation and GHG emissions, rather than local concerns at watershed or farm scales. In response to this imbalance, this paper primarily outlines examples of existing tools and approaches to avoid, reduce, manage and mitigate the environmental risks and socio-economic inequalities of individual developments on the ground.

ⓘ Further resources:

- IUCN (2008) Factsheet on Biofuels http://cmsdata.iucn.org/downloads/biofuels_fact_sheet_wcc_30_sep_web.pdf

4 Environmental Tools

The tools in this section have been developed to address existing environmental challenges commonly encountered by the agricultural, forestry, infrastructure and manufacturing, natural resource management and conservation communities. They can be used to analyse material and energy flows within project boundaries; quantify a project's impact on natural resources such as water and biodiversity; and improve decision-making regarding the optimum management practices for balancing feedstock production and processing with other environmental objectives such as conservation and ecosystem restoration.

4.1 Impact Assessment tools

Many of the current concerns surrounding biofuels stem from poor analysis of the material, nutrient and energy flows involved in their production and use. Unfortunately, flawed assumptions about the greenhouse gas (GHG) and ecological benefits of biofuels and bioenergy have resulted in poor options being promoted. There are a number of tools that can help quantify material flows, greenhouse gas emissions and other ecological impacts - these can be grouped under the umbrella of industrial ecology, which encompasses a range of scientific approaches and tools to assess the sustainability of various production processes, including: life cycle assessments, waste management and utilization systems, eco-efficiency, closed-loop production systems, industrial symbiosis and dematerialization.

Whilst life cycle assessment is given prominence in this paper, a number of other system tools and approaches from industrial ecology may be useful for improving the sustainability of bioenergy production and processing systems, for example, by improving efficiencies and highlighting innovative ways of using wastes. Alongside LCAs, conventional environmental impact assessments and strategic environmental assessments also provide a useful set of approaches and tools that may be used to quantify the impacts of bioenergy developments.

Box 3 — GREET

The Greenhouse Gases, Regulated Emissions, and Energy use in Transport Model[7] (GREET) is a freely available LCA methodology developed by the US Argonne National Laboratory. GREET is particularly applicable to assessment of life cycles of biofuels for transport and is well adapted to a range of the most common present day feedstock to fuel pathways.

Life Cycle Assessments

The Life Cycle Assessment (LCA) is an analytical tool used to assess the "cradle to grave" impacts of products or services. When applied to bioenergy, LCAs are usually employed to assess the impacts of the full feedstock-to-fuel pathway (see box 3 on GREET). Factors such as local ecological effects, overall energy and GHG balances of production and consumption of biofuel, and energy and material flows of production equipment are commonly included. Social and economic impacts such as human health risks and commodity price signals are sometimes included, as are secondary impacts such as land use change from displacement effects.

LCAs have been conducted for a range of biofuel pathways[5,6] and have proven to be extremely useful for comparisons of different biofuel options for policy makers, and increasingly for industry benchmarking. LCAs are expected to become increasingly important to ensure compliance as bioenergy performance standards and certification schemes mature.

Despite their obvious appeal and value for assessing the inputs and outputs along the process chain, LCAs do have some limitations and drawbacks. They are generally complex, costly and time-consuming, and may be beyond the capacity of many small-scale producers or communities. LCAs may also present a barrier to producers in developing countries who lack the resources to carry out LCAs to ensure compliance with certification requirements for export markets. In response to these concerns, EMPA, the Swiss Federal Laboratories for Materials Testing and Research, is currently developing a simplified sustainability check tool for rapid assessment of environmental impacts of biofuels. The tool uses questionnaires to identify local variables, which are then used to calibrate generic reference process chains.[8]

Other limitations include their inability to provide absolute figures, since a number of numerical assumptions are made along the process. Also, there is currently no clear and universally agreed upon LCA methodology, which would enable more transparent comparisons between assessments for different bioenergy production pathways. Another problem is that impact assessment factors such as soil and water impacts have usually been designed and based on European or North American data, which may not be relevant to other environments. Furthermore, LCAs are generally designed to score impacts over large areas and times scales, and are therefore not useful for gaining understanding of immediate impacts such as water pollution events. Because of these limitations, LCAs should be seen as a tool that complements other assessment methodologies and not as a stand-alone method for quantifying impacts.

Despite their limitations, LCAs are currently the most reliable method of assessing the relative efficiency and sustainability of different biofuels and as such, they are extremely valuable tools. LCAs will become increasingly critical for ensuring compliance with standards for trade, subsidies and other future legislation as bioenergy production and use increases. Whilst there is currently no standard LCA methodology, there are ongoing efforts to address this by the Roundtable on Sustainable Biofuels which sees LCA methods as the most reliable and effective method of assessing biofuels for standards compliance (see box 7 on RSB).

Impact Assessments

A number of tools and approaches for assessing environmental impacts have been developed to address different scales and requirements. In general these can be divided between approaches that assess direct, local impacts, such as Environmental Impact Assessments (EIA) and Ecological Risk Assessment; and approaches that assess overall impacts including indirect issues such as economic and social impacts, such as Strategic Environmental Assessments (SEA) which cover a broader set of metrics. There have also been very large assessments such as the Millennium Ecosystem Assessment, which assessed mankind's impact on ecosystems worldwide. Whilst such a large assessment is beyond the means or the requirements of most bioenergy projects, the methodologies can be of use at smaller scales.

The Convention on Biological Diversity, the Ramsar Convention on Wetland, and the Convention on Migratory Species (CMS) have developed voluntary guidelines on incorporating biodiversity issues into impact assessments, which may be of use to a number of bioenergy project stakeholders.

FAO Bioenergy Impact Analysis (BIAS)

One relevant tool that has been tailored for bioenergy projects is the Bioenergy Impact Analysis (BIAS) methodology currently under development by FAO which uses a set of existing GHG, land and water tools to assess impacts of different bioenergy production systems.

[5] Zah, R. et al. (2007) Life Cycle Assessment of Energy Products: Environmental Assessment of Biofuels – Executive Summary. Empa, Bern.
[6] Turner, B. T. et al. (2007) Creating Markets for Green Biofuels: Measuring and improving environmental performance. Research Report. TSRC, UC Berkeley
[7] www.transportation.anl.gov/software/GREET/
[8] www.empa.ch - An overview of the simplified LCA approach is currently available from the RSB website at: http://cgse.epfl.ch/webdav/site/cgse/shared/Biofuels/First%20In-Person%20Steering%20Board%20Meeting/ZahQuick%20Scan%20Tool%20Outlinem.pdf

Further resources:
- The International Society for Industrial Ecology: http://www.is4ie.org/
- International Association for Impact Assessment (IAIA): http://www.iaia.org
- UNEP (2004) Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated Approach. http://www.unep.ch/etb/publications/EnvImpAss/textONUBr.pdf
- United Nations University EIA Open Educational Resource: http://eia.unu.edu/
- Millennium Ecosystem Assessment: http://www.millenniumassessment.org
- CBD Impact Assessment Guidelines: http://www.cbd.int/impact/guidelines.shtml;
- Ramsar: http://www.ramsar.org/
- CMS: http://www.cms.int/
- EPEA: http://www.epea.com/

4.2 Agricultural tools

Numerous approaches to improving the sustainability of agriculture are already well developed under various banners such as "conservation agriculture", "sustainable agriculture" or "biodiversity-friendly" agriculture. In general, these approaches involve reduction or elimination of synthetic inputs, improved productivity (see box 3), set aside of natural areas and improvement of wildlife habitat and agro-biodiversity, crop rotation, and soil and water conservation measures. These approaches may add value to products and provide other socio-economic benefits.

