A Decision Support Tool for Sustainable Bioenergy

An Overview

UN ENERGY

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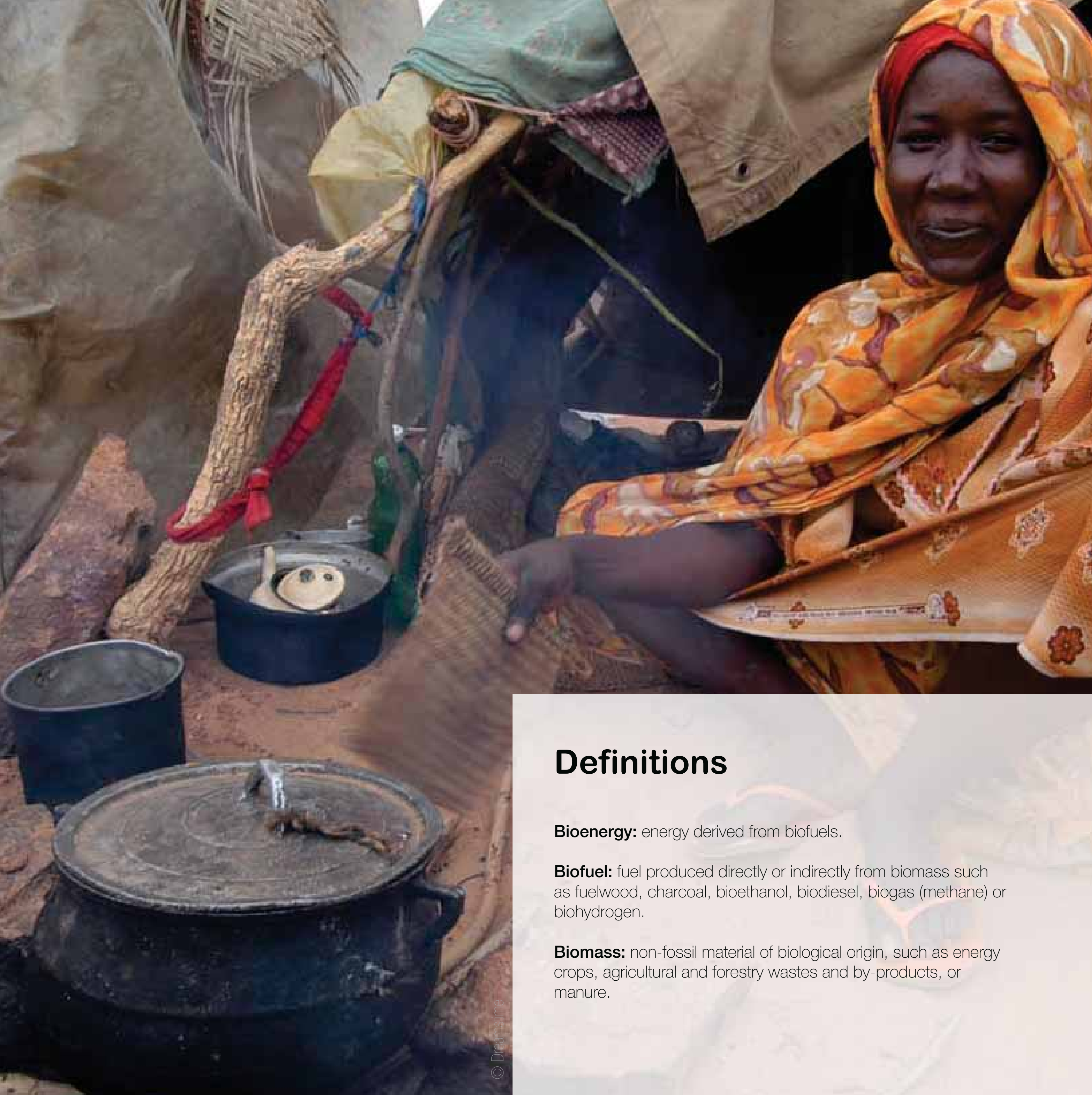

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Definitions

Bioenergy: energy derived from biofuels.

Biofuel: fuel produced directly or indirectly from biomass such as fuelwood, charcoal, bioethanol, biodiesel, biogas (methane) or biohydrogen.

Biomass: non-fossil material of biological origin, such as energy crops, agricultural and forestry wastes and by-products, or manure.

Preface

The Secretary General's Advisory Group on Energy and Climate Change (AGECC) proposed an ambitious goal to ensure universal access to modern energy services by 2030. Lack of access to sustainable, affordable, reliable energy has been recognised as a key constraint in the attainment of the Millennium Development Goals (MDGs). This, combined with the urgent need to reduce GHG emissions globally, provides the impetus for prioritising the use of low-carbon energy technologies alongside energy efficiency measures.

Modern bioenergy has the potential to make an important contribution to rural development and poverty alleviation. It can do so by increasing access to safe and sustainable energy in poorly served areas while opening up new employment and business opportunities that may change lives for the better. Bioenergy can be a particularly potent tool for developing countries seeking to develop along a low-carbon growth path with increased energy security.

Bioenergy currently makes up some 14% of global energy supply, and the production of modern bioenergy for heat, electricity and transport is growing rapidly worldwide, not least due to an increasing number of governments implementing supportive policies and measures. However, as any energy source, bioenergy comes with a number of environmental and social risks that need to be addressed, for example those related to biodiversity, water, food security and land tenure. To ensure that potential benefits from bioenergy development materialize and potential risks are minimized, government authorities and decision-makers at national, regional and local levels need to make choices, both in bioenergy strategy development and decisions on promotion and licensing of investment options. These choices should be made based on science and with the aim of using resources efficiently. Meeting all policy objectives equally may not be possible, and trade-offs for different objectives might be necessary.

We are pleased to present this new Bioenergy Decision Support Tool. UN-Energy aims to assist countries in creating responsible decision-making processes that manage risks and challenges in a transparent and effective manner. The Tool proposes step-wise guidance for both the strategy formulation and the investment decision-making processes, and offers a repository of technical resources and links to existing tools, guidelines and information resources.

Putting into place clear frameworks helps create a more sustainable bioenergy sector, stable investment climates, and ultimately helps to achieve the goal of energy access from sustainable and low carbon sources.

Kandeh Yumkella,
Director General UNIDO and Chair UN Energy

Jacques Diouf
Director General FAO

Achim Steiner
Executive Director UNEP

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UN-Energy

UN-Energy was established to help ensure coherence in the UN system's multi-disciplinary response to the World Summit on Sustainable Development (WSSD) and to ensure the effective engagement of non-UN stakeholders in implementing WSSD energy-related decisions. It aims to promote more system-wide collaboration in the area of energy with a coherent and consistent approach since there is no single entity in the UN system that has primary responsibility for energy.

The group focuses on substantive and collaborative actions both in regard to policy development in the energy area and its implementation as well as in maintaining an overview of major ongoing initiatives within the system based on the UN-Energy work program at global, regional, sub-regional, and national levels.

Introduction

Whether or not bioenergy can deliver on the objectives without creating new and additional pressures depends largely on the existence of a robust and inclusive national planning process and project design and management.

Bioenergy has received a lot of attention over the past years, both from the side of governments looking for ways to mitigate climate change, ensure energy security, strengthen the agricultural sector and promote development, and investors seizing business opportunities that occurred largely due to government support in the form of targets and mandates. At the same time, a number of concerns have been voiced regarding potential impacts on food security and the environment related to the rapid expansion of bioenergy feedstock production, and in particular, competition between different land uses.

Decision makers in governments are faced with complex decisions on trade-offs between often conflicting goals. Decisions about bioenergy occur at two distinct levels: the *national level* in the definition of a bioenergy strategy, and the specific project or *investment level* in an approval or licensing process. Ideally, a government has a clear strategy in place before making decisions on major investments. However, in practice, investment decisions may have to be made without the guidance of an established strategy, or while the strategy is being formulated. Therefore, the DST proposes step-wise guidance for both the strategy and the investment decision-making processes. The underlying concept of the DST is that identification and mitigation of risks and a longer-term perspective of sustainable use of resources are key to maximising the potential benefits from bioenergy.

How can this Decision Support Tool help you?

This tool has been developed to assist decision makers in the process of developing a national bioenergy policy and strategy and/or assessing investment opportunities, by:

- Providing step-wise guidance on the key issues that need to be addressed when considering tradeoffs, and processes that need to be undertaken to optimize opportunities and minimize risks;
- Providing a set of technical resources and links to existing tools, guidelines, information and resources that are relevant to each country's critical risks and challenges;
- Offering guidance on identification and inclusion of stakeholders in the bioenergy decision-making process and on adopting transparent processes for good governance.

It is recognised that each country's context differs and the best process is the one that is developed by the government through adequate stakeholder engagement within its own particular context. This tool sketches out typical steps that can serve as a basis for adaptation to specific country contexts. Because facilitating a bioenergy strategy is dynamic and constantly evolving, with new tools being developed to help guide processes and decisions, the DST by nature is also dynamic. The tool is therefore a work in progress as these new ideas, learned lessons and tools are made available.

National Bioenergy Policy and Strategy Formulation

Comprehensive and inclusive planning is a precondition to ensure that bioenergy delivers on national objectives in a durable manner, without creating new pressures on land, food security and ecosystem functions.

Bioenergy decisions are complex because the sector cuts across different disciplines covered by a range of Ministries - notably energy, agriculture, environment, industry, and trade. Hence bioenergy policy needs to be embedded in a broader context of relevant strategies and policies. Development of bioenergy policy and strategy should be undertaken with a clear view of the underlying objectives and be based on an analysis of the trade-offs between these different objectives. Given the differences of pathways in terms of potential input (e.g. resource utilisation and related risks), and output (e.g. energy provision for different end uses and delivery of employment and other benefits), a range of analyses should be undertaken as part of the policy and strategy formulation process.

This will allow for:

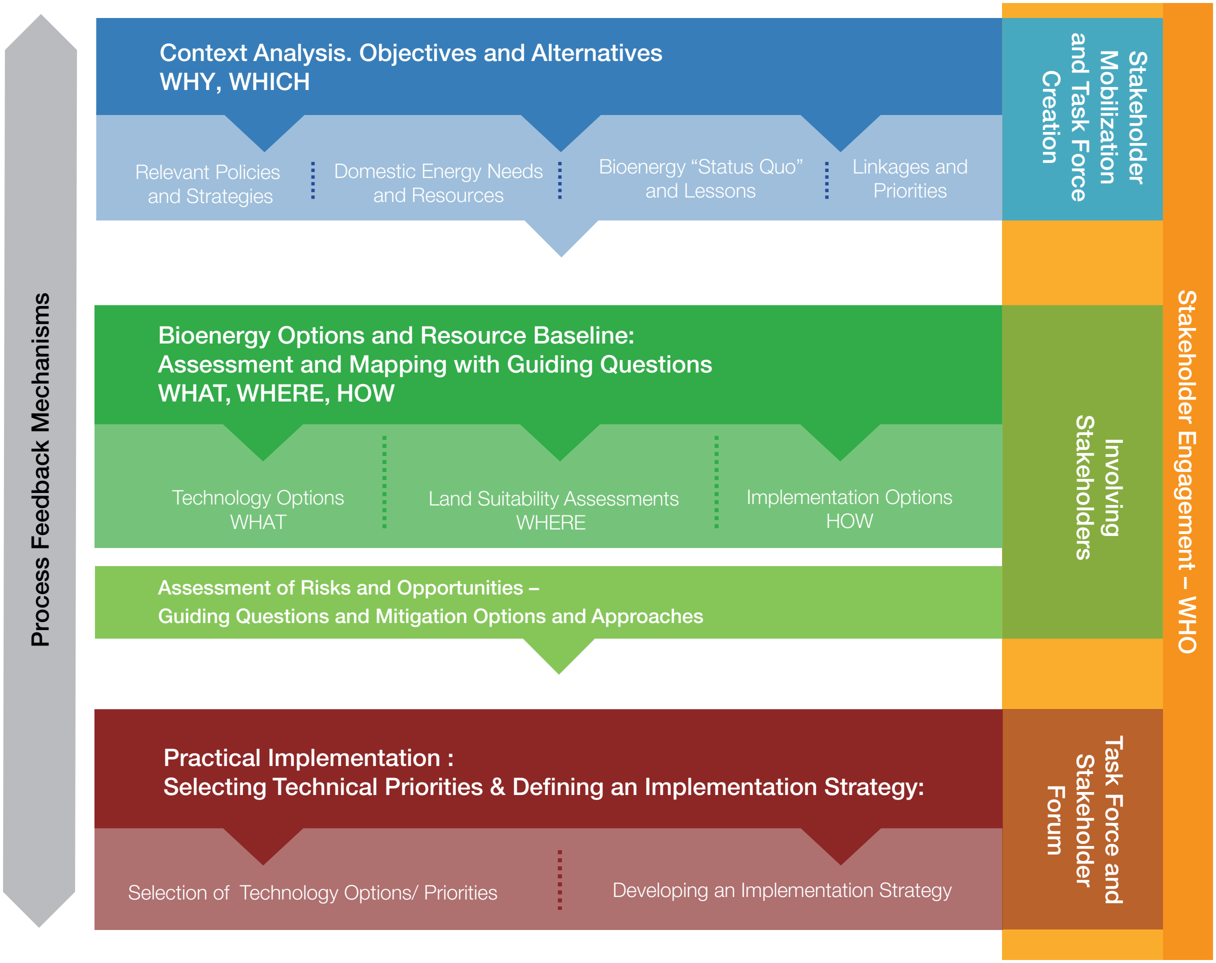
- Optimization of gains from proposed bioenergy activities
- Avoidance of negative consequences that may arise from either activities related to bioenergy production/processing or from the policy itself
- Resource allocation to the right activities that will promote the policy objectives defined through a comprehensive and inclusive planning process
- Enhancing the effectiveness of the national bioenergy policy and strategy

Figure 1 outlines a step-by-step decision tree that can facilitate the transparent strategic planning process for bioenergy at the national level.