Ecoagriculture

Ecoagriculture is a landscape-management approach to agriculture that aims to achieve three goals at a landscape scale:

- Sufficient agricultural productivity
- Improved rural livelihoods
- Conservation and sustainable use of ecosystems and their services

The large-scale approach of ecoagriculture aims to integrate conservation and livelihood objectives by looking beyond the scale of individual farms, protected areas, and local ecosystems, to identify broader synergies at the landscape scale. Ecoagriculture may include approaches such as:

- Mimicry of ecosystem functions within an agricultural matrix, achieved with diversified patches of trees, grasses, annual and perennial crops
- Increasing connectivity between unfarmed areas
- Halting and reversing conversion of natural areas by increasing productivity of farmed areas
- Intercropping, conservation tillage, improved fallow systems, livestock diversification, integrated waste and soil nutrient management processes

Organic Agriculture

Organic agriculture is a carefully regulated agricultural production system that excludes synthetic fertilizers and pesticides, genetically modified organisms (GMOs) and plant growth regulators, and instead relies upon crop rotation, biological pest control and other more traditional inputs to produce crops that are certified to meet specific legal standards. Organic food is usually certified and labelled by an independent body such as the Soil Association in the

Box 4 — AGRO-BIOTECHNOLOGY

Conventional plant breeding has greatly improved the productivity of many biofuel feedstocks such as maize, sugar cane and palm oil, primarily in order to maximise yields for food production. However, scientists are increasingly interested in the potential of using various biotechnologies to develop "energy-designed"[9] crops that improve the productivity and ease of conversion of feedstocks to biofuels. However, many prospective biofuel feedstocks such as jatropha are still little studied, and low-yielding, wild cultivars are still commonly used. Thus, there is considerable scope for improving productivity and reducing land footprints through carefully planned use of biotechnologies, using a range of techniques such as:

- **Simple intraspecific hybridization and crossing**
- **Marker assisted selection**
- **Genetic modification and synthetic biology**

In the short to medium term, the productivity gains from using these technologies offer significant opportunities for increasing incomes and food security, particularly for small-scale farmers in developing countries who often do not have access to improved crop cultivars. In the longer term, more complex biotechnologies such as synthetic biology may offer opportunities for greatly improving the productivity of bioenergy feedstocks. For such programmes to be successful there is an urgent need for improved capacity building, technology transfer and programmes that assist farmers in adopting technologies that best meet their needs.

Further information:
Virgin, I. 2007. *Agricultural Biotechnology and Small-scale Farmers in Eastern and Southern Africa*. Stockholm Environment Institute

UK, which operate under the umbrella organisation – International Federation of Organic Agriculture Movements (IFOAM).

While there is currently little demand from consumers for organically grown biofuels since there are no perceived direct health benefits, the other benefits of organic, ecoagriculture and other sustainable agriculture approaches can inform the design of more sustainable production processes at plot, farm, and landscape scales.

More generally a wide range of agricultural tools have been developed that may be of use to project planners such as the FAO ECOCROP database which can help planners identify crop environmental requirements and thus choose appropriate feedstocks.

[9] Syngenta is currently trialling a modified corn variety that produces amylase in the corn that breaks down the starch in the plant and reduces processing energy requirements. www.syngenta.com/en/corporate_responsability/products_biofuels.html

Further resources:

- Ecoagriculture Partners. www.ecoagriculturepartners.org
- The Soil Association. www.soilassociation.org
- International Federation of Organic Agriculture Movements (IFOAM) www.ifoam.org
- The Sustainable Agriculture Information Platform www.saiplatform.org
- FAO ECOCROP Database: www.fao.org/AG/AGL/agll/ecocrop.htm

4.3 Water Resource tools

Bioenergy production can potentially be detrimental or beneficial to water quality and quantity in much the same way as conventional agriculture and forestry. For example, well-planned watershed reforestation programmes can reduce runoff, flooding and soil erosion, improve groundwater infiltration rates and stabilise river flow regimes in some scenarios. Conversely, many row crops require significant levels of irrigation and agrichemicals in some regions, which can deplete and pollute water sources; and forest plantations often lower water tables and reduce river baseflow. Some biofuels also require large inputs of water during processing. Thus, the benefits and services provided by water in a catchment such as those to pre-existing agriculture, wildlife, hydroelectricity production, and human health may all be affected if the impact of biofuel production on water resources is poorly balanced with other demands.

Impacts need to be accurately assessed to inform the establishment of suitable bioenergy feedstock crops and conversion processes, and to ensure that other demands on water resources are not adversely affected. Due to the complexity of water access regimes and the serious potential for conflict over water resources, it is imperative that all stakeholders are fully engaged in any dialogue on the potential implications of bioenergy developments for water resources.

The tools developed to improve water resource management can be considered to fall within the umbrella term of Integrated Land and Water Resource Management (ILWRM).

Downstream Response to Imposed Flow Transformations (DRIFT)

IUCN's Water and Nature Initiative (WANI) have published a handbook on environmental flows, which provides a rationale and framework for determining and implementing sustainable environmental flows. More specifically, DRIFT, developed by Southern Waters for assessment of environmental flows for the Lesotho Highlands Water Project, is a data-management tool designed to describe the biophysical consequences of any number of potential future flow regimes (scenarios). It is designed specifically for use in negotiations over water resources.

DRIFT is made up of four modules, each of which uses a sub-set of tools:

Module 1. Biophysical – Scientific assessments of the hydrology, ecology and geology of a river are used to determine how the ecosystem will be affected by alterations to the flow regime.

Module 2. Socio-economic – Social studies and stakeholder engagement are used to assess the social impacts of different river flows.

Module 3. Scenario-building – For any potential flow regime, scenarios are developed based upon the databases collected from modules 1 and 2. The impact on common property subsistence users is also described.

Module 4. Economics – The compensation costs of each scenario for common-property users are calculated.

One of the scenarios created using DRIFT for the Pangani River Basin in Tanzania was a "maximum agriculture" scenario, which may be a useful analogy for areas where biofuels are to be grown in addition to existing crops, especially in water-stressed areas with limited agricultural land.

The online network at www.eflownet.org is a useful resource for groups involved in developing environmental flow projects. A number of case studies and reports are accessible to show how environmental flows have been implemented in various contexts.

FAO also provide a number of water resource tools including:

Aquastat – A global database on water and agriculture www.fao.org/nr/water/aquastat/dbases/indexes.stm

CropWat – A decision support tool to help agronomists design and manage appropriate crop irrigation systems www.fao.nr.water

A number of tools are under development by the environmental modelling community to assess the impact of different land uses on water resources. The Hydrology of Land Use Change (HYLUC) hydrological model[10] is one example of a quantitative rainfall-runoff model, which underpins the Exploratory Climate Land Assessment and Impact Management (EXCLAIM), which illustrates the effects of land use change and climatic variability on hydrological outputs in a basin. These tools are being actively developed for assessing water impacts of bioenergy feedstock production, and feed into the Rural Energy (RE)-Impact project on forestry-based bioenergy for sustainable development.

Many tools designed to assess water resources and model the impacts of management interventions are quite complex and may not be relevant to stakeholders such as industry. To address this, the World Business Council for Sustainable Development (WBCSD) has developed a Global Water Tool that simplifies datasets such as Aquastat and enables businesses to assess their current and future water footprints.

Numerous barriers to successful implementation of ILWRM exist. First, water is often seen as a freely available resource and it is therefore hard to attach any financial or administrative burden to its use and management. Second, due to the need for accurate monitoring, and the increasing cost and complexity of monitoring larger-scale catchments, successful projects have tended to be carried out in smaller catchments. The tools presented here attempt to overcome these barriers by encouraging stakeholder dialogue and negotiation and improving the technical understanding of how different land uses affect freshwater resources.

[10] Jewitt, G. P. W. et al. (2004) Water resource planning and modelling tools for the assessment of land use change in the Luvuvhu Catchment, South Africa. *Physics and Chemistry of the Earth*, 29, 1233-1241

ⓘ Further resources:

- FAO Water http://www.fao.org/nr/water/
- IUCN Water and Nature Initiative: www.waterandnature.org
- Dyson, M., Berghamp, G., Scanlon, J. (eds). Flow. *The Essentials of Environmental Flows.* IUCN, Gland, Switzerland and Cambridge, UK. xiv + 118 pp.
- Jewitt, G. P. W. et al. (2004) *Water resource planning and modelling tools for the assessment of land use change in the Luvuvhu Catchment, South Africa.* Physics and Chemistry of the Earth, 29, 1233-1241
- EXCLAIM http://www.needs.ncl.ac.uk/exclaim
- RE-IMPACT http://ceg.ncl.ac.uk/reimpact
- WBCSD Global Water Tool http://www.wbcsd.org/web/watertool.htm

4.4 Forestry tools

Whilst liquid fuels from agricultural crops currently dominate much of the debate on bioenergy, the potential for production of heat, electricity and second-generation liquid biofuels from forest biomass is perhaps of greater long-term significance. Countries such as Sweden have shown that forest biomass can meet a significant[11] proportion of energy needs when integrated into efficient forest product industries and combined with sustainable forest management (SFM) practices.

However, in many countries, sustainable management of forest resources remains elusive and forest ecosystems face increasing pressures from illegal activities and associated illegal trade in timber and timber products. Poor law enforcement and lack of effective governance are the root causes of unsustainable forest exploitation, and a number of tools have been developed to address these gaps.

Methodology-based tools

Analytical frameworks for planning and monitoring forest management projects and participatory processes that engage key stakeholders.

Forest Law Enforcement and Governance (FLEG)

Whilst certification is often thought of as the primary way of improving the sustainability of forest management, to date it has had relatively little success in tropical forest contexts. FLEG is a tripartite collaboration between Government, Civil Society and Private Sector to curb illegal logging, associated trade, and other forest crimes.

FLEG is a tool in the broadest sense, its aim is to facilitate national and regional level debate and mobilize international commitment for forest governance reform through a participatory process. However, FLEG encompasses a number of specific tools to address illegal logging such as:

- Legality verification
- Participatory tools such as mapping and visioning tools
- Chain of custody certification
- Wildlife trade monitoring as carried out by TRAFFIC to expose illegal trade

Technology-based tools

Computer modelling with GIS software and remote sensing offer increasingly sophisticated tools for monitoring forest landscapes, assessing changes and modelling potential outcomes of different interventions.

STELLA is a multi-layered model that has been used to assess impacts of different development projects on forests. It has been applied to assess the socio-economic impact of potential palm oil plantations in Indonesia[12] and is well adapted for use by modellers wishing to explore the impact of biofuel and bioenergy feedstock production on forests.

In addition to commercial software packages such as ArcGIS and ESRI, a number of free GIS software tools are available such as GRASS GIS and QGIS. There are also a large number of free online satellite image databases. However, for GIS to be an effective tool, significant investment in learning software packages is usually required, which may divert attention and resources from simpler and more inclusive approaches.

In conclusion, whether using complex analytical tools, or more general methodological frameworks; addressing deforestation and degradation requires a coherent policy-practice loop to be in place to ground policy discussions on field realities and vice versa. Policy discussions should not take place in isolation and should be as responsive as possible to field test results.

[11] In Sweden, district heating accounts for 40% of all heat consumption. 62% of this heat is generated from combustion of biomass, mostly in the form of compressed wood pellets. http://www.sweden.gov.se/sb/d/5745/a/19594

[12] Sandker, M. (2007) The STELLA model: visualizing tradeoffs. Arbor*Vitae* 35, pp12. IUCN/WWF

Further resources:

- FAO (2008) Forests and Energy – Key Issues. FAO Forestry Paper 154
- STELLA www.cifor.cgiar.org/conservation/_ref/research/research.2.1.htm
- Sandker, M. (2007) The STELLA model: visualizing tradeoffs. ArborVitae 35, pp12. IUCN/WWF
- GRASS GIS Free Software http://grass.osgeo.org
- QGIS Free Software http://www.qgis.org
- Free GIS-Ready satellite imagery is available from sites such as www.resmap.com and the Global Land Cover Facility http://glcf.umiacs.umd.edu/index.shtml
- Google Earth also provides high resolution coverage for many regions and is a simple and intuitive tool for communication purposes www.earth.google.com

4.5 Ecosystem Restoration tools

Ecosystem degradation from overgrazing, deforestation, agricultural activity, overexploited vegetation, and industrial activities is a major threat to biodiversity and people's livelihoods.

A growing number of ecosystem restoration tools have been developed to assist efforts to recover degraded, damaged or destroyed ecosystems. Bioenergy production and use can be developed to support ecosystem restoration in two ways:

- Bioenergy feedstocks, byproducts and production processes may be used that actively improve soil quality (see box 6), water infiltration and other ecosystem functions, which promote ecosystem resilience and greater biodiversity.
- The use of more efficient bioenergy sources reduces pressures on natural systems and encourages recovery and restoration of degraded ecosystems. Use of jatropha as a cooking fuel in developing countries is one example, which reduces pressure on local forests from fuelwood collection.

Forest Landscape Restoration (FLR)
The growth of second-generation biofuels, and bioenergy for heat and electricity, is likely to place increasing importance on forest landscapes as feedstock sources. Whilst intensive forest monocultures are still common, attempts to integrate conservation objectives within productive forest landscapes and gain additional economic and environmental benefits from more heterogeneous forest landscapes are increasingly common. Forest Landscape Restoration is an example of one such approach.

FLR seeks to create and restore sustainable forest landscapes and resolve the numerous and conflicting needs of different stakeholders. An example of such an approach is the recent Grand Perfect[13] forest plantation in Sarawak, which aims to balance pulp plantation species with native forest reserves, wildlife corridors and access for local indigenous communities.

Carefully chosen bioenergy feedstocks can potentially add heterogeneity to plantation landscapes and lower transaction costs by diversifying markets for producers that often currently only serve one buyer. Fast growing tree species with low density wood such hybrid poplar, eucalyptus, anthocephalus and gmelina, which are currently used for paper pulp, may be suitable bioenergy feedstocks. However, they are known to deplete soil nutrients and may remove soil carbon depending on the rotation length and the baseline of the land being used (e.g. agricultural vs. grassland). Such trade-offs need to be made with care and should be based on adequate scientific assessments.

Landscape Outcomes Assessment Methodology[14] (LOAM) is another tool that helps those working on landscape level projects to *"measure, monitor and communicate the nature and extent to which a landscape is changing over time with respect to a small number of agreed conservation and livelihood outcomes."* LOAM has been developed by the World Wildlife Fund (WWF) and is currently being

Box 6 — BIOCHAR

There is growing interest in the potential of biochar (also known as terra preta and agrichar), to increase soil fertility, water retention, carbon sequestration and crop yields. Biochar is an inert, highly porous form of charcoal that can be used as a soil improver. There are potential synergies for biomass producers and processors to improve yields and incomes, add value to waste char from biomass pyrolysis[15], and reduce land footprint requirements with higher yields, whilst also greatly improving the greenhouse gas balance[16] of bioenergy.

field-tested. In addition, the Landscape Measures Resource Center (LMRC) provides a framework for assessing the performance of landscapes in meeting a range of stakeholder goals such as food and fibre provision, biodiversity conservation, ecosystem services and local livelihoods.

When properly planned, bioenergy production can act as an incentive for ecosystem restoration and support rural development, for example, by development and restoration of degraded lands, which also generate higher and more diversified income opportunities for local communities and restore ecosystem services. To succeed in achieving this synergy, project planners should choose feedstocks carefully to ensure they are suited to the local ecology, clearly communicate the opportunities and limitations of the project and allow local stakeholders to choose options that best suit their needs. In conclusion, many of these tools are designed to help project planners and stakeholders determine appropriate extent, scale, location and type of ecosystem restoration, and can be used to support appropriate development of bioenergy at landscape scales.