Three broad steps have been identified. While the diagram shows a linear process, it is recognised that multiple feedback loops exist amongst them.

1. **Context Analysis** including the analysis of different and possibly conflicting policy and strategy objectives, the analysis of domestic energy needs and alternative energy resources, including but not limited to bioenergy, and the bioenergy status quo. (WHY and WHICH)
2. **Assessing Options and Potentials** including the analysis of what is a sustainable bioenergy potential by considering several factors that are relative to specific geographical locations, such as: technical and implementation options for bioenergy production, geographical suitability and constraints, an assessment of risks and possible mitigation options, and an identification of suitable combinations of technology and institutional mechanisms. (WHAT, WHERE, HOW, and Risks and Opportunities)
3. **Designing an Implementation Strategy** including forming an understanding of the technical priorities in a country, and clear indications of how these identified bioenergy priorities will be implemented, supported and monitored.

Figure 1: National Bioenergy Policy and Strategy Formulation Decision Tree



The entire process should be inclusive, engaging with relevant stakeholders in government, industry and civil society to ensure that the interests and concerns of all affected by bioenergy decisions are adequately taken into consideration (WHO).

Assessing Specific Development and Investment Proposals

Making investments fit with the vision - the assessment of investments should be undertaken in line with priorities and conditionalities identified in the national policy or strategy.

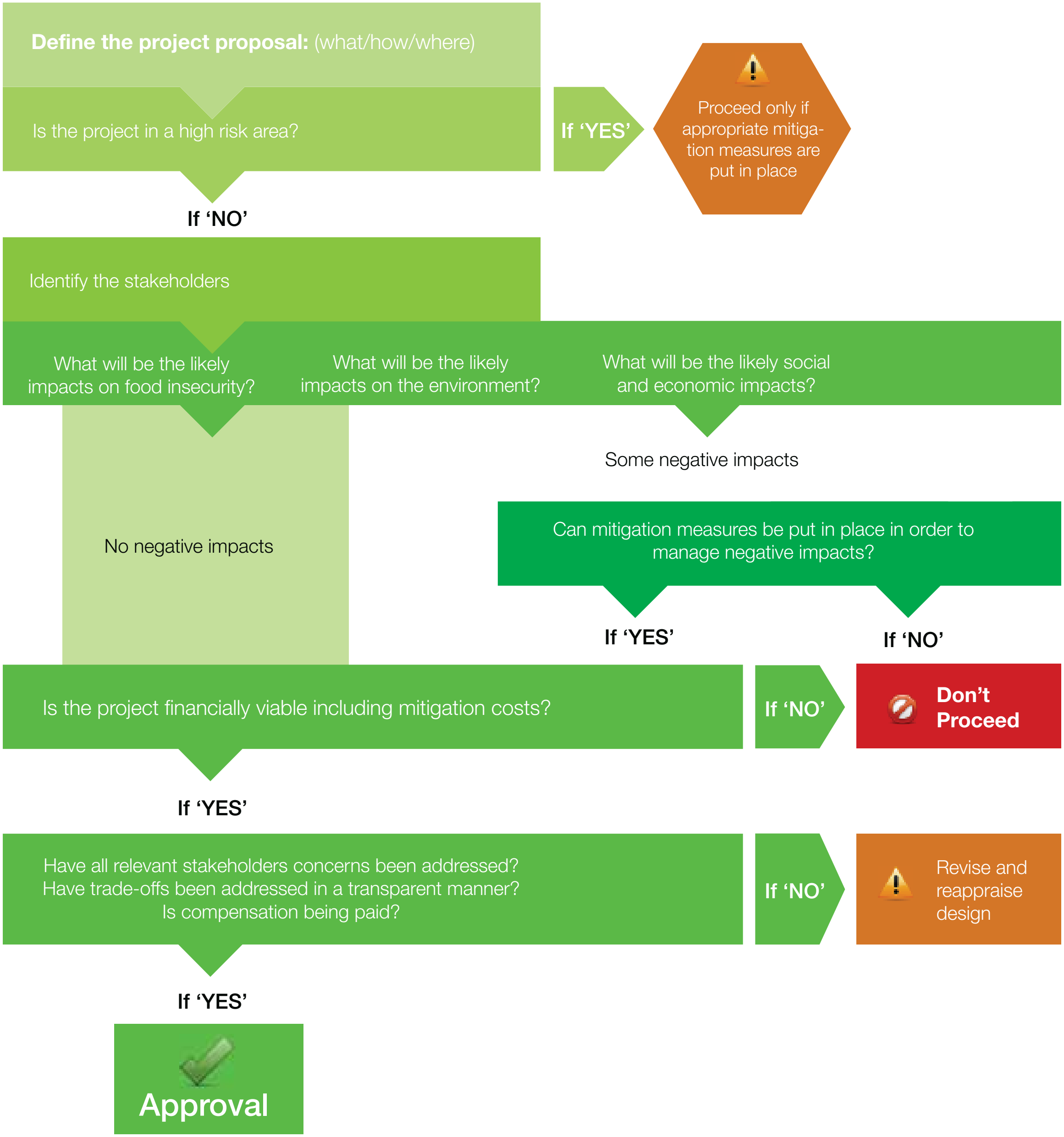
With the continuing push for bioenergy investment, many countries are faced with investment proposals before they have had a chance to devise a national strategy. In order to make an informed and responsible decision on whether to give the go-ahead to a particular investment project, including knowing what types of conditions to include in the eventual licence agreement, and how to structure and implement a publicly funded bioenergy investment project, many of the same questions need to be considered that are also relevant to setting national strategic priorities for bioenergy (e.g. issues relating to 'what', 'where' and 'how'). However in this case, the questions need to be considered in the context of a concrete and specific project proposal.[1]

The decision tree in Figure 2 aims to provide step-by-step guidance on how to confront the questions of 'what', 'where' and 'how'. Every country has legal and regulatory requirements for project appraisal and licensing, and the dedicated authorities with relevant decision-making powers. The process proposed here is intended to complement those processes, not to replace them. This process should follow the following steps:

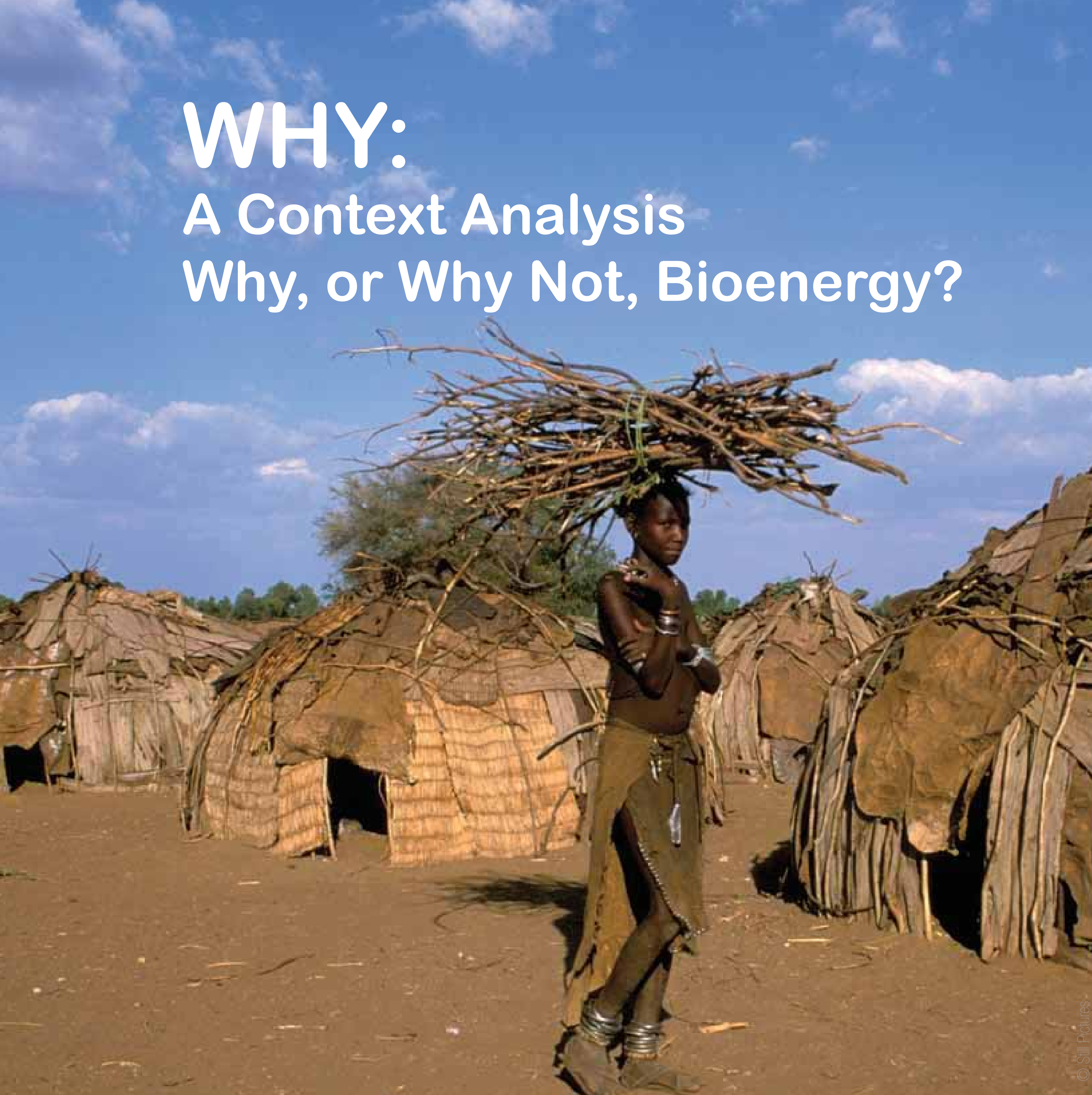
1. **Define the project proposal:**
   The process must start with a clear definition of the proposal
2. **Screening for high risk areas:**
   The proposal should be screened to make sure it does not involve unsustainable bioenergy development on high risk areas without appropriate mitigation measures being available
3. **Stakeholder identification:**
   Key stakeholder groups should be identified and engaged with
4. **Assessing potential project impacts:**
   After the initial screening, a more detailed assessment of risks and opportunities should be carried out
5. **Assessing risk mitigation options:**
   Appropriate risk mitigation options should be identified
6. **Financial viability:**
   Financial viability of the project is addressed, taking into consideration additional costs related to mitigation
7. **Final stakeholder review:**
   Make sure that stakeholder concerns have been addressed