[13] Cyranoski, D. (2007) Biodiversity: Logging: the new conservation. Nature 446, 608-610
[14] Aldrich, M. & Sayer, J. (2007) Landscape Outcomes Assessment Methodology "LOAM" – In Practice. WWF Forests for Life Programme
[15] Pyrolysis is a thermochemical conversion process, which converts solid biomass into liquid bio-oil which can be refined into a range of liquid fuels. Biochar is a waste by-product of the pyrolysis process.
[16] Lehmann, J. (2007) Bio-energy in the black. *Frontiers in Ecology and the Environment* 5, 381-387

Further resources:

- Society for Ecological Restoration International http://www.ser.org
- Global Partnership on Forest Landscape Restoration: http://www.unep-wcmc.org/forest/restoration/globalpartnership
- Dudley, N., Mansourian, S. & Vallauri, D. 2005. *Forest Restoration in Landscapes: Beyond Planting Trees*. Springer: New York
- IUCN Commission on Ecosystem Management www.iucn.org/CEM
- Landscape Measures Resource Center http://treadwell.cce.cornell.edu/ecoag1a/
- Lehmann, J. (2007) *A handful of carbon*. Nature 447, 143-144
- The International Biochar Initiative (IBI) www.biochar-international.org
- Marris, E. (2006) *Putting the carbon back: Black is the new green*. Nature 442, 624-626

4.6 Protected Area tools

Protected area (PA) planning frameworks are used to design environmentally, economically and socially appropriate conservation areas based on biodiversity gap-analyses, cultural, and landscape values, and the level of threat, among other criteria and metrics[17]. Project planners can use PA planning principles, frameworks and guidelines to help identify areas of particular value, which should be excluded, reserved or managed in such a way as to retain their biodiversity and other values, and to identify areas more suitable for bioenergy development. Many of the tools developed for successful creation and management of protected areas also provide approaches that may be applied to other goals of bioenergy projects, such as ensuring equitable inclusion and participation of indigenous peoples in the planning process.

In some cases, there may be synergies between a protected area system and bioenergy, including outside of the PAs themselves. For example, by using carefully chosen feedstock species and production scales, bioenergy production may be used to provide habitat connectivity benefits, buffer zones and other conservation benefits alongside a carefully managed PA network.

The IUCN World Commission on Protected Areas (WCPA) has developed a range of planning principles, frameworks and guidelines for:

- Planning nationally coherent systems of protected areas[18]
- Identification and gap analysis of key biodiversity areas[19]
- Categorising protected areas using the IUCN protected area categories[20]
- Management planning of protected areas[21]
- Evaluating effectiveness of protected areas management[22]
- Ensuring equitable participation and involvement by indigenous and local communities in protected areas[23,24]

Protected area management categories have already been used to determine whether activities such as agriculture are appropriate in certain protected areas. Some industries have gone further to exclude certain PA categories, e.g. the International

Council on Mining and Metals (ICMM) have agreed not to explore in World Heritage Sites and are considering their position vis-à-vis protected areas equivalent to Categories I-IV, as per the recommendation of the IUCN Members in Amman Recommendation 2.82. They can be used by project planners, in conjunction with communities, to guide development of appropriate bioenergy development in and around protected areas. Communities may also benefit by using the IUCN protected area guidelines to react to government bioenergy plans and other top-down decision-making.

Opportunities for sustainable use in category V protected areas, which balance environmental conservation with other uses including small-scale agriculture, agro-forestry and sustainable forestry may be particularly relevant to bioenergy production scenarios where unsustainable harvesting of biomass for energy is affecting the protected area. Further information and guidance from IUCN is available on use of category V protected areas. Many of the principles that apply to supporting traditional agricultural land uses might be applied to carefully designed bioenergy production systems where indigenous feedstock species and agricultural methods can be used.

High Conservation Value Approach

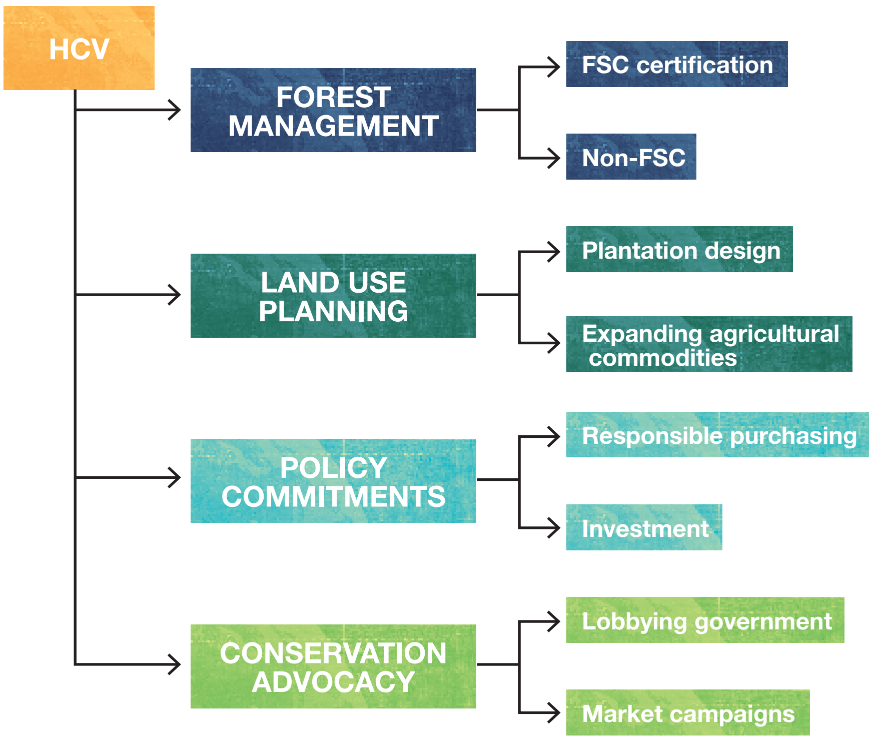
The High Conservation Value Forests (HCVF) approach was developed by the Forest Stewardship Council (FSC) as part of their forest certification process to ensure that areas of especially high ecological, cultural, landscape and socio-economic value are maintained and enhanced within production landscapes. It is also referenced in the respective sustainability roundtables

Box 5 — PROTECTED AREA MANAGEMENT CATEGORIES

- **Ia Strict Nature Reserve: protected area managed mainly for science**
- **Ib Wilderness Area: protected area managed mainly for wilderness protection**
- **II National Park: protected area managed mainly for ecosystem protection and recreation**
- **III Natural Monument: protected area managed mainly for conservation of specific natural features**
- **IV Habitat/Species Management Area: protected area managed mainly for conservation through management intervention**
- **V Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation**
- **VI Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems**

These categories are defined in detail in the Guidelines for Protected Areas Management Categories, http://www.unep-wcmc.org/protected_areas/categories/

High Conservation Value



for palm, soy and biofuels. Six types of high conservation value are specified:

HCV 1 – Biodiversity
Significant concentrations of biodiversity values

HCV 2 – Landscapes
Large natural landscapes (e.g. forests) where species exist in natural patterns of distribution and abundance

HCV 3 – Ecosystems
Rare, threatened or endangered ecosystems

HCV 4 – Ecosystem services
Basic ecosystem services in critical situations

HCV 5 – Livelihoods
Basic needs of local communities

HCV 6 – Cultural identity
Local communities' traditional cultural identity.

Overall, approaches to protected area designation and management are highly relevant tools for bioenergy project developers. They provide frameworks and guidelines to support a number of aspects of bioenergy projects including: assessing site suitability and minimising damage to valuable ecosystems, balancing sustainable use with strict conservation in protected areas, mainstreaming concerns of indigenous communities, among others.

[17] Conservation International's Hotspot approach and WWF Ecoregions maps are examples of broad scale assessments. High Conservation Value Forests (HCVF) developed by the FSC is an example of a more fine-grained methodology that uses a wider range of six key value types to identify values in a production landscape, develop suitable management options and monitor progress. Olson, D. M. et al. (2001) Terrestrial Ecoregions of the World: A new map of life on Earth. Bioscience, 51 (11) 933-938 www.worldwildlife.org/science/ecoregions

[18] Davey, A. G. 1998. *National System Planning for Protected Areas.* Gland, Switzerland & Cambridge, UK: IUCN

[19] Langhammer, P. F. et al. 2007. *Identification and Gap Analysis of Key Biodiversity Areas: Targets for Comprehensive Protected Area Systems.* Gland, Switzerland: IUCN

[20] IUCN. 1994. *Guidelines for Protected Area Management Categories.* Gland, Switzerland

[21] Thomas, L. & Middleton, J. 2003. *Guidelines for Management Planning of Protected Areas.* Gland, Switzerland and Cambridge, UK: IUCN

[22] Hockings, M., Stolton, S., Leverington, F., Dudley, N. and Courrau, J. 2006. *Evaluating Effectiveness: A framework for assessing management effectiveness of protected areas. 2nd edition.* Gland, Switzerland and Cambridge, UK: IUCN

[23] Beltran, J. (Ed.) 2000. *Indigenous and Traditional Peoples and protected Areas: Principles, Guidelines and Case Studies.* Gland, Switzerland and Cambridge, UK: IUCN, WWF

[24] Borrini-Feyerabend, G., Kothari, A. and Oviedo, G. 2004. *Indigenous and Local Communities and Protected Areas: Towards Equity and Enhanced Conservation.* Gland, Switzerland and Cambridge, UK: IUCN

Further resources:

- Global High Conservation Value Toolkit http://hcvnetwork.org/resources/global-hcv-toolkits
- IUCN Protected Area Categories: www.unep-wcmc.org/protected_areas/categories
- Phillips, A. 2002. *Management Guidelines for IUCN Category V Protected Areas: Protected Landscapes/Seascapes*. Gland, Switzerland and Cambridge, UK: IUCN
- RSPO (2007) RSPO Principles and Criteria for Sustainable Palm Oil Production http://www.rspo.org

4.7 Threatened Species tools

Tropical regions have high rates of plant growth – a comparative advantage for feedstock growth – as well as high species richness, including highly threatened species. In such locations, it is even more critical to find production processes that incorporate conservation outcomes. Species distribution maps and species datasets are available for an increasing number of species groups e.g. birds, mammals, and amphibians. It can be used as one of a number of pieces of information to feed into ESIA, Rapid Ecological Assessment, HCV and biodiversity risk assessments or action planning.

Occurrence of threatened species can be used as an indicator of ecosystem degradation. The Roundtable on Sustainable Palm Oil states under Criterion 5.2 that endangered species shall be "identified and their conservation taken into account in management plans and operations".

2007 IUCN Red List Indicators

Major group of organism	Mammals	Birds	Amphibians	Fish	Invertebrates	Plants
Number of threatened species worldwide in 2007 (as a % of species evaluated)	22%	12%	31%	39%	51%	70%

On the opportunity side, it is also possible that some indigenous plants may be identified as suitable feedstocks. However, due to economies of scale, only a few plants will dominate international biofuel markets.

IUCN Red List of Threatened Species

The IUCN Red List is the world's most comprehensive inventory of the global conservation status of plant and animal species. The IUCN Red List is a global reference for threatened species and is freely available for stakeholders to access. It uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies. These criteria are relevant to all species and all regions of the world. With its strong scientific base, the IUCN Red List is recognized as the most authoritative guide to the status of biological diversity.

The overall aim of the IUCN Red List is to convey the urgency and scale of conservation problems to the public and policy makers, and to motivate the global community to try to reduce species extinctions. Birds and amphibians have been completely assessed.

The IUCN Red List is responding to demands to make relevant data available in a format that is more readily usable for decision-makers by working with business groups, development organizations and others in the conservation community. In the meantime, this data needs to be used in conjunction with other assessment schemes.

Further resources:

- IUCN Red List: www.iucnredlist.org

4.8 Invasive Species tools

Invasive species pose a wide range of environmental, economic and human health threats. Invasive species risks may apply to biofuels in a number of ways:

1. The biofuel feedstock itself poses a risk to the ecology of an area in which it is to be cultivated – especially if there are no precautions to ensure that it does not escape from monoculture
2. The feedstock species are known to be potential carriers of phytosanitary pests and diseases which pose a threat due to transport of feedstocks during biofuel production
3. Cleared land and associated infrastructure to support biofuel production such as dams, irrigation and roads may alter the distribution and threat posed by harmful pathogens and expose populations to disease that originally circulated within wild animal populations
4. Clearing of land and associated changes of natural or agricultural ecosystems may encourage the invasion of other potentially-invasive plants – either inadvertently introduced with the feedstock, or awaiting opportunities for expansion in the selected areas

Currently there are serious concerns that many of the traits that make certain plant species such as *Miscanthus x giganteus* ideal as feedstocks for second-generation biofuels (efficient C4 photosynthesis, efficient water and nutrient use, pest resistance, rapid spring growth, and the ability to sprout from rhizomes), also make them potentially invasive in a number of environments[25]. *Jatropha curcas* grows readily in many countries and is promoted in some regions of Africa and South Asia as an ideal feedstock for biodiesel production due to low water requirements and because it does not directly compete with food production. However, in Western Australia Jatropha is a Declared Plant[26] (regulated noxious weed) and is banned because it has been found to be invasive – this illustrates the need for assessments of invasion risk to be area-specific.

A number of organisations involved in assessing the risks of invasive species (Global Invasive Species Programme, European and Mediterranean Plant Protection Organization, IUCN SSC Invasive Species Specialist Group) have developed a range of tools for assessing the risk of different species, monitoring their introductions to non-native habitats and ensuring ongoing monitoring:

Global Invasive Species Programme

The Global Invasive Species Programme (GISP) has a set of recommended actions[27] for consideration by those developing biofuels and has identified a list of potentially invasive species that are being considered as biofuel feedstocks.

The Invasive Species Specialist Group (ISSG) maintains a database of invasive species, which is a useful tool for preliminary risk assessment of potential feedstocks.

Pest Risk Analysis (PRA) and Pest Risk Management (PRM) are tools developed by the European and Mediterranean Plant Protection Organization (EPPO) to "evaluate biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it." The PRA is part of the International Standard for Phytosanitary Measures (ISPM) on Pest Risk Analysis (ISPM no. 11) that has been developed in the International Plant Protection Convention (IPPC) framework. This tool is most likely to be of use to agricultural agencies, and should be employed to assess the potential risk of invasion when choosing potential feedstock species. Little adaptation of the tool is needed since the tool already addresses all possible invasive species, including potential biofuel feedstocks.

Where non-native species are under consideration as feedstocks for biofuels, adequate risk analysis should be carried out in advance of their introduction to assess the threat of invasion. The above tools provide a set of recommendations and specific methodologies for assessing the risk and carrying out ongoing monitoring. The threat of species invasion should be taken very seriously by any group planning biofuel production, not only due to the potentially severe environmental impacts, but also because the costs of an invasive species are likely to outweigh any potential economic benefit of developing biomass energy.

[25] Raghu, S. et al. (2006) Adding Biofuels to the Invasive Species Fire? Science, Vol. 313, no. 5794, p. 1742
[26] http://www.agric.wa.gov.au/content/PW/WEED/DECP/fn2007_jatropha_biodiesel.pdf
[27] http://www.gisp.org/publications/newsletter/GISPnewsletter9.pdf

Further resources:

- Global Invasive Species Programme: www.gisp.org
- Invasive Species Specialist Group Database http://www.issg.org/database/welcome/
- European and Mediterranean Plant Protection Organization http://www.eppo.org/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm

5 Socio-Economic Tools

The tools in this section have been designed to address a number of existing socio-economic challenges commonly encountered by conservation and development projects. They may be used, for example, to improve stakeholder participation, balance trade-offs (for example with food security), support the equitable participation of marginalized groups, and improve the economic rationale for promoting bioenergy options that support rather than undermine ecosystem services.

5.1 Food Security tools

The recent surge in food prices has firmly positioned global food security as a major political concern. The price rises in 2008 were the result of a combination of factors including market speculation, extremely high oil prices, relatively poor harvests of wheat and rice staples in 2007, and booming demand for meat from rapidly industrialising Asian countries (which greatly increases demand for feed grain). However, the rapid growth of first-generation biofuels has also had an impact on food security either directly by converting food crops into fuel, or indirectly by diverting land from food production. The impacts are particularly severe for poor countries that are also net food and fuel importers.

Despite these impacts, there are some opportunities for bioenergy to enhance food security, for example by diversifying farmer's incomes through mixed "food and fuel" systems. Use of efficient bioenergy can also have an indirect impact on food security by reducing workloads in poor rural communities that rely heavily on inefficient fuelwood and dung for energy. Nevertheless, the negative impact of bioenergy on food security is likely to rapidly undermine the viability of the whole sector unless it is carefully addressed through adopting appropriate bioenergy options that reduce competition for land and food resources, and the introduction of better safety nets for the poor.