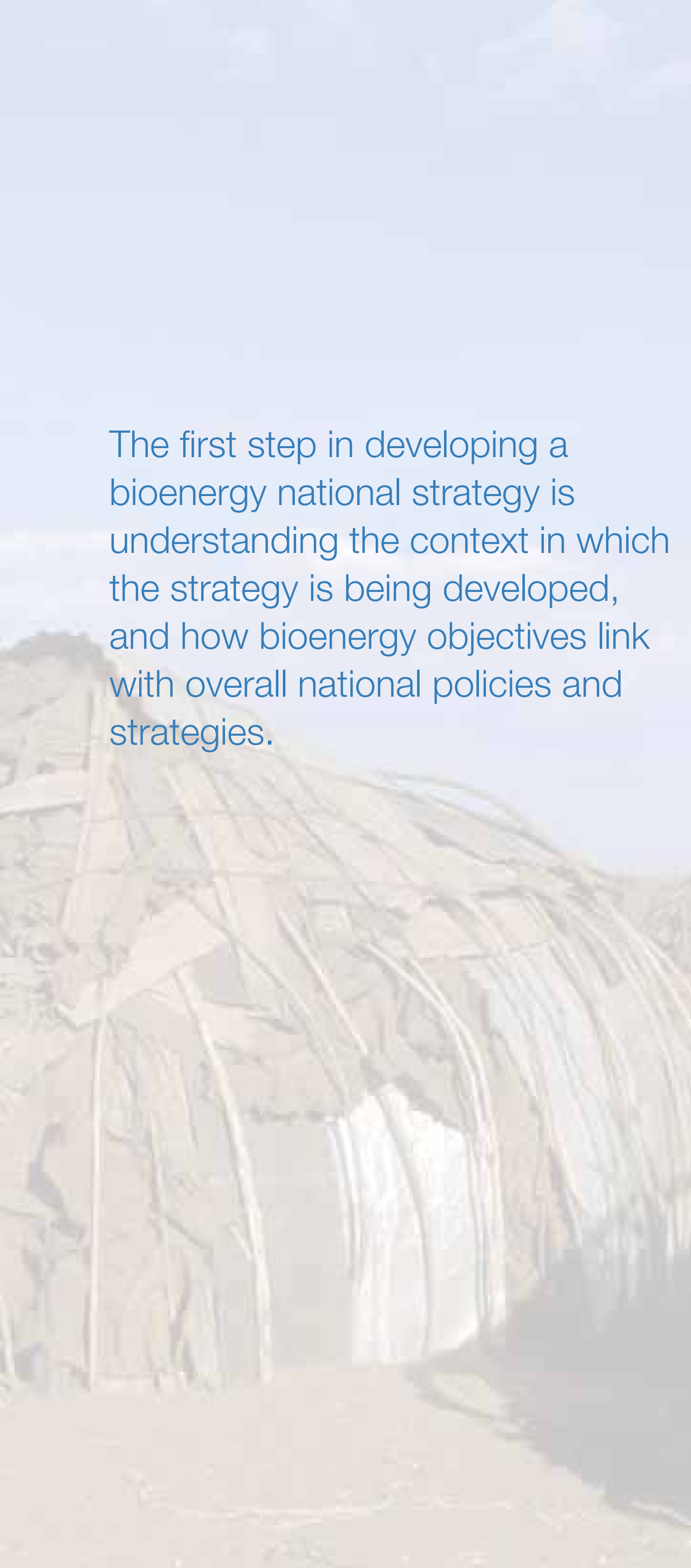
1. The DST provides a set of questions related to each of the key issues. They can be found in the full document.

Figure 2: Investment Level Decision Tree



WHY:
A Context Analysis
Why, or Why Not, Bioenergy?





The first step in developing a bioenergy national strategy is understanding the context in which the strategy is being developed, and how bioenergy objectives link with overall national policies and strategies.

Bioenergy development does not happen in a vacuum and therefore must be consistent with a country's overall policies and strategies. In the initial phase of national strategy development, due consideration should therefore be given to assess how bioenergy fits into existing overall development strategies, including strategies for poverty reduction, economic development, and conservation. The strategy should also align with sectoral policies and strategies in energy, agriculture, forest management, natural resources, industry and technology, rural development and the social sector.

Drivers

The drivers for the development of bioenergy strategies can be divided into two separate categories: (1) national objectives, and (2) external drivers.

National objectives for a bioenergy programme or project can be diverse and depend much on the national context. They might include:

- Improving access to energy services (particularly in rural areas)
- Increasing energy security and reducing the dependency on oil imports
- Reducing GHG emissions and accessing carbon markets
- Revitalizing agriculture and rural economies
- Improving trade balances through exports

As these objectives call for different approaches and choices from a public decision-maker's perspective, trade-offs have to be made in order to meet national objectives (SEE BOX 1 and BOX 2).

External drivers are principally the result of other countries' objectives translating into international market demand. This includes things such as the creation of policies in importing countries that have standards for imports in respect to climate mitigation strategies and diversification in energy supply. Potential feedstock or bioenergy producer countries may not be able to control these drivers directly, and may be faced with decisions dealing with investment proposals made by domestic or foreign investors linked into the international market. National and local authorities should consider whether or not these investment proposals are consistent with the country's national objectives, considering also that alternative uses of land may be more coherent with the strategic goals for the development of the specific area.

Policy and Institutional Context

This analysis of drivers should be followed by an analysis of what policies and what policy gaps exist that are of relevance to bioenergy development. This assessment will help ensure coherence of policies and prevent unintended consequences. Policies to be looked at include energy policy, agricultural policy, industrial and rural development policy, and trade policy. An assessment needs to consider relevant constraints and contexts such as as water and land rights as well as existing planning and regulatory processes.

Box 1: Illustrating the need for trade-offs to meet policy objectives

Meeting all policy objectives equally may not be possible, and trade-offs are often necessary, as illustrated by the following examples:

- A policy objective of maximizing revenues from export of bioenergy may call for increased bioenergy production based on investments in large-scale plantations and processing plants. But this might be in direct opposition to a policy of meeting local energy needs through local bioenergy production and use with implications for productivity.
- Competition for land use in case of large and rapid expansion of bioenergy production may lead to negative impacts on climate change if carbon storage areas are used, e.g. forests or wetlands are converted, or if areas of high conservation value, containing biodiversity which is the basis for ecosystem services, are converted, e.g. forests, savannah, etc.
- Rapid population growth, changing diets, and expected negative impacts on agriculture of climate change are reducing the carrying capacity of ecological systems in several developing countries. Hence additional pressure on arable land that is needed for food production might have, in the medium and longer term, and without any significant technological advancement, a negative consequence on food security.

Trade offs need to be assessed outside and within the boundaries of bioenergy. The result of the assessment and related decision on trade-offs be that bioenergy provide only a small share of the energy mix.

Box 2: Key decision making criteria

Opportunities and potential impacts in bioenergy projects								
SCALE	WATER		BIODIVERSITY		CLIMATE CHANGE		SOCIO-ECONOMICS	
	Opport.	Impacts	Opport.	Impacts	Opport.	Impacts	Opport.	Impacts
GLOBAL TRANS-BOUNDARY	Global water resources and systems are protected	Change in large system ecological processes and social services Change in transboundary water systems	No global biodiversity loss	Change in biodiver-sity including – species extinction, biome loss, etc.	Stabilize global net GHG emissions	Net global increase in GHG	Meet MDGs	Change/ impacts on global food and fuel markets
NATIONAL PROVINCIAL/ STATE	National water systems are protected and maintained	Change in ecological reserve for rivers Change in total steam flow and available water to downstream users	No national net loss in biodiversity	Change in biodiver-sity including – species extinction, intactness of habitat, introduction of invasive species, biodiversity loss	Stabilize/ reduce national GHG emissions	Positive national GHG carbon balances (based on national carbon accounting)	National food security Employment	Food insecurity on the national level (due to imports, etc.)
LOCAL GOVERNMENT TERTIARY CATCHMENT COMMUNITY HOUSEHOLD	Local water resources are protected and maintained	Change in seasonality of stream flow Change in security of supply Change in depth to groundwater or yield of groundwater Change in water quality	Local biodi-versity and ecosystems/ ecosystem services are protected	Change in ecosystem services provided by biodiversity: • Provisioning (food, wood) • Regulating impacts (floods, drought) • Regenerative capacity • Soil degradation	Access and use CDM funds for projects Reduction of traditional biomass use	-----	Household income Household food security Equity of distribution Access to and tenure of land and resources	Local food insecurity Gender inequities in employment opportunities and wages

Adapted from the re-impact project (www.ceg.ncl.ac.uk/reimpact/Related%20Documents/WP2_SustDecisionCriteria_07.pdf.

Assessment of Domestic Energy Needs and Resources

Nations differ in their energy needs as well as their resource potential for bio- and other types of energy. Thus, the assessment of the current and projected energy situation, both in terms of demand, energy uses and different energy sources, is a precondition to ensure the most efficient use of available resources and ensure that will also tie into objectives.

It is important to recognize that reliance on a mix of diverse energy sources and an overall increase in energy efficiency is an important feature of a sustainable energy system that supports the emergence of a green economy[2]. The mix in each given context will vary according to preconditions and needs. Hence, it is critical to assess the potential for a variety of renewable energy options in a resource assessment, including wind, solar, hydro, geothermal, biomass, etc.

Energy solutions need to match the energy needs. An assessment of domestic energy needs provides both an insight into existing energy use and "suppressed energy needs", or energy that individuals would use if they had access to it. An energy needs assessment could supply a country with an aggregate needs projection for the whole country, or for specific population groups, and solutions for supplying energy. For example, if a country faces difficulties in providing electricity to widely dispersed rural populations beyond the conventional grid network, decentralized generation options may be more efficient than grid connections. In this context, the use of locally produced biofuels to power electric generators on mini-grids may be a sustainable alternative to central grid extension. The assessment would shed light on potential end uses and related pathway choices. For example, if a country requires fuel to run generators in small remote villages, the route of straight vegetable oil may receive priority over biodiesel which would require a set up of larger production plants. Finally, the assessment would also encompass the identification of outdated technologies and ways to increase overall energy efficiency and demand – with the remembrance that the cleanest energy is energy saved. In the case of transport, whose overall contribution to climate change is on the rise, the use of biofuels should not do away with efforts to reduce the need for transport and the promotion of most efficient means of transport.

Resource efficiency should guide decision making. This applies to decisions on two levels: (1) whether or not, or to what extent, to pursue a bioenergy route; and (2) how to develop efficiency gains within the chosen bioenergy route. For example, mineral based solar energy systems transform solar energy more efficiently into energy, and also require less land and pose potentially less environmental impacts[3]. On the other hand, solar energy is still subject to a cost disadvantage. Furthermore, it is important to look not only at the physical resource base, but to consider and utilize local knowledge in a way that enhances the absorption of the chosen technology and the chances of success. Taking a bioenergy route, for example, natural resource availability needs to be assessed. For example, biofuel production should be subject to increased scrutiny in water stressed areas. However, resource efficiency potentials can be realized in the form of integrated systems where bioenergy feedstocks and production is maximized with other uses. For example, integrated systems that produce more than one product from the same feedstock, such as combined heat and power (CHP) from incineration of biomass; or sugar, ethanol, electricity and fertilizer from sugar cane; or ethanol and animal feed from maize can be an efficient form of biomass utilization. Utilizing by-products in this way also increases the economic competitiveness of the system. Cascading use of food-energy systems (i.e. Integrated Food-Energy Systems/IFES) is another way of achieving multiple objectives by maximizing food and energy outputs while minimizing waste and negative environmental impacts by transforming by-products of food production into feedstock for energy.