FAO Bioenergy and Food Security Project

The UN Food and Agriculture Organization has initiated a Bioenergy and Food Security (BEFS) Project[28] to "mainstream food security concerns into national and sub-national assessments of bioenergy potential through three main activity pillars:"

1. *Develop a conceptual and analytical framework of the bioenergy and food security nexus, plus methodological guidance, for partner countries* (Phase 1)

2. *Estimate bioenergy potential and analyze food security implications within context-specific national and sub-national settings* (Phase 2)

3. *Strengthen institutional capacities, transfer knowledge and exchange information between public and private sectors* (Phase 3)

BEFS uses the FAO Quickscan[29] tool for modelling bioenergy potential to 2050, coupled to the COSMIO agricultural trade model to build a picture of food security and bioenergy potential trade-offs. BEFS also uses existing household data and vulnerable populations and stunting data to assess sub national food security risk and is currently being validated in Africa. FAO hopes to have BEFS available for distribution and use in the near future.

- Where first-generation feedstocks are used, farmers should be encouraged to grow feedstocks that increase their flexibility and security. This may be achieved by promoting crops that are already well known, and helping producers gain access to markets for both food and fuel
- In the longer term, as production of bioenergy increases, investment in research and development for second-generation technologies that do not compete with food is urgent if biofuels are to help rather than hinder food security
- Projects should promote the use of waste biomass wherever possible
- There are a range of approaches to adaptation of agriculture that may help simultaneously increase food production and bioenergy feedstock availability (see Agricultural Tools)

[28] FAO Bioenergy and Food Security Project: http://www.fao.org/NR/ben/befs/
[29] Smeets, E. M. W. et al. (2006) *A bottom-up assessment and review of global bio-energy potentials to 2050.* Progress in Energy and Combustion Science 33, 56-106
[30] Joachim von Braun & R. K. Pachauri (2006) *The Promises and Challenges of Biofuels for the Poor in Developing Countries.* IFPRI

Further resources:
- *IFAD, 2008. Biofuel Expansion: Challenges, Risks and Opportunities for Rural Poor People.* International Fund for Agricultural Development
- Consultative Group on International Agricultural Research (CGIAR): www.cgiar.org
- International Food Policy Research Institute (IFPRI): www.ifpri.org IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) may be of use for developing various food security scenarios[30] www.ifpri.org/themes/impact.htm

5.2 Gender tools

"In many developing countries, women are responsible both for securing energy for the household and producing crops. Consequently, developments in bioenergy and related biofuel markets have the potential to benefit women if well planned: yet if gender and poverty considerations are not incorporated into bioenergy policies and practices, the livelihoods of women and their families could be threatened." [31]

Women stand to benefit significantly from improved access to cleaner and more efficient bioenergy sources. In many developing countries, energy-related work burdens and health impacts from use of dung and fuelwood, disproportionately affect women and girls.[32] Thus, bioenergy projects that mainstream women's energy needs when addressing energy poverty can improve women's and girl's health and reduce their work burden, potentially boosting rural incomes and food security.

Several developing countries are currently planning and developing first generation biofuel industries. There is a risk that women will be marginalized from these activities and that consequently, these developments might compromise food security and the energy needs of the rural poor.

Numerous guidelines[33,34] address gender issues in natural resource management that are applicable to bioenergy projects. More specifically, tools exist for project design and appraisal, which help integrate gender issues with other social variables such as poverty, age, class and ethnicity, through approaches such as Social Gender Analysis.[35] There are also gender guidelines specific to resources such as water[36], and management approaches such as protected areas.[37] The FAO Socio-economic and Gender Analysis Programme provides a number of guidelines and handbooks that are designed for development project workers and can be used at a range of scales to assess the impacts of projects and facilitate equitable outcomes. These tools also complement approaches to ensuring that communities are fully engaged in the planning process of any project and that free prior and informed consent is obtained before any operations begin.

[31] Araujo A. & Quesada-Aguilar A. Gender & Bioenergy Factsheet, 2007, IUCN

[32] Indoor smoke inhalation causes approximately 5% of all death and disease in some of the poorest countries. World Health Organization. (2007) *Indoor Air Pollution: National burden of disease estimates.* Geneva: WHO http://www.who.int/entity/indoorair/publications/indoor_air_national_burden_estimate_revised.pdf

[33] IGNARM Guidelines. (2005) *Integrating Indigenous and Gender Aspects in Natural Resource Management – Guidelines for Practitioners.* WWF, IWGIA, KULU, Nepenthes & DIIS

[34] UNDP. (2004) Gender & Energy for Sustainable Development: A Toolkit and Resource Guide. UNDP, New York

[35] Espinosa, C. (2004) *Unveiling differences, finding a balance. Social Gender Analysis for Designing Projects on Community-based Manaegment of Natural Resource.* IUCN

[36] Siles, J. & Soares, D. (2003) *The Force of the Current: Watershed management from a gender equity perspective.* IUCN

[37] Aguilar, L., Castañeda, I. & Salazar, H. (2002) *In Search of the Lost Gender: Equity in Protected Areas.* IUCN

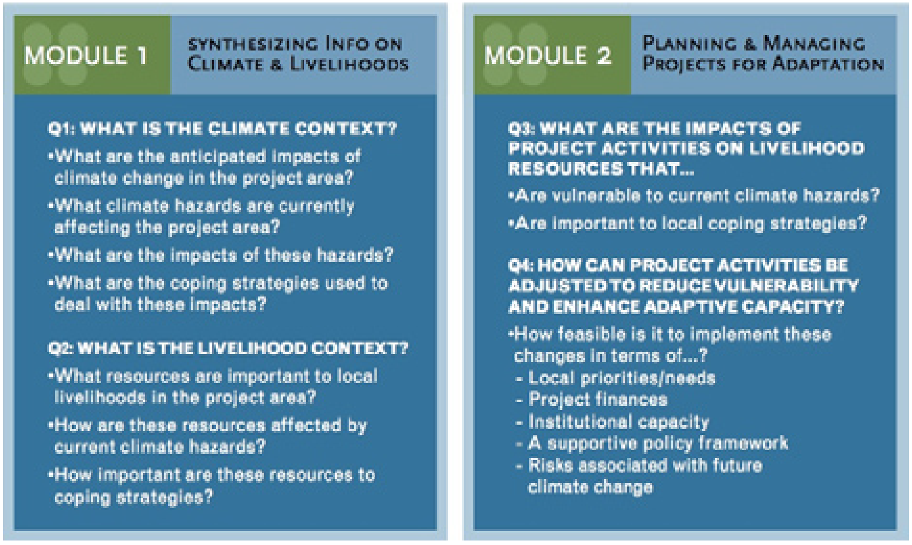
Further resources:
- Gender and Environment – IUCN Gender Programme www.genderandenvironment.org
- The International Network on Gender and Sustainable Energy www.energia.org
- FAO Socio-Economic and Gender Analysis Programme http://www.fao.org/sd/seaga/
- RSPO Principles and Criteria on Free, Prior and Informed Consent: http://www.rspo.org/

5.3 Climate Adaptation tools

Increased reliance upon bioenergy, either for energy security at national scales, or for improving livelihoods in rural areas will introduce new vulnerabilities by coupling the energy system and rural livelihoods to new risks, especially those related to climate change.

Climate change is likely to be partly responsible for the spread of pathogens, increased climatic extremes such as droughts and floods, and loss of soil fertility, among other impacts. Such factors are likely to contribute to lower and less predictable yields of feedstocks, whether from forests or agricultural land, and in severe cases, to crop failures. Meanwhile, natural systems provide many benefits and protective functions to communities facing threats from shifting climates and extreme events, which may be threatened by unsustainable bioenergy development.

Supporting the efforts of governments, farmers, and rural communities to better understand, mitigate and adapt to the risks posed by climate change should be a priority if biofuel is to be a sustainable contributor to energy security, rural development and climate change mitigation/adaptation strategies. In response to the risks posed by climate change, a number of international organisations have developed tools and guidelines for integrating adaptive capacity to climate change into project planning.



Source: CRiSTAL Brochure: Summary of CRiSTAL, 2007

CRiSTAL

IUCN, the International Institute for Sustainable development (IISD), the Stockholm Environment Institute (SEI), and Intercooperation have developed CRiSTAL (Community-based Risk Screening Tool – Adaptation & Livelihoods) – a project planning and management tool that is designed to help project planners and communities integrate risk reduction and climate change adaptation into community-level projects. CRiSTAL is comprised of two modules; the first describes the climate and livelihoods context of the community, whilst the second module assesses the impacts of the project on the adaptive capacity of the community and promotes project alignment to reduce vulnerability and enhance adaptive capacity.

ADAPT

The World Bank is currently developing ADAPT (Assessment and Design for Adaptation to climate change: a Prototype Tool) in response to concerns about the climate sensitive nature of many World Bank-funded projects. Like CRiSTAL, ADAPT is designed to be accessible and intuitive for project planners and runs on MS Excel. ADAPT ranks project activities by their sensitivity to current and projected climate and will also include spatial elements such as hazard maps, crop yield maps and current land use maps which will improve spatial planning.

A number of other guidelines for incorporating climate change into project planning are available. USAID has published a manual on climate change adaptation, which provides a set of useful steps to incorporate climate adaptation into development projects. The OECD has drafted a set of guidelines on integrating climate change adaptation into development co-operation, and the FAO has also published a framework document on adaptation in agriculture, forestry and fisheries, which provides a useful overview of many of the issues that require consideration, and also provide analytical tools such as the Climwat database and CropWat[38] software tool which allow agricultural planners to assess water requirements, irrigation supply and other water variable for a range of crops under a variety of climates.

Many of the tools described are already designed for agricultural projects and so they are already well adapted for use by stakeholders seeking to improve the climate robustness of bioenergy projects.

[38] FAO Water Development and Management Unit www.fao.org/nr/water/infores_databases.html

Further resources:

- IUCN Climate Change Initiative: www.iucn.org/climate
- Information on CRiSTAL and the tool can be found on several of the project partner websites, including:
  http://www.iisd.org/security/es/resilience/climate.asp
  http://www.sei.se/index.php?section=climate&page=projdesc&projdescpage=99976
- World Bank ADAPT Site: http://go.worldbank.org/AWJKT60300
- USAID (2007) Adapting to Climate Variability and Change: A Guidance Manual for Development Planning http://www.usaid.gov/our_work/environment/climate/docs/reports/cc_vamanual.pdf
- FAO (2007) "Adaptation to climate change in agriculture, forestry and fisheries: Perspective, framework and priorities." Rome, United Nations Food and Agriculture Organization

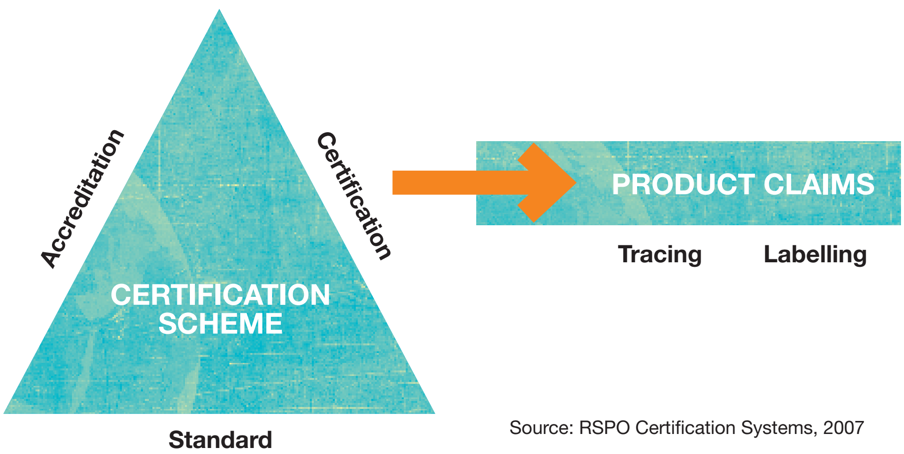
5.4 Certification, Standards & Labelling

Certification schemes can potentially be used to promote biofuels that are produced with lower environmental impacts and greater socio-economic benefits. Certification helps producers to add value to their products, and consumers are empowered to support positive change through purchasing certified products.

Currently, a range of certification processes and sustainability criteria may apply to bioenergy:

- The Roundtable on Sustainable Biofuels (RSB) which is developing principles, criteria and indicators on biofuels (see box 7).

Elements of a typical certification scheme



Source: RSPO Certification Systems, 2007

- Feedstock-specific approaches such as the Roundtable on Sustainable Palm Oil (RSPO) and Roundtable on Responsible Soy (RTRS).
- Organic certification can be applied to most agricultural feedstocks, but it is doubtful whether the public will demand them since there are no direct health linkages as with organic food.
- Forest Stewardship Council (FSC) certification can be applied to forest bioenergy and second-generation cellulosic biofuels produced from forest biomass.

Box 7 — THE ROUNDTABLE ON SUSTAINABLE BIOFUELS

The Roundtable on Sustainable Biofuels (RSB) at the Ecole Polytechnique Federale de Lausanne (EPFL) is currently developing principles and criteria for sustainable biofuels with the input from a broad range of stakeholders. Whilst the Roundtable has not developed them further into a certification process – voluntary industry compliance with the principles and criteria is a possible alternative to full certification, or governments may use the RSB principles and criteria upstream to differentiate between sustainable and unsustainable sources for biofuel importation.

- The Cramer Report[39] on (Cramer et al., 2006) was commissioned by the Dutch government in 2006 to define social and environmental criteria for sustainable biofuel feedstock production. The report includes a range of criteria on GHG emissions, food security, biodiversity and socio-economic issues.

Limitations of certification

Certification and labelling schemes are unlikely to achieve high overall market penetration, and booming markets for cheaper, non-certified products, may erode benefits. Secondly, certification often favours the bigger and more established producers who can cover the costs of verification and compliance; the accreditation process has often proved to be too big a step for developing world producers. To address this, the FSC and NGOs such as the Rainforest Alliance[40] have developed a stepwise approach to certification, which starts with legality, and then moves towards management criteria. Certification also raises complex legal issues[41] with regards to World Trade Organization laws and there are concerns that restricting trade to certified biofuels could flout free trade agreements. Lastly, full certification and labelling requires consumers to be informed and selective about products. Communicating the benefits of certified products and fostering demand amongst the public can be extremely difficult.

In conclusion, certification offers a range of tools that can help ensure feedstocks are grown sustainably. However, there is currently no product label for sustainable biofuels and since the public is confronted with an ever-growing number of labels for products, it may be that adoption of industry-wide standards such as those under development by the Roundtable on Sustainable Biofuels offers many of the benefits of certification without proliferation of labels.

[39] Cramer, J., Wissema, E., Lammers, E., Dijk, D., Jager, H., van Bennekom, S., Breunesse, E., Horster, R., van Leenders, C., Wolters, W., Kip, H., Stam, H., Faaij, A., Kwant, K., Hamelinck, C., Bergsma, G. and Junginger, M. (2006) *Project Group Sustainable Production of Biomass: Criteria for Sustainable Biomass Production*, downloadable from: http://www.forum-ue.de/bioenergy/txtpdf/project_group_netherlands_criteria_

[40] Rainforest Alliance. http://www.rainforest-alliance.org

[41] The United Nations Conference on Trade and Development (UNCTAD) has recently published a study on certification of biofuels that provides a detailed insight into certification and WTO legality issues: UNCTAD, United Nations Conference on Trade and Development. 2008. Making Certification Work for Sustainable Development: The case of Biofuels. New York and Geneva: UNCTAD. http://www.unctad.org/en/docs/ditcted20081_en.pdf

Further resources:

- Roundtable on Sustainable Biofuels: http://cgse.epfl.ch/page65660.html
- Roundtable on Sustainable Palm Oil: www.rspo.org
- Roundtable on Responsible Soy Association: www.responsiblesoy.org
- Forest Stewardship Council: www.fsc.org

5.5 Economic tools

Benefits that society derives from ecosystems include clean water and air, soil, natural recreation areas, protection from natural disasters, etc.[42] Whilst their value to human welfare is immense, they are often ignored or undervalued in land management and resource-use decision-making. As a result, the natural capital of ecosystems is being eroded at multiple scales.