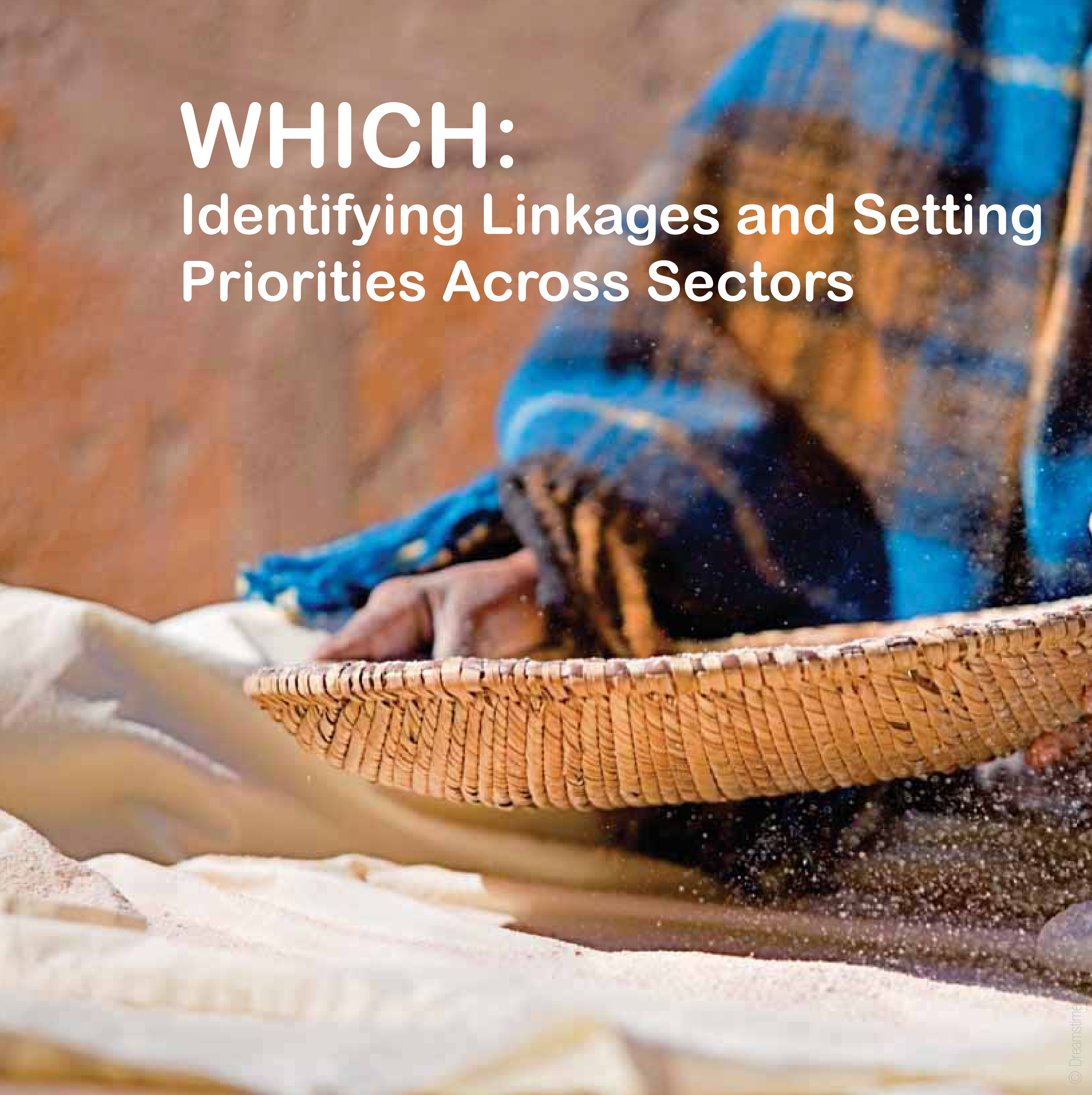
Bioenergy "Status Quo" and Lessons Learned

The planning process should give due consideration to review the current status of bioenergy in the country, highlighting the current use of bioenergy, the population groups and economic sectors served by bioenergy and the technologies used for different purposes. The assessment should also provide a perspective on how bioenergy development has evolved over time, and should identify the capacity development needs for the country relating to bioenergy development for both the public and private sector.

2. Recognizing that developed and developing countries have different considerations for the development of a green economy, developing countries can utilize the emergence of a bioenergy sector towards an 'eco-efficient', sustainable resource economy. More information on green economy initiatives can be found at: http://www.unep.org/greeneconomy.

3. See further information on resource efficiency options: report by the International Panel for Resource Management entitled: 'Towards sustainable production and use of resources: Assessing Biofuels'.

WHICH:
Identifying Linkages and Setting Priorities Across Sectors



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Bioenergy options cross all sectors, end-uses, energy carriers, and implementation platforms. Consequently, policymakers need to consider the linkages across sectors and set priorities according to the objectives (the WHICH).

Policymakers will need to consider the relationships among the various sectors and end-use options as they develop their bioenergy strategy, set priorities, and establish guidelines for investors. There can be a tendency to focus policy development on those areas that attract foreign investors, namely transport fuels and heat & power provision, while the traditional biomass sector and the agricultural sector receive less attention due to their domestic focus. In order for bioenergy strategies to support development and poverty reduction goals, there must be greater emphasis on agriculture and also on the opportunities to upgrade energy services in the household and small commercial sectors.

Traditional Biomass Sector

The traditional biomass sector includes household and institutional use of biomass for cooking, heating and lighting. Although the majority of traditional biomass is burned in solid form, use of biogas has expanded considerably in some regions and there is also some use of refined liquid fuels (e.g. ethanol, SVO, gels and briquettes) for cooking.

Agriculture

Modern bioenergy will transform the agricultural sector by providing additional roles to the existing ones of being the guarantor of food security and the basis of rural livelihoods. The expansion in bioenergy will link the agricultural sector to the industrial sector.

Heat & Power

Bioenergy for heat and power is provided at different scales. Small industries can make use of low-grade heat, mechanical energy and off-grid electricity. Large industries will need continuous electricity supply and may require high-pressure steam.

Bioenergy Policy
Linkages across sectors and end-uses

Traditional Biomass
Used for cooking, heating & lighting by households & small businesses

Heat & Power
Provision of heat, power and mechanical energy at various scales

Transport
Biofuels for transport, including bioelectricity, biogas and liquid fuels

Agriculture
Use of bioenergy for agricultural machinery and operations

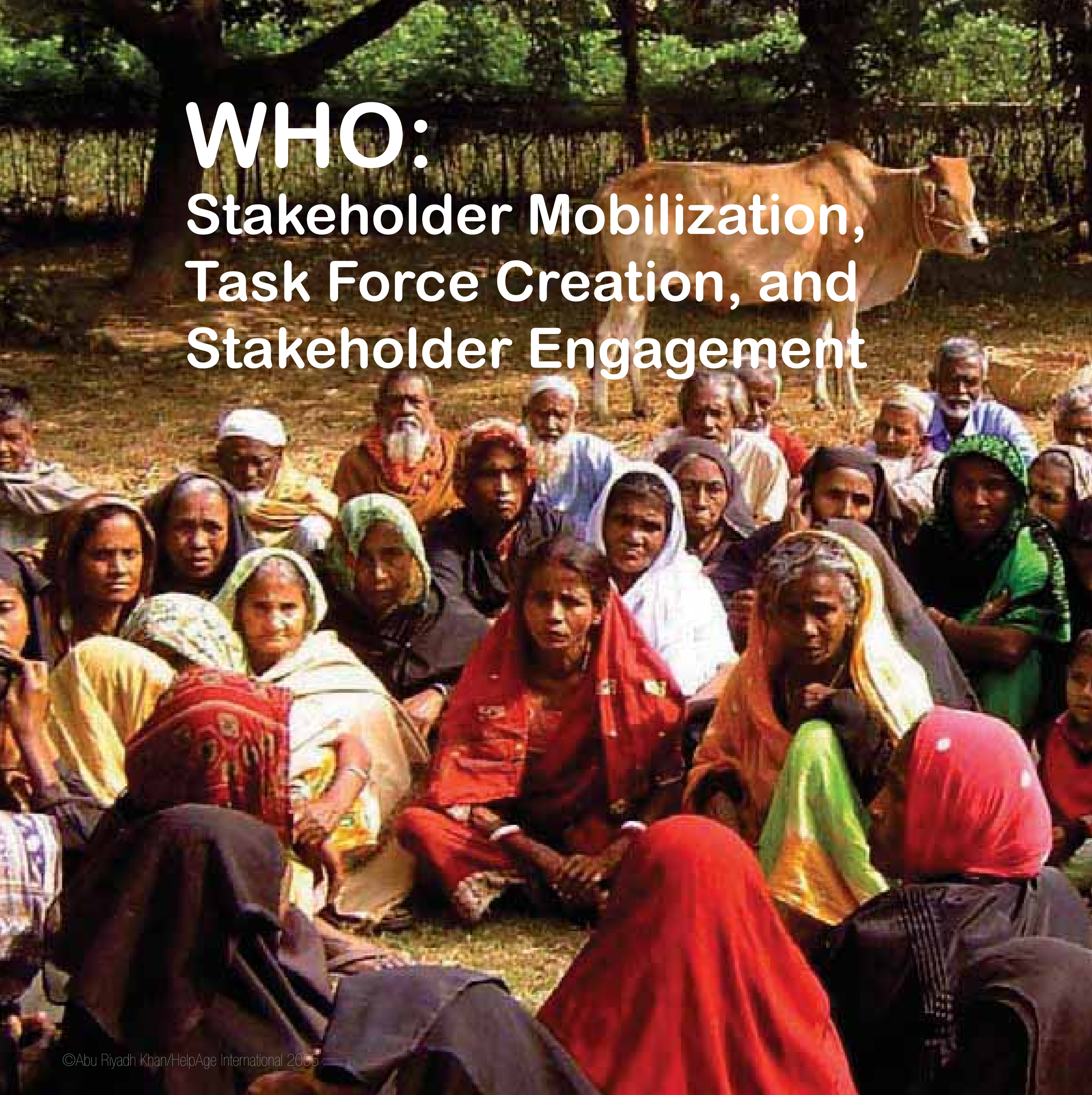
Transport
The provision of transport fuels includes various options with respect to technical specifications (fuel vehicle compatibility) and marketability. Currently, main transportation fuels are ethanol and biodiesel. However, depending on circumstances and envisaged end use, straight vegetable oil can be an option too. Furthermore, biogas and bioelectricity increasingly receive interest.

Economic development issues to consider in relation to sector priorities and linkages:

- Can energy access goals be addressed by improving the availability of biomass residues that are by-products or potential additional bioenergy feedstocks from small industries?
- Are there key inputs for agriculture (e.g. fertilisers) that can be provided through expanded bioenergy production in adjacent areas and what are the options for establishing delivery systems for these inputs?
- Are there potential linkages between the infrastructure needed for transport, power, and communications needs (e.g. off-grid power for new communications systems)?
- Are there under-served demands in selected industries for heat and power that can be met by expanding the supply of biomass feedstocks in the vicinity – and if so what infrastructure is lacking to complete the bioenergy supply chain?
- Are there elements in the regional transportation infrastructure that can be better exploited either for end-use biofuel markets or for distribution and supply of bioenergy feedstocks? If not, what are the prospects for advancing those regional linkages as bioenergy markets develop further?

The bioenergy strategy needs to balance the objectives of improving energy access and stimulating rural development with the need to attract investment in the larger-scale projects needed for transport and power. The identification of innovative combinations of infrastructure along with a better articulation of the demands of end-users in households and small business will help to facilitate the cross-sector synergies.

WHO:
Stakeholder Mobilization, Task Force Creation, and Stakeholder Engagement



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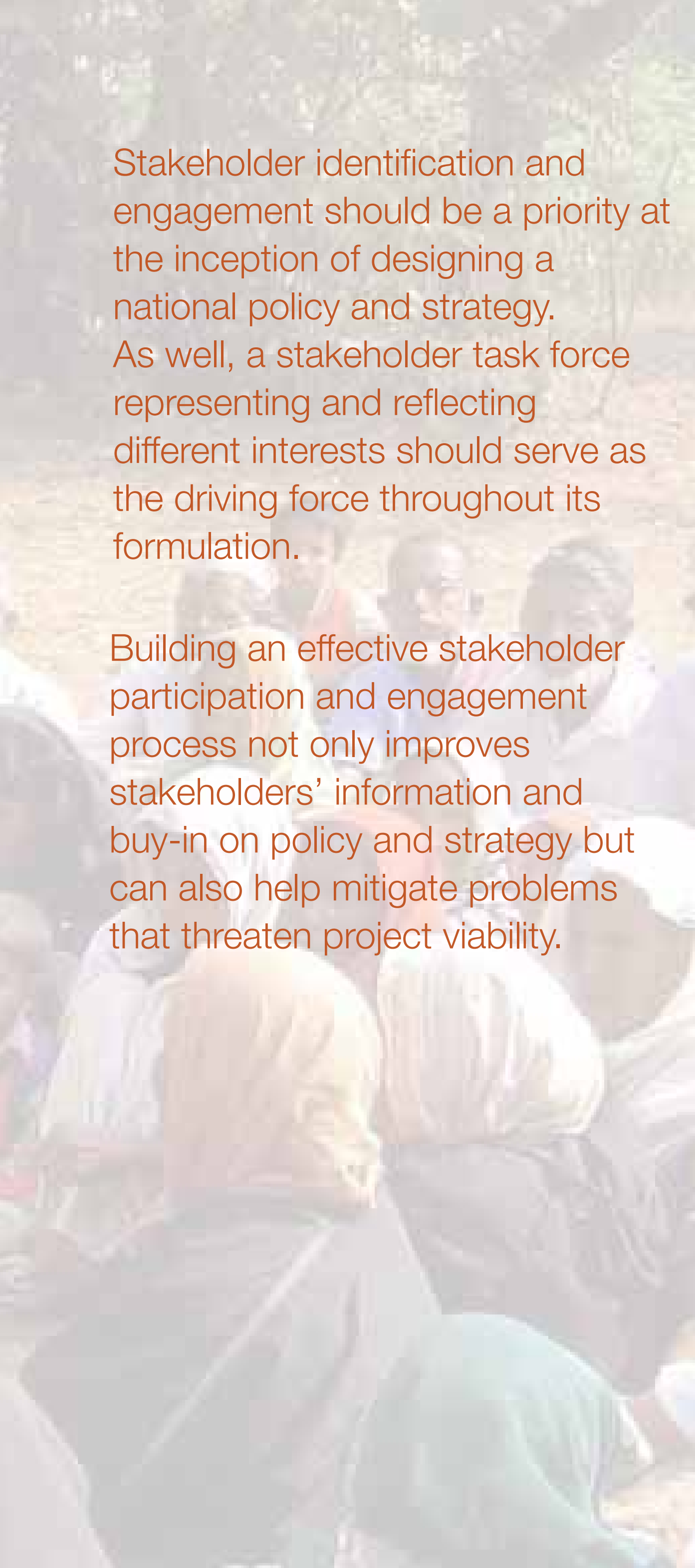


Stakeholder identification and engagement should be a priority at the inception of designing a national policy and strategy. As well, a stakeholder task force representing and reflecting different interests should serve as the driving force throughout its formulation.

Building an effective stakeholder participation and engagement process not only improves stakeholders' information and buy-in on policy and strategy but can also help mitigate problems that threaten project viability.

As bioenergy development relates to, and relies upon, many sectors, a strategic planning process must start with the identification and mobilization of all relevant stakeholders that have an active interest in bioenergy development or that will be affected by it. Box 3 provides an illustrative list of stakeholders at the national level. Representatives of all these stakeholder groups should be consulted in the process of planning for bioenergy development and should be given the chance to provide feedback on choices, assessment methodologies and implementation strategies.

To facilitate the consultation both across central government authorities and with representatives of regional/ local government, the private sector and civil society it is suggested to create two processes: (1) a stakeholder forum in which all interested parties can participate, and (2) a "Bioenergy Task Force' that would facilitate the decision-making and could be the executive organ that reports to the broader stakeholder forum. Such a task force should consist of a core group of members, and is usually best coordinated by a government representative from one of the main sectors concerned.

The bioenergy stakeholder forum and Task Force need not, and should not, be stand-alone institutions. They should be tied into subsidiary bodies of existing national development institutions and fora, for instance stakeholder bodies and executive organs in charge of national development and poverty alleviation.

The Task Force would be the driving force throughout the entire process of strategy formulation. It should report back to the stakeholder forum at each step in the process to invite feedback and to allow for eventual corrections in view of information and clarification brought about by those key stakeholders.

State-Citizen synergy is an essential ingredient to achieve credible policy and strategy formulation and implementation. To enable this, active participation and commitment by key stakeholders throughout all stages of the policy and strategy process are important, as well as the involvement of stakeholders throughout the project cycle.

BOX 3: National level stakeholders: an illustrative list

Central government authorities, including those responsible for

- Energy
- Science and research
- Agriculture
- Rural development
- Poverty and food insecurity
- Environment
- Forests
- Water
- Finance
- Planning
- Trade
- Donor liaison

Representatives of regions/local government, agricultural extension providers/organizations, energy related parastatals, for example:

- Energy utilities
- Regulatory bodies

Non-governmental organizations, for example:

- NGOs for environment and development
- Labour organizations
- Trade organizations
- Farmers organizations
- Community-based Organizations

Private sector, for example:

- Producers, distributors and users of biomass
- Providers of bioenergy facilities
- Producers of bioenergy technologies
- Research agencies
- Providers of advisory services
- Private utilities

Financing institutions

- Banks and finance institutions
- Small-scale finance providers

Bilateral and multilateral organizations in development cooperation

(ESMAP, 2005)

Who should be engaged in national strategy and policy

For stakeholder engagement to be effective, it is critical to identify the appropriate stakeholders or stakeholder representatives to include in the process. This should cover the entire bioenergy value chain.

Engaging stakeholders on the national level

Returning to one of the first steps of developing a bioenergy policy and strategy, key national level stakeholders and national representatives of important regional/local level stakeholders should be represented in the stakeholder forum and have their interests represented by a member on the Bioenergy Task Force. On the national level, these two should be the primary stakeholder-based institutions that drive the strategy process.

Engaging local communities, particularly in project preparation and implementation

Although communities are not the only local stakeholder group, they are the group who usually faces the greatest difficulties in having their voice heard in the decision-making process. Therefore, meaningful and inclusive engagement of local communities is imperative in project planning and implementation. Besides the social responsibility concerns to project developers, effective community engagement can also help in identifying, preventing and mitigating social and environmental impacts that can threaten project viability, or in ground truthing, building upon local communities' unique understanding of the local environment and social context. Following Herbertson K et al. (2009), engaging local communities should include the following:

- **Prepare communities before engaging**
  Engagement can only be effective if the right people are engaged and if those stakeholders are given transparent information about the processes and how potential impacts might affect them. Providing full access and information about the project should be undertaken at the outset of project identification.

- **Determine what level of engagement is needed**
  The level of engagement and respective investment in managing community engagement should be commensurate with the size of the project on the one hand and the anticipated level of impact, in particular negative impacts, on local communities on the other. Informing, consulting and negotiating are all community engagement processes that can be undertaken, although the approach will depend on the level of engagement.

- **Integrate community engagement into each phase of the project cycle**
  Engagement throughout the project cycle (i.e. from pre-feasibility, feasibility, construction, operation and decommissioning) can create stronger relationships with communities. Particular attention should be given during the feasibility stage of a project where communities can help define and provide feedback for environmental and social impacts assessments (ESIA). In the same line, during operation, a monitoring and evaluation system should allow communities to verify adherence to the environmental and social management plan that arises from the ESIA.

- **Include traditionally excluded stakeholders**
  Groups excluded from a community engagement process are often those that are already and traditionally marginalized within the community. To identify these marginalized groups within a community, a social assessment process is necessary to differentiate characteristics by gender, ethnicity, religion, age, or other characteristics and associated interests.

- **Gain free, prior, and informed consent**
  "Free prior and informed consent [FPIC] is a collective expression of support for a proposed project by potentially affected communities reached through an independent and self-determined decision-making process undertaken with sufficient time, and in accordance with their cultural traditions, customs and practices. Such consent does not necessarily require support from every individual" (WRI, 2009). An instance where FPIC is most appropriate is when the project developer suggests that a community relinquish a collective legal right, such as customary land ownership. To achieve FPIC, community consultations should occur during the feasibility phase and must allow adequate time for communities to deliberate.

- **Resolve community grievances through dialogue**
  A project level grievance mechanism, ideally established from the earliest stages of project preparation, can assist ongoing mitigation of risks and provide a cheaper and faster way to resolve grievances than formal external mechanisms. "Grievance mechanisms are a systematic method for recording, negotiating, and resolving disputes between project proponents and local communities (WRI, 2009)." For a grievance mechanism to function effectively, the project proponent must a) clarify possible remedies to identified grievances, b) set aside adequate budget and staff resources for the mechanism, and c) undertake regular joint reviews with the community on the outcomes and effectiveness of the grievance mechanism.

- **Promote participatory monitoring by local communities**
  Engagement is only effective if it is informed, and without transparent information on project compliance there are risks that communities may turn against the project even if agreements are adhered to. Participatory monitoring instead can be a way to build trust among communities. "Participatory monitoring is a process through which local communities systematically track the impacts of a project, and work jointly with proponents to resolve key concerns that are detected (IFC, 2007)." Communities may need capacity support through training and independent technical advice, or by setting up multi-stakeholder monitoring schemes in which communities participate alongside technical experts.

Dreamstime

WHAT:

Bioenergy Technology and Feedstock Options

In this phase of developing a strategy, the suitability of bioenergy systems should be analyzed considering the national objectives, agro-ecological context, and social and environmental concerns.

A bioenergy system is characterized by the cultivation, production, gathering and transport of feedstock, and its conversion to yield an energy carrier which delivers an energy service to an end user. Examples of some of these energy services are heating, lighting, mechanical power or transport. The suitability of a particular system in a particular context depends on several aspects and no "best" technology route exists. The choice of route will vary with the type and volume of available (or sustainably feasible) feedstock, type of energy service(s) needed, investment possibilities and technological readiness of the region. As in nature, diversity will help mitigate economic and climate related risk, but comes with a trade off in terms of economies of scale due to constraints of limited investment capital.

Choice of feedstock

There are several different options of feedstock for a bioenergy system and choices have to be made in view of agro-ecological conditions and the broader natural resource baseline, local traditions, and the purpose of the project/programme. Feedstocks differ in their impacts on soil quality and water use, biodiversity and greenhouse gas balances, and the extent of these impacts varies with cropping cycles and management methods. Besides environmental impacts, social impacts also vary as some crops demand intense labour for manual planting and harvesting, while some crops are best harvested mechanically. Furthermore, competition with labour for other crops, in particular during land preparation and harvesting times, should be taken into account in the planning.

Bioenergy feedstocks can be divided into three main categories: waste/residues, dedicated energy crops, and biomass harvested from natural resources. The potential for these different types of feedstock vary significantly between areas and within areas, as do the production/collection and conversion costs and the end products they can be used for. Each source has its specific advantages and disadvantages and the type of feedstock should be chosen in consideration of national objectives.

Waste and residues are feedstocks that do not directly compete with food production for land, water or inputs, or with biodiversity and carbon sinks for land use, and can provide significant GHG savings, as long as they are collected and used in a sustainable manner. Due to costly collection/conversion, waste/residues tend to be more suited for conversion into heat, electricity or biogas.

Waste and residues often already have a local market (e.g. non-formal markets), and by redirecting flows, indirect effects may be caused. Further research is needed to determine the proper balance of residues that should remain in the field or in the forest to maintain soil fertility and soil carbon content, and improve soil conservation. In that sense, it is important to note that while utilisation of waste and residues can feature as a win-win to address waste disposal and an energy generation, not all waste or residues are easily accessible or economically viable for energy utilization.

Dedicated energy crops are crops grown for energy purposes. Energy crops can be divided into the four groups of sugar crops, starch crops, oil crops and lignocellulosic crops. The theoretical potential for energy crops in many regions is large, but can be limited by land and water availability as well as competition for other uses (food, feed, fibre). The potential environmental and social impacts from the production of dedicated energy crops differ depending on the choice of crop and management system. These impacts (further elaborated in the full version of the DST), as well as a determination of the resource base (see Box 4), should be taken into consideration before promoting a specific crop.

Biomass harvested from natural resources is another form of bioenergy feedstock. These include forest, woodland, grassland or aquatic resources. Some areas might have the potential to harvest naturally growing biomass for local needs; however, the potential is often low and generally not able to supply large-scale bioenergy systems.

Box 4: Brief delineation of variables in estimating a resource base

- Estimate areas of potentially available and suitable land.
- Estimate yields associated with areas of suitable land.
- Calculate the gross potential resource (by land type and/or subregion).
- Estimate production costs and delivered energy prices.
- Estimate delivered energy prices (and ranges).
- Final integration and assessment of energy crop potential.

Source: ESMAP - Bioenergy guidelines

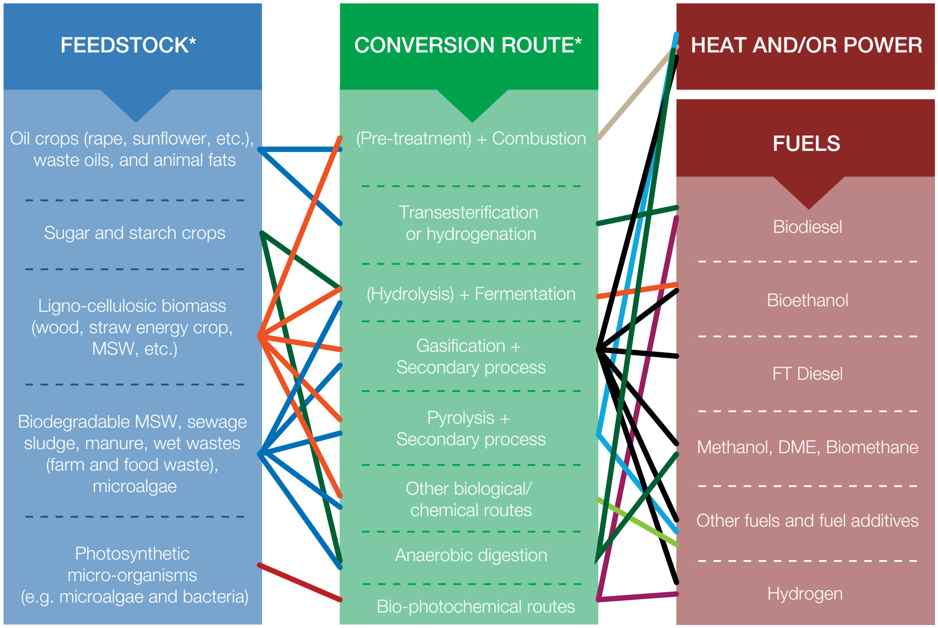
Conversion technologies

The choice of conversion technology should be based on the objectives of the programme/project and the resources available - biophysical, economic, infrastructure, and human resources. A large number of possible feedstocks, conversion technologies and end uses for bioenergy already exist; and, at the same time, innovation processes are creating further options for advanced and more efficient conversion technologies.