Approaches that combine market forces with conservation and development objectives to support sustainable land use practices are becoming increasingly common. Valuation of, and payments for ecosystem services attempt to internalise the positive benefits of healthy, functioning ecosystems that are currently not adequately accounted for in decision-making.

Payments for Ecosystem Services (PES)

Payments for ecosystem services, or payments for environmental services (PES) have been applied successfully to water infrastructure projects[43], and could potentially be used to support sustainable bioenergy use and act as a disincentive to deforestation or other unsustainable land uses. To be successful, PES schemes should operate in settings where there are real choices between various land uses, where payment is conditional upon compliance, and where payments can be sufficiently large to compensate for opportunity costs of alternative and more destructive land use options.[44]

Lessons can be learned from ongoing discussions on how to adapt PES approaches for reducing emissions from deforestation and degradation (REDD) by leveraging changes in land use practices or funding improved law enforcement and monitoring. The REDD process is gaining momentum; however the challenge remains to ensure that funds reach those able to leverage changes in land use. Poor governance, weak local representation and uncertain land tenure all act as barriers to implementation. In relation to bioenergy, PES and REDD initiatives are likely to make certain types of bioenergy less economically attractive whilst improving the profitability of more sustainable options.

Biodiversity Offsets and Conservation Banking

Biodiversity offsets are commonly applied to offset any damage to biodiversity resulting from infrastructure developments and help to ensure that no net impact on biodiversity occurs within a defined area. Offsets are usually developed within tightly regulated legal frameworks that require impact assessments to be carried out prior to developments so that offsets can be planned appropriately. Conservation banking entails protecting specific types of habitat and 'selling' that protected biodiversity to developers seeking to offset the impact of their developments. Whether such a model can be applied to agricultural developments remains to be seen, there are several[45] barriers:

- Environmental baselines are harder to define across large areas
- Impacts of extensive agricultural developments are harder to define and impact assessments are rarely carried out prior to agricultural development
- Offsets cannot easily compensate for social impacts and do not address existing social issues such as tenure or gender inequalities
- Avoiding or minimising impacts on biodiversity is always preferable to offsetting damage – offsets should only be used as a last resort.

This last point is particularly relevant for tropical environments where restoration ecology is not far enough developed to be able to ensure restoration of biodiversity values. Critiera could be developed to screen for project areas where offsets are not suitable, such as some HCVs, and other thresholds.

Because of these current weaknesses, offsets are unlikely to be effective if used in isolation, but they may complement other tools and approaches such as sustainability standards in some settings where the risk to biodiversity is acute and quantifiable.

Green Investment Funds

Venture capital funds are increasingly targeting sustainable enterprises, both in developed and developing countries, to support businesses that contribute to conservation efforts. Many funds are managed by large Environmental Non Governmental Organizations (ENGOs), which use the funds to support projects that are aligned with their organizational missions. Examples include:

- Root Capital: www.rootcapital.org
- EcoEnterprises Fund: www.ecoenterprisesfund.com
- Verde Ventures: http://web.conservation.org/xp/verdeventures

Small-scale bioenergy projects, which can demonstrate positive synergies with conservation goals and other environmental benefits such as maintenance and improvement of carbon sinks, may be eligible for funding.

Whilst market mechanisms such as PES, biodiversity offsets and green investments all aim to generate incentives and support for sustainable land use, their efficacy remains dependent on them being able to generate sufficient economic value to leverage change. In many countries, this is not the case because such schemes have to swim against the tide of top-down bioenergy subsidies and mandates.[46] Unless such macroeconomic distortions are abolished or significantly readjusted to support only truly sustainable options, the ability of smaller-scale economic tools to support biofuel sustainability is likely to remain stifled.

[42] Millenium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Synthesis.* Island Press, Washington, DC http://www.maweb.org
[43] Redondo-Brenes, A. & Welsh, K. 2006. *Payment for Hydrological Environmental Services in Costa Rica: The Procuencas Case Study.* Tropical Resrouces Bulletin, 25, 19-24
[44] Wunder, S., The, B. D. & Ibarra, E. 2005. *Payment is good, control is better. Why payments for forest environmental services in Vietnam have so far remained incipient.* CIFOR
[45] McCormick, N. & Haye, S. 2008. *A role for biodiversity offsets in sustainable biofuels?* Business. 2010, Vol 3, Issue 2, pp. 28
[46] For more information on biofuel subsidies, see The Global Subsidies Initiative of the International Institute for Sustainable Development (IISD): www.globalsubsidies.org

Further resources:

- Bishop, J., Kapila, S., Hicks, F., Mitchell, P. and Varhies, F. (2008) *Building Biodiversity Business*. Shell International Limited and IUCN: London, UK, and Gland, Switzerland. 164 pp.
- Business and Biodiversity Offsets Program (BBOP): www.forest-trends.org/biodiversityoffsetprogram

6 Key Recommendations

1) Do not re-invent the wheel

Despite serious and legitimate concerns about the risks, it should be noted that bioenergy is not new[1] and is here to stay. Soaring fossil fuel prices and growing concern about climate change recently prompted the IEA to note that "the question is no longer whether bioenergy can play a role in future energy supply, but more the extent, timing and cost of the contribution" (IEA, 2007). Due to the recent rapid growth of the sector, careful planning, and adaptation of existing knowledge is called for that quickly maximises the opportunities of bioenergy whilst minimizing the risks.

2) Think broadly about objectives

While the tools and guidelines presented in this paper can help improve the sustainability of bioenergy developments, assuming that the project is needed and is an optimal use of resources is a flawed starting point – it is worthwhile to question such assumptions before setting out. Project planners should assess the opportunity costs of all viable project options and not assume that bioenergy provides the best synergies between energy, environment and development goals in every context.

3) Do not wait

Numerous tools already exist that may serve various demands, often with minimal adaptation in order to be applicable to bioenergy or biofuel-specific scenarios. Biofuels, after all, are the product of diverting existing biomass production (food crops such as corn and soy, wastes, and cellulosic biomass from grasses, forests etc…) into new processes and products. The challenges of sustainable management of the natural or agricultural resource remain essentially unchanged.
What is different from conventional agriculture and forestry is the added complexity of understanding energy pathways, the interplay of agricultural and energy markets, and in some cases, complex industrial processing technologies and standards. Despite this complexity, many potential tools are well suited to addressing a wide range of sustainability challenges. Indeed, due to the large number of potential tools, it should be noted that the ones presented in this paper are indicative of the range of tools available and are not necessarily the "best" or only tools to use in any specific context.

4) Expand and adapt existing tools

We encourage project planners and other stakeholders to adapt the tools in this paper to best fit the specific contexts in which they are to be used. This paper intentionally avoids giving step-by-step guidelines since so many aspects of sustainability are context-specific. There are numerous opportunities to use existing tools and datasets innovatively to feed into decision-making at multiple scales. An example might be to overlay World Heath Organization smoke inhalation data with bioenergy feedstock potential models from the FAO to identify areas of greatest potential to reduce health impacts from traditional fuelwood and dung combustion.

5) Common sense

Many of the tools presented in this paper encourage and facilitate common sense: engaging stakeholders, agreeing on and setting objectives, establishing environmental, economic and social baselines, and monitoring outcomes of project interventions are not new actions that apply only to bioenergy. Indeed, many of the tools are in fact structured and packaged methodologies for applying a common range of skill sets that are the foundation of any successful conservation or development project. These skills, which should underpin any project process, can be summarized as:

- Knowledge of resources
- Knowledge of laws and institutions
- Humility & learning
- Observing and adapting

6) Bioenergy is not just about biofuels

Whilst liquid biofuels produced from agricultural crops currently dominate much of the debate, the potential for production of heat, electricity and second-generation liquid biofuels from a wider range of non-food biomass is perhaps of greater long-term significance. As bioenergy use becomes more widespread and second-generation technologies mature, it is likely that the nature of environmental and social risks will shift and so will the focus of the current sustainability debate.

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