Different conversion routes vary in terms of their complexity, as they are adapted to work on different physical and chemical compositions of feedstocks. Figure 3 provides an overview of possible conversion routes in a bioenergy system.

More advanced technologies tend to have higher conversion efficiencies, but tend to have higher capital cost as well. Furthermore, an efficient technology does not work effectively if there is no human capacity to absorb it, run it, and maintain it (See Project Level Consideration box). Trade-offs may have to be made in order to find the best technical solution that is viable in a specific country context. For instance, optimizing a system for a particular end use may call for a change in feedstock (and subsequent human resources) in order to use the requested technology in the most efficient and cost effective way. The technological absorption capacity in a country should be carefully evaluated in relation to human capital, manufacturing and process inputs (FAO, Bioenergy and Food Security Project, Module II).

Figure 3: Conversion routes for the most common choices of feedstocks, conversion technologies and energy carriers



*Parts of each feedstock, e.g. crop residues could also be used on other routes

*Each route also gives co-products

(Source: IEA, 2009)

Project Level Consideration: Investment risks associated with feedstock supply

Bioenergy is unique in comparison to other classes of energy in that much of the risk associated with new investment falls on the supply of feedstock rather than in the other parts of the chain (conversion, transport, distribution, end-use). The following questions are relevant in assessing the feedstock risk:

- **Location** – where is the expected biomass feedstock supply located in relation to the processing facilities?
- **Homogeneity** – is the expected feedstock of a homogenous quality (e.g. a specific variety of tree) or is it heterogeneous (e.g. collection of different residues)?
- **Alternative buyers** – are there alternative buyers, either existing or potential, for the feedstock?
- **Climate** – is the availability of the feedstock subject to climatic, seasonal or other (non-price) fluctuations?
- **Pre-processing** – will the feedstock require pre-processing (and if so, can it potentially be done at a separate location?) or if not strictly required, will there be significant economic benefits to incorporating pre-processing?
- **Measurement** – is it difficult and/or costly to measure the quality or quantity of feedstock?
- **Procurement** – are there non-price limitations or conditions on the type of procurement or contracting that can be used to obtain the feedstock from the supplier?
- **Experience** – Does the operator of the facility that will use the feedstock have previous experience with the specific type of biomass that will be supplied?

WHERE:
Identifying Suitable Areas for Production

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Determining a country's potential for bioenergy production must build upon an assessment of the availability and suitability of land resources.

Land is a scarce and contested resource: we need land as habitat and for different economic sectors, but also to preserve biodiversity and ensure that ecosystem services are available as a basis for human activity and livelihoods, including carbon sinks to help address climate change. Impacts can occur directly through land conversion, or indirectly by replacing a different kind of land use which will then encroach in natural areas that may provide ecosystem services.

Displacement effects can occur in the same country or region or beyond country boundaries. Carbon sink losses due to indirect land-use change (iLUC) due to bioenergy production have received heightened interest both by governments and the research community. Due to the difficulty of establishing a quantifiable direct causal link to a given project, mitigation of iLUC needs to be addressed on a national level; ideally by mapping all land use, not only that for bioenergy production.

In order to assess land availability for feedstock production for energy use from a national perspective, a data-based top-down approach can be pursued which is complemented with ground truthing in potential priority areas. To assess available suitable land for feedstock production, which does not generate significant competition with land for the production of food crops that contribute to food security, or convert land that provides a high degree of ecosystems services, or an area of biodiversity, the following steps can be taken (not necessarily in the following order):

- **Conduct a land suitability assessment to identify land that holds promise for feedstock production and map suitability and potential yield across the country.**

Land suitability assessments identify areas of promise for bioenergy production within a country from a biophysical prospective based on geo-referenced data. Using the Suitability Assessment Model, two steps can be used to establish these areas (FAO Bioenergy and Food Security Project, 2009. Suitability Assessment Model for Bioenergy Crops – Module I). The first step is conducting a Land Resources Inventory, which synthesizes information on land resources, overlaying information and inventory of climatic resources, soil resources, and landform resources. The next step is implementing a Land Suitability Assessment which will assess specific feedstocks and production systems. Initially, in a Land Suitability Assessment, Land Utilization Types (LUT) are defined based on the assessment of agro-climatic suitability, agro-edaphic suitability, and landform suitability. The result of the suitability assessment is expressed in "land suitability classes" ranging from very suitable, to not suitable, always with respect to a specific feedstock.

- **Identify and map areas of special sensitivity ("high risk" areas).**

High risk areas for feedstock production in terms of potential damage to vital ecosystem functions should be clearly delineated and mapped. High risk areas include: Areas that contain high levels of carbon that, if converted for bioenergy production, could potentially be released and contribute to negative GHG balances; and Areas that contain high levels of biological diversity, that include areas that: support a large diversity of species; be important for supporting a species of conservation value such as rare, endangered or threatened species; contain ecosystems or habitats of significance and concern; and areas that because of their biological components supply goods and services that are culturally important to people; and areas of water scarcity.

Identification of these areas in a given country context should follow a transparent and inclusive process.

Bioenergy development in these areas should only be taken forward if appropriate mitigation measures and good practices can be put into place that safeguard these areas. The burden of proof is high; and if it cannot be reached, the area should be classified as 'exclusion zone' or 'no-go' area.

- **Identify and map existing agricultural production areas. Assess the likely expansion path for food production over the short to medium term.**

In order to ensure that bioenergy production does not endanger food availability, decision-makers should take into consideration possible competition for natural resources, such as land and water, to food production by an expansion of feedstock production. Overlaying mapping data on areas currently under agricultural production with the areas identified as "suitable land" for feedstock production highlights the areas where competition with agricultural production of food may arise immediately. If bioenergy is to be developed in these areas, it should only be done with precaution to ensure there is no negative impact on food security, keeping in mind that food security does not depend solely upon availability of food but that access to food is critical. Some measures such as intercropping referred to in the best practices section can reduce risks to food availability.

In addition, as land requirements for food production are expected to grow over time, an assessment and mapping of possible competition for land should also consider land requirements for future supply of key staples, taking into account likely alternative supply options to meet expanding demands.

Assessments should be carried out by using a combination of top-down and bottom up approach:

- **Overlay infrastructure information on suitability and potential yield maps to evaluate market accessibility and the economic feasibility of feedstock production.**

Mapping existing infrastructure helps to identify areas that have good access to markets and are thus more likely to be suitable for commercial operations. Key infrastructure to map, if there is available data, includes transport and communication infrastructure (e.g. major roads, railroads, ports and airports), and processing infrastructure (e.g. refineries or wood processing plants). The latter provide an indication of existing opportunities for processing or pre-processing selected biofuel feedstocks. Mapping should also include availability and reliability of electricity supply and telecommunications which are important utilities for industry. Decentralized energy supply schemes for local use may need very little infrastructure to be feasible, and in fact may be profitable precisely in areas where (grid) connection is absent or unreliable.

- **Conduct "ground-truthing" of promising areas for feedstock production.**

The identification of potential feedstock production areas following a "top-down" data-based assessment must be accompanied by ground-truthing measures in those areas that are flagged as having a significant potential for feedstock production. Ground-truthing should verify and

The **Four Step Process*** is another approach or process that can be used in determining land suitability for bioenergy production. The process is as follows:

1	Use of publicly available global map datasets to identify strictly protected areas, and broad zones of high and low risk for development.	SCREENING	**Review of publicly available maps** • Global data on carbon, biodiversity and other values • Identification of protected areas and broad zones of high and low risk.
2	An explicit requirement for national or regional level consultation to identify important features that are not apparent from global level mapping processes, and facilitate site selection.	LANDSCAPE LEVEL ASSESSMENT	**National/Regional consultation** • Consultation with relevant institutions and experts • Identification of important features not identified in global maps • Site selection
3	Detailed site level management planning, where definitive "no-go areas" are mapped and protected, and appropriate areas for potential development are identified	SITE LEVEL MAPPING	**Detailed site-level assessment and planning** • Consultation with local people and feild-based data collection • Delineation, and management plan for no-go areas • Identification of appropriate areas for potential development
4	Application of best agricultural management practices in areas where development is agreed.	RESPONSIBLE MANAGEMENT	**Implementation of responsible land management** • Development of appropriate areas, involving stakeholders in decision making • On-going monitoring of impacts, and adaptive management • Compliance with international best practice

*The Four Step Process has been developed by IUCN. In its suitable land identification process it uses the terms 'no-go' and 'go' areas to signal potential areas for cultivation. 'No-go' terminology in this process is similar to the use of the term 'exclusion area' or 'exclusion zone' in this document.

provide better details on the information generated by statistics and maps. Ground-truthing teams must include or work closely with local communities and other relevant local stakeholders as well as technical experts in the area to ensure that the analysis is reflective of the reality on the ground. Field level assessments should also clarify the status of land ownership and current and projected land use, possibly by overlapping user groups.

Special emphasis could be given to areas with potentially lower opportunity cost – marginal and degraded lands

The use of marginal or degraded land for crop production may provide an opportunity to produce bioenergy limiting competition with food production, and if managed in an appropriate way can restore or improve soil quality – leading to enhanced carbon sequestration. Marginal land can be defined either with respect to biophysical or economic performance. In biophysical terms it is land that can only support less than 40% of yields– always in relation to a specific crop. In economic terms marginal land is land where cost-effective production is not possible. Land degradation is a long term loss of ecosystem function, services and land productivity. Many degraded lands are in use. Utilizing marginal and degraded lands for feedstock production may reduce some risks, yet there are significant challenges and trade-offs to be considered. These include low yields and greater needs for irrigation and fertilizers. Others are related to the identification whether the lands are truly marginal or degraded.

Even though some land may be classified as marginal or degraded with respect to dominant use systems, this seemingly marginal and unproductive land may fill invaluable roles and possess other values such as: providing environmental services, serving as a source of natural resources for pastoralists and subsistence farmers, as wildlife corridors, and for the filtration and maintenance of water quality. Displacement of such functions may disrupt important balances with consequences outweighing any environmental benefits from the bioenergy production. Therefore, great care should be taken when identifying these areas and current land use patterns must be analysed systematically, and performed in dialogue with local stakeholders.

HOW:

Bioenergy Implementation Options

The way that bioenergy production is implemented might have significant social implications for the achievement of development goals including income generation opportunities and employment in rural areas. These implications have to be considered in order to benefit social and rural development.

How bioenergy is implemented also has an effect on the environment and natural resources. Implementing sustainable practices can be a mechanism to reduce potential risks – these practices are referred to in the 'Mitigation Measures' section.

Just as there are many different technology options to produce bioenergy, there is an array of different institutional options. These various institutional options can be identified during the feedstock production stage and will differ in terms of: scale of operations, ownership structure and the level of partnership between different stakeholders. The extremes are large-scale plantation models owned and operated by a single company on the one hand and small scale community initiatives for the production of energy for local or even household use on the other.

Concession farming, contract farming, and small scale schemes are three main types of processing schemes that are particular to bioenergy feedstock production, although six broad categories of feedstock production schemes can be distinguished, these depend on:

- The relationship between the feedstock producer and the processing company, namely:
  - Concession farming: A processing company (large or small) that produces the feedstock on its own land or leased land
  - Contract farming: A processing company (large or small) that buys the feedstock from outgrowers (large or small)
- The scale of operations of the processing plant, i.e. large scale for national or export markets or small scale for local use, and;
- The scale and ownership of the farming operation. i.e. large industrial plantations owned by the processing company (corporate ownership), large commercial private farms (individual or corporate ownership) or small scale farmers (private, but often on customary land without individual freehold title)

Table 1: Main types of bioenergy feedstock production schemes			
Land belongs to	Size of the land unit on which the feedstock is produced	Size of the processing scheme and intended market	
		Large scale – bioenergy produced for national or international markets	Small scale – bioenergy produced for local use
Company	Large scale commercial farms owned by the biofu-els producing company	A : Concession	D: Concession
Farmer	Large scale private farms (including farms that produce biofuel for their own on-farm use)	B: Contract (though these farms may be concessions as well)	E: Contract or concession
	Small scale private farms	C: Contract	F: Contract or Cooperative
Scheme			
A: Large corporate farms for large scale biofuel production			
B: Private commercial farms in support of large scale biofuel production			
C: Small scale outgrowers providing feedstock to large scale biofuel production			
D: Large corporate farms for small scale biofuel productionm			
E: Private farms for small scale biofuel production			
F: Small scale private farms providing feedstock to local small scale energy providers			

Table 1 provides an illustration of the context for these processing schemes. The choice of appropriate schemes must take into account the end use market of the product and the technology adopted. As well, the potential risks and benefits of each of these types of schemes must be considered, with particular attention to risks and implications on social aspects such as income generation opportunities and rural employment.

Impacts and risks linked to bioenergy implementation and ways to address them

Concession farming is usually used to describe large scale bioenergy feedstock production by a large operator but could also describe small operations run collectively by a single operator such as a co-operative. In bioenergy development, concessions can entail primarily two types of risks related to employment and labor conditions, and competition for land and natural resources. Although large scale schemes can generate many employment opportunities, this depends on the degree of mechanization employed – these potential job losses have to be considered before implementation.
In addition to the amount of jobs that are created, one has to look at the quality of working conditions with respect to international labor standards.

Competition for land and natural resources can be a concern if in large scale concession farming farmers are evicted from their land without compensation or the compensation is worth much less than the actual value of the land. However, competition for scarce resources does not automatically have to lead to conflict. Processes related to conflict resolution, reconciling competing interests and good governance of land and natural resources should be utilized to ensure transparency and stakeholder communication.

Contract farming/ outgrower schemes on small farms refers to a 'a system where a central processing or exporting unit purchases the harvests of independent farmers and the terms of the purchase are arranged in advance through contracts' (Baumann, 2000). The terms of the contract vary and usually specify how much produce the contractor will buy and what price they will pay for it. The contractor frequently provides credit, inputs and technical advice to the outgrower. This can reduce risks for small producers, increase their access to technology and open up new markets which would otherwise be unavailable to small farmers.

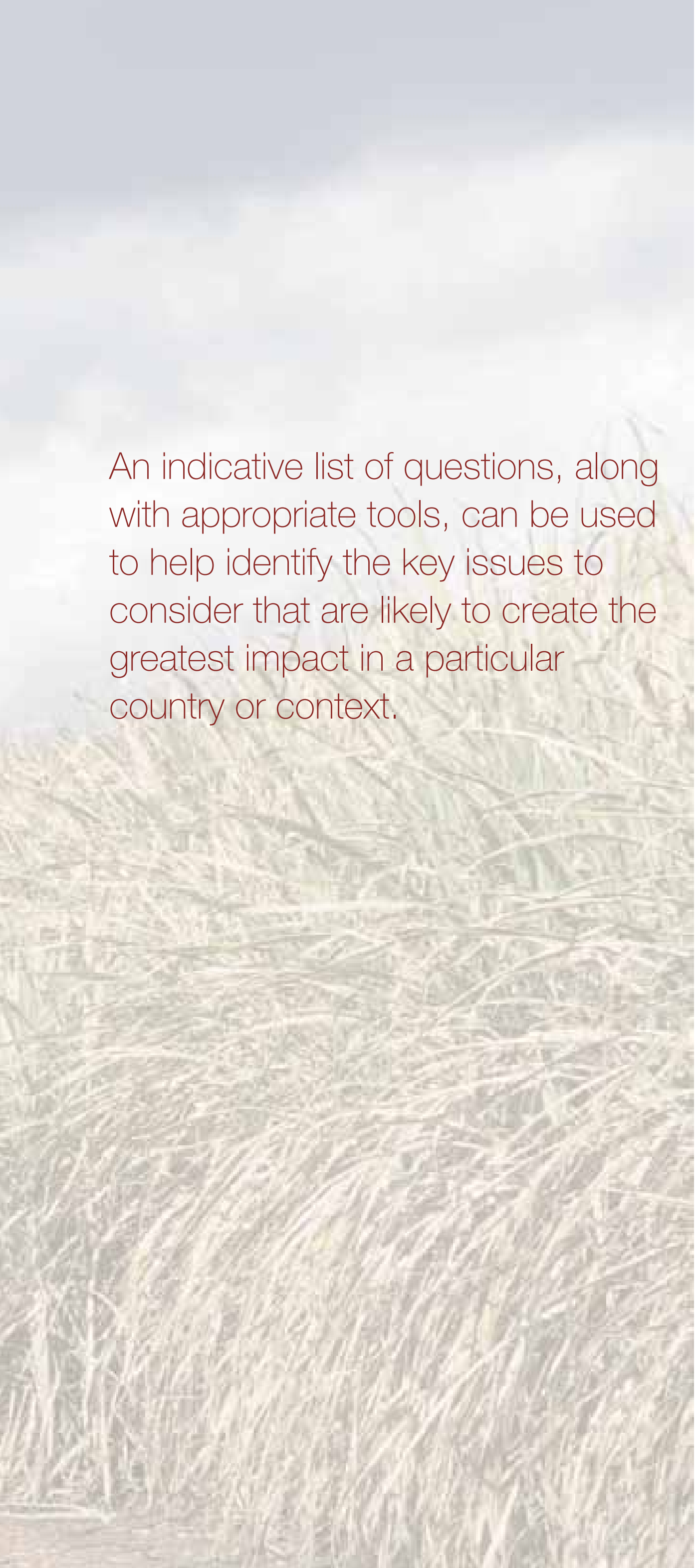
Although this type of scheme can bring several benefits to both the contractor/company and farmers, it can also come with disadvantages. Some of these disadvantages to farmers include: market failure risks and production problems with new crops, manipulation of quotas and not all contracted production is purchased, companies may exploit a monopoly position, and company staff may be corrupt, particularly in allocation of quotas (FAO, 2001b). Although experience shows that it's easier said than done, many of these potential risks to farmers' livelihoods can be mitigated by collective action through farmer's groups, associations, or working with farmer leaders (this would be a more informal approach).

Small-scale schemes are bioenergy processing schemes in which bioenergy is produced locally for local use. An example of this model might be a community or co-operative that utilizes its own land for growing feedstock and will use the fuel derived to operate small bioenergy equipment to generate energy for local use. Truly satisfying local needs, contributing to poverty reduction and protecting food security is a complex challenge, and finding solutions can be an iterative path that takes time. An important consideration for inclusive development and sustainability of these schemes is the need to link them to income generating activities as it enables more end-users to afford new energy services.

A crucial risk and concern to the sustainability of these systems is the technical and financial viability of small-scale operations – the major challenge lies in making such schemes affordable, accessible and appropriate to local circumstances and people. However, experience has shown that there are some ingredients essential to success for community-type bioenergy initiatives, some of them being: adopting participatory approaches throughout the project cycle, treating the total supply chain as integral to the project, involving the private sector, and getting the financial mechanisms right.

ASSESSING IMPACTS:

Guiding Questions and Tools



An indicative list of questions, along with appropriate tools, can be used to help identify the key issues to consider that are likely to create the greatest impact in a particular country or context.

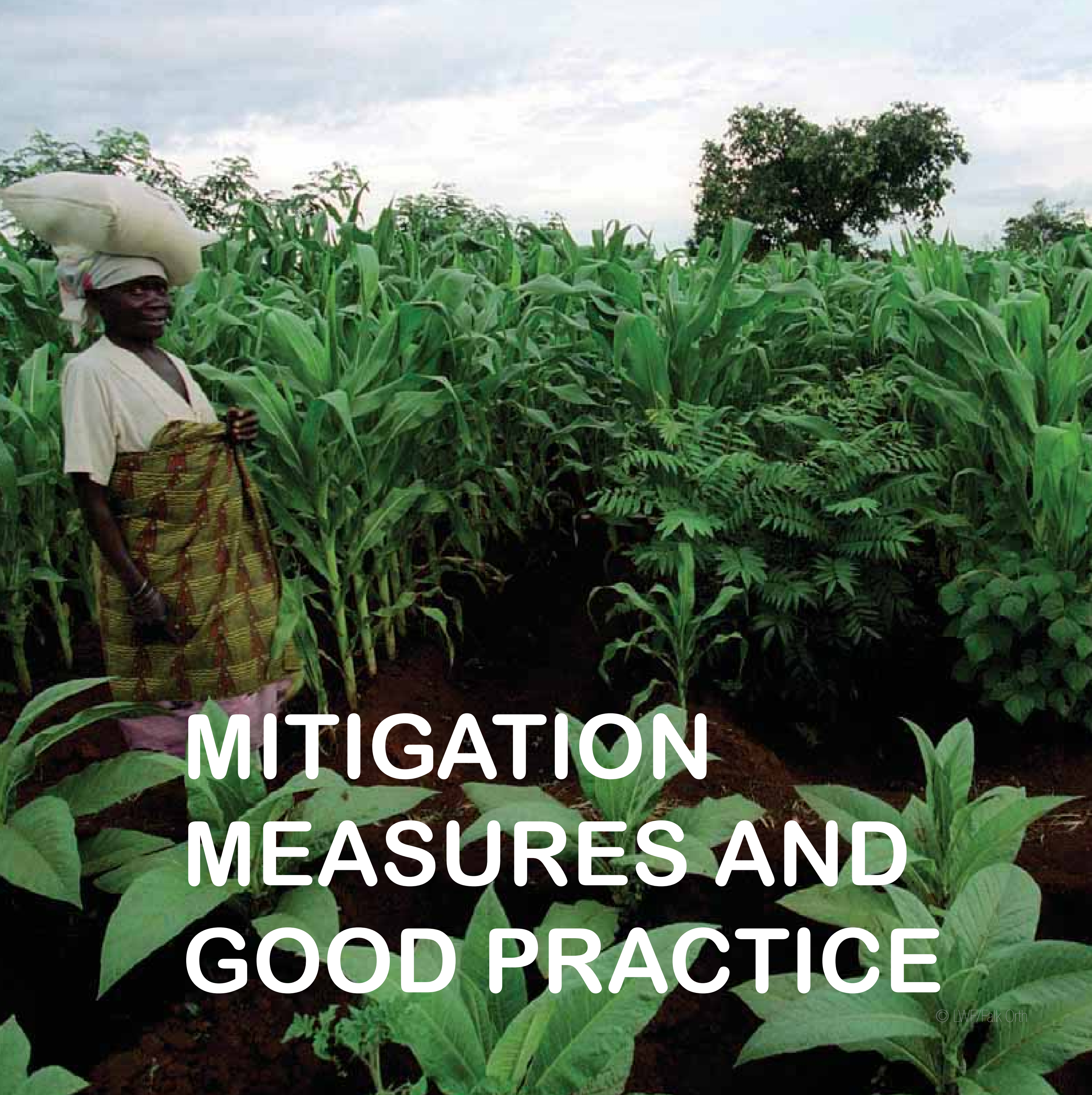
As discussed in UN Energy publication “Sustainable Bioenergy: A Framework for Decision-Makers” (UN Energy, 2007) both the nature and the magnitude of the environmental and socio-economic effects of bioenergy production and use in developing countries will depend on a number of biophysical, technological and socio-economic factors. Examples of such factors include the type of biofuel, feedstock and conversion technology considered, the scale of production, the previous uses of the land and the structure of land ownership, and all vary within a given context.

An indicative list of questions has been put together to help decision-makers identify issues that are likely to create the greatest impact in their country or given context, and to assess trade-offs. In addition, cross-reference to tools that can be used to assess and/or address the key issues are flagged for specific themes or questions. The guiding questions should not be seen as a checklist which has to be worked through from top to bottom. Rather the questions provide an indication of key issues to consider, with the aim to ensure that those likely to create the greatest impact in a particular country and context are then assessed in further detail with the help of appropriate tools.

These questions are grouped into three main categories:

- **Environment and natural resources:** potential impacts to ecosystems, biodiversity, water, forest resources and products, soil, GHG balances, and air quality;
- **Socio-economic effects:** land tenure and displacement risk, income generation, potential exclusion of certain groups/individuals, employment, labour conditions, increased energy access, local governance; and
- **Food security impacts:** food availability, access, stability and utilisation.

Some key guiding questions to assist in assessing impacts are (the rest are accessible in the larger report)		
Environment and Natural Resource Impacts	**Socio-economic Effects and Impacts**	**Food Security Impacts**
■ Will bioenergy production directly affect any rare or threatened ecosystems or habitat types through conversion, habitat loss or fragmentation? ■ Will bioenergy production lead to a reduction in soil productivity? ■ Will bioenergy production result in the introduction of non-endemic invasive species? ■ To what extent will bioenergy production adversely impact water availability and/or quality both for downstream ecosystem processes and services and for downstream human activities and domestic uses (both current and projected)? ■ Will the GHG balance be positive or negative compared to traditional fuels?	■ To what extent will bioenergy production lead to the displacement of local communities or of certain groups/individuals (particularly vulnerable groups such as indigenous communities and women) within them? ■ Will the opportunities associated with bioenergy production be equally distributed across groups and individuals? ■ Will bioenergy production generate more jobs than it will replace? ■ To what extent will the bioenergy produced (or part of it) be used to meet the local demand for energy? ■ Is bioenergy production profitable without explicit and implicit subsidies? In the short, medium and long run? ■ What action can the local population take in case of bad performance of local government/local line agencies/economic operators?	■ What is the status of food insecurity (chronic and transitory)? ■ What are the main staple foods in the diet of the country's poor and vulnerable populations? ■ To what extent will bioenergy production affect the availability of the key staple crops - now, throughout the year, and in years to come? ■ To what extent will increased demand for agricultural commodities for bioenergy production affect the prices of key staple foods? At the national level? In the local area? ■ How will increased use of agricultural inputs for feedstock production affect input availability for food production? Now, and in the future? ■ Do safety nets exist to protect against temporary food insecurity?



MITIGATION MEASURES AND GOOD PRACTICE

After completing an overall assessment of bioenergy option baselines, and risks, risk mitigation measures can be adopted and good practice followed throughout the supply chain to help improve social equity and reduce negative environmental impacts. Good practices apply to technologies as well as to socio-economic factors.

Sustainable Agriculture

There is a large and broad variety of practices and methods that contribute to the achievement of what is called sustainable agriculture and they have been implemented by people in many different capacities, from farmers to consumers. It encourages stewardship of both the land and natural resources which involves maintaining or enhancing this vital resource base for the long term, as well as stewardship of the human resources which includes consideration of social dimensions. These practices take into account the complex, reciprocal and ever-changing relationships between agricultural production and the broader society.

The adoption of sustainable farming practices can mitigate environmental risks related to feedstock production. Intensification can limit the pressure for land expansion for food, feed and fuel production, but intensification must also occur in a sustainable manner to minimize negative impacts on the local and global ecosystem services. Sustainable production intensification aims to increase productivity and economic benefits to farmers and reduce negative environmental impact by capitalizing on inherent ecological processes.
Sustainable intensification can be promoted through a variety of different agricultural management approaches, which address different environmental challenges. Some of the key approaches are listed in Table 2.

Sustainable Forest Management

Sustainable Forest Management (SFM) aims to ensure that the goods and services derived from the forest meet present-day needs while at the same time securing their continued availability and contribution to long-term development. In its broadest sense, forest management encompasses the administrative, legal, technical, economic, social and environmental aspects of the conservation and use of forests. It implies various degrees of deliberate human intervention, ranging from actions aimed at safeguarding and maintaining the forest

ecosystem and its functions, to favouring specific socially or economically valuable species or groups of species for the improved production of goods and services.
SFM enables forest resources to produce to perpetuity and at the same time maintain the environmental and protection services that the resource provides such as soil and watershed protection. Although Sustainable Forest Management is a very broad concept that includes a number of elements, there are many practices that can be used to ensure the sustainability of forest resources including for use in biofuel production, such as: the use of certification schemes, forest pest and disease management, forest fire management, creation of forest governance and clear tenure rights, restoration, and community-based forest management.

Transport, Conversion, and Storage
In addition to agricultural practices, there are a variety of good practices for transport, storage and conversion along a bioenergy supply chain. For transportation, the first general recommendation for mitigating harmful practices is to minimize transport as much as possible. Developing infrastructure for bioenergy supply chains is an important component for this, and planning cultivation areas that are close to conversion facilities and end-users would minimize the traditional fossil fuels that are often used in transportation. Transportation modes that also reduce energy needs (and subsequently reduce GHGs from conventional transport fuels) should also be considered.

For storage, most types of feedstock can only be harvested for parts of the year and storage is thus essential for supplying the energy service and/or energy carrier all year around. Storage can be done in many different ways and the best way often depends on the feedstock. Dry storage, when possible, is preferable as it reduces dry matter loss. If the produced energy carrier such as vegetable oil, biodiesel, ethanol, woodpellets and charcoal is stored, appropriate storage tanks that do not pose a threat to the environment should be utilized. For advanced biofuels,

Table 2: Sustainable Agricultural Approaches

Agroforestry	Agroforestry focuses on integrating trees into agriculturally productive landscapes to preserve the crucial role that trees play in almost all terrestrial ecosystems, where they provide a range of products and services to rural and urban people.
Conservation Agriculture (CA)	CA follows three basic principles - avoiding continuous mechanical soil disturbance, maintaining permanent organic soil cover and using adapted crop rotations.
Eco-agriculture	Eco-agriculture is an approach to managing landscapes to meet three goals: conserve biodiversity and ecosystem services; provide agricultural products sustainably and support viable livelihoods for local people.
Good Agricultural Practices (GAP)	Good Agricultural Practices refer to codes of practices and principles to apply on voluntary basis for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economical, social and environmental sustainability.
Integrated Pest Management (IPM)	IPM is the careful integration of a number of available pest control techniques that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and safe for human health and the environment.
Organic Agriculture	Organic farming is a form of agriculture that relies on crop rotation, green manure, compost, biological pest control, and mechanical cultivation to maintain and improve soil productivity and control pests, excluding or strictly limiting the use of synthetic fertilizers and synthetic pesticides, plant growth regulators, livestock feed additives, and genetically modified organisms.
Sustainable Land Management (SLM)	SLM is "the adoption of land use systems that, through appropriate management practices, enables land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources" (TerrAfrica vision paper, 2008, www.terrafrica.org).
Integrated Water Resource Management (IWRM)	IWRM has been defined as "a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Global Water Partnership).

torrefaction, which increases density more than pelleting in some cases, is an efficient storage system.

Defining what a good practice is for conversion technologies can be difficult, since it is highly dependent on the objectives of the bioenergy project. For example, use of coal power for conversion of biomass to liquid is a bad practice if improved GHG balance is an objective, but can be a good practice if only energy security and financial competitiveness are considered. For conversion practices, applying the principles of high resource and conversion efficiencies can be regarded as general good practice - utilise as much of the feedstock for useful energy and recover the waste whenever viable.

Integrated Food Energy Systems

The concept of Integrated Food Energy Systems (IFES) (Sachs & Silk, 1990) is a farming system model designed to integrate, intensify and thus increase the simultaneous production of food energy either by physical coexistence (i.e. combining food and fuel feedstock on the same land, through intercropping of agroforestry systems), and closed loop systems (i.e. transforming the by-products of one system into the feedstocks for the other).

Closed loop agricultural systems maximize synergies between food crops, livestock, fish production and sources of renewable energy (see Case Study). They are characterized by some operational principles:

- High productivity in cultivation
- Optimal use of biomass (based on the idea that nothing is 'waste')
- Closing the loop: waste treatment by anaerobic digestion
- Often crop and livestock integration

Case study: Vietnam Biogas Farms

In Vietnam, not unlike many other developing countries, traditional fuels such as wood and coal for cooking, are becoming increasingly scarce and expensive, and can contribute to deforestation. Increasing livestock production in rural communities with high population density leads to health and environmental issues from the quantity of animal dung being produced. Realizing this Vietnam has embarked on an integrated land management scheme, supported by the Vietnamese Gardener's Association (VACVINA) called the VAC integrated system. It combines gardening, fish rearing and animal husbandry to make optimal use of the land.

Biogas digesters are part of the solution offered by this initiative, using the wastes to generate energy, and the resultant slurry as a fertilizer to improve soil quality. A market-based approach has been adopted to disseminate the plants. The service provided to those buying the digester is comprehensive. The customer must have at least four to six pigs or two to three cattle that provide all the inputs (animal dung). Households use the biogas as fuel and slurry as fertilizer. They pay the total installation cost for the digesters to local service providers, and operate the biodigester using instructions provided by local service providers.

A biodigester produces enough daily fuel for cooking and lighting. It improves the surrounding environment, whilst livestock produce meat, milk and fish products for local consumption and subsistence farming. Vegetable production is enhanced through use of biogas slurry, and latrines can be added to the system to enable human waste to be used for energy.

Practical Action, 2009

SELECTING TECHNICAL PRIORITIES AND DEFINING AN IMPLEMENTATION STRATEGY

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Defining technical priorities and an implementation strategy for bioenergy development should be based on the considerations and outcomes of the full context analysis and assessment of bioenergy baselines, resource assessment, risks and opportunities.

These next steps serve as the practical implementation of all of the considerations that were realized in the previous steps. At this stage the context for a bioenergy strategy should be understood, risks assessed, mitigation identified, and stakeholders engaged.

Based upon the risk assessment of the different technology options and settings, it would be up to the Task Force, in consultation with the Stakeholder Forum, to select priorities that the countries should pursue to exploit its specific potential for sustainable modern bioenergy systems. Priorities that are to be pursued with public financial support should be ranked for inclusion in an implementation strategy. Ranking of priorities can be done against different criteria, which must be clearly stated. Criteria could include:

- Technical merit, including technological soundness and accessibility of technology
- Financial and economic merit, including cost effectiveness, cost-benefit ratios and coherence with local and national development priorities
- Ecological soundness, including climate proofing
- Fit with ongoing programmes and institutional capacities, and
- Existence of local champions

Priority settings would then be presented by the Task Force to the larger Stakeholder Forum for review and vetting.

Defining an Implementation Strategy
Once priorities are identified, the Task Force should proceed in leading the preparation of an Implementation Strategy (Bioenergy Strategy). Although the process and detailed contents of such an implementation strategy are not part of the discussion of this Decisions Support Tool, Table 4 describes areas for policy implementation. Some of the main elements that should be contained in the implementation strategy are:

- An institutional capacity needs assessment of both local and national capacities to implement the identified priorities
- An assessment of financing options for priority investments
- A proposed new or revised regulatory framework to support implementation
- Investment formulation and costing
- An assessment of necessary support systems – both commercial (including input and output marketing, technology providers, etc.) and advisory (technical advisory services including private and public extension providers, financial advisers, business advisers, etc.)
- A monitoring and evaluation strategy (including identifying appropriate institutions and bodies to conduct and carry out monitoring and evaluation) building upon participatory monitoring and evaluation principles and experience

Table 4 – Four key areas for policy implementation

Technology	Market/ Fiscal support	Regulation	Institutions
Which technology will be preferred under what circumstances?	To which market is the product destined?	What instruments will be used to regulate? • Licensing • Certification • Mandates	What institution will house and implement the policy?
How will technology choice be supported? • Grants, research, micro credit schemes, reduced import tariffs,etc.	What support is required to ensure it reaches its intended markets? • Infrastructure, trade agreements, certification, import restrictions, etc. • Incentives Grants, taxes, subsidies, fuel charges, etc.	How to use regulation to support certain activities • Supporting certain activities with grants	What additional capacity is needed in the country to implement • Skilled biofuels experts, extension officers, regulatory bodies, etc.

A part of the implementation strategy might be drafting statements that will support the objectives. Indicative examples of implementation priority statements are outlined in Table 5.

As complex as building a bioenergy strategy seems, the efforts involved are worthwhile to realise the potential that a sustainable bioenergy system can bring. Not only does a comprehensive bioenergy strategy process facilitate improved social welfare and support economic opportunities, but it can also help protect the integrity of natural resources and ecosystem services that underpin a country's overall development.

Table 5: Examples of statements of implementation priorities

Area	**Statement**
Agriculture	Support will be given to small scale farmers to enter the bioenergy sector
Water	Water conserving practices will be promoted for bioenergy
Socio-economic	Job creation will be promoted though labor intensive bioenergy technologies
Impact assessments	Bioenergy specific issues will be incorporated into the ESIA process
Food security	Access by vulnerable populations to sufficient staple foods will be ensured by regulation and ongoing food security assessments
Soil	Conservation agriculture will be supported
Industry	Support will be given to small and medium enterprises
Land	Land reform will be prioritized

Notes

THIS REPORT

This document is an overview of what is contained in a UN-Energy publication entitled "Sustainable Bioenergy Decision Support Tool (DST)". Targeted to decision makers to assist them in developing robust bioenergy policy and strategy, it summarises key issues and approaches to provide an entry point to the full material collection, which provides further detail, includes case studies, a set of guiding questions and reference to existing tools.

The full document is available through an interactive website.

This document complements an earlier UN Energy publication Sustainable Bioenergy: A Framework for Decision Makers (2007), which outlines the key sustainability challenges and development opportunities for bioenergy in developing countries. It does not re-visit a discussion of all sustainability challenges but only provides further detail where appropriate and where additional information has come to the fore since the publication of the Framework.

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