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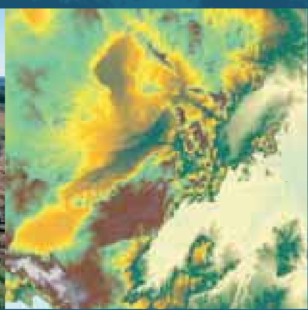
16

Bioenergy and Food Security

The BEFS Analytical Framework



ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT SERIES

ENVIRONMENT CLIMATE CHANGE [BIOENERGY] MONITORING AND ASSESSMENT

BEFS

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ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT SERIES

ENVIRONMENT CLIMATE CHANGE [BIOENERGY] MONITORING AND ASSESSMENT

Bioenergy and Food Security

The BEFS Analytical Framework

BEFS

The Bioenergy and Food Security Project
Food and Agriculture Organization of the United Nations, Rome 2010

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FOREWORD

Recent years have witnessed a renewed interest in bioenergy both within the developed and the developing world. Bioenergy, and particularly liquid biofuels, have been promoted as a means to enhance energy independence, promote rural development and reduce greenhouse-gas emissions. Compared to other sources of energy, bioenergy potentially offers poor countries many advantages if properly managed. However, bioenergy developments have also been a cause for deep concern regarding their economic, social and environmental viability, because of their potential negative impacts on food security through crowding out of staple food production and on the environment due to natural resource scarcity and intensive agriculture production. While there has been a rush by many governments to develop bioenergy alternatives to fossil fuels this has often been done in the absence of a wider understanding of the full costs and benefits of bioenergy. In this context, the Food and Agricultural Organization of the United Nations (FAO) with generous funding from the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) set up the Bioenergy and Food Security (BEFS) project to assess if and how bioenergy developments could be implemented without hindering food security.

The BEFS project sought to approach the problem of food security in an integrative and comprehensive manner. The project inherently understood that promoting food security through bioenergy or indeed any other instrument could not be done in a one-dimensional way. Rather, it required balancing the many issues that have an effect on bioenergy and food security and considering them jointly to arrive at a set of considerations that better reflected reality and could support policy in a more meaningful way.

The project developed an analytical framework that is published in the present document. The BEFS Analytical Framework offers the tools to assist policy makers in making informed decisions on the basis of clear information concerning the many varied consequences of bioenergy developments on food security, poverty reduction and agriculture development and economic growth. This analytical framework has been implemented in Peru, Tanzania and Thailand/Cambodia. The results of the country implementations are published in the FAO Environment and Natural Resources Management working paper series.

The BEFS Analytical Framework with its tool box is now available for use by other countries to support considering food security within the context of bioenergy.

Heiner Thofern
Senior Natural Resources Management Officer
BEFS Project Coordinator

ABSTRACT

A potent argument for bioenergy development lies in the ability of the sector to unlock agricultural potential by bringing in much needed investments to raise agricultural productivity to spur food security and poverty reduction. This document presents the BEFS Analytical Framework (AF) developed to test this argument. Agriculture lies at the heart of the BEFS AF and allows governments to consider viable pro-poor strategies for bioenergy development. The set of tools within the BEFS AF offers an integrated approach to decision-making that combines the technical viability with the country's prevailing social and economic development objectives.

This document explains the rationale and structure of the BEFS AF, provides a general overview of the tools and their application, and illustrates how the analytical information generated assists policy makers in making informed decisions concerning the many varied consequences of bioenergy developments on food security, poverty reduction and agriculture development and economic growth.

Bioenergy and Food Security: The BEFS Analytical Framework

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The various parts and chapters of this document drew upon country work and references listed in the respective parts and chapters.

Part I "The BEFS Analytical Framework" was prepared by Yasmeen Khwaja.

The Part II technical chapters were prepared by the following authors:

- BEFS (NRC) and COSIMO (EST) teams: chapter 7 "Diagnostic Analysis: Agricultural Outlook";
- Mirella Salvatore (NRC): chapter 8 "Natural resources analysis: Land Assessment";
- Erika Felix (NRC): chapter 9 "Natural resources analysis: Water Resource Management"; chapter 10 "Natural resource analysis: Woody biomass and residues"; chapter 11 "Techno-economic and environmental analysis: biofuel production costs"; chapter 12 "Techno-economic and environmental analysis: Greenhouse gas emissions";
- James Thurlow of the International Food Policy Research Institute (IFPRI): chapter 13 "Socio-Economic Analysis: Economy-wide impacts";
- Irini Maltsoglou (NRC): chapter 14 "Socio-Economic Analysis: Household food security and vulnerability".

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CONTENTS

DEFINITIONS[1]

Agricultural by-products represent biomass by-products originating from production, harvesting and processing in farm areas.

Agrofuels are biofuels obtained as a product of energy crops and/or agricultural (including animal) and agro-industrial by-products (see definitions below) (FAO, 2004).

Agro-industrial by-products represent several kinds of biomass materials produced chiefly in food and fibre processing industries.

Animal by-products are agricultural by-products originating from livestock keeping. It includes among others solid excreta of animals.

Bioenergy is energy produced from biofuels. It comprises electricity, heat and a wide range of transportation fuel.

Biofuel is energy produced directly or indirectly from biomass. Biofuels can include for example, liquid biofuels i.e. fuel derived from biomass for transportation uses, gaseous biofuels such as methane gas, and solid biofuels like fuelwood, charcoal etc.

Biofuels from municipal waste include municipal solid waste incinerated to produce heat and/or power, and biogas from the anaerobic fermentation of both solid and liquid municipal wastes (FAO, 2004).

Biomass is material of biological origin excluding material embedded in geological formations and transformed to fossil. Sources of biomass include energy crops, agricultural and forestry wastes and by-products, manure or microbial biomass.

Biomass streams are biomass products that can be used to produce bioenergy. Some examples are leaves, residues, cutover residues, sawdust, bark, chip, and corn husks among others.

Biomass supply chain is an integrated approach to describe the entire bioenergy production system. The supply chain incorporates all of the required production processes that are critical to the production of the end energy carrier. The starting point in a biomass supply chain is the production of biomass feedstock. This is typically followed by the industrial conversion of the biomass to energy, an energy carrier that is then used to generate energy.

Energy carrier is a substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes. To create an energy carrier

1 Bioenergy related definitions are extracted from the Unified Bioenergy Terminology of FAO (2004).

from an energy source a conversion process must occur. Typical energy carriers include electricity, gasoline, heating oil, diesel, ethanol, biogas, biodiesel, propane, and methane.

Food security exists when all people, at all times, have physical, social and economic access to sufficient amounts of safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. There are four dimensions to food security as it relates to bioenergy: availability, access, stability and utilization.

Net food producer is someone for whom total sales of food to the market exceed total purchase of food from the market.

Net food consumer is someone for whom total sales of food to the market is less than the purchases of food from the market.

Woodfuels are all types of biofuels originating directly or indirectly from trees, bushes and shrubs (i.e. woody biomass) grown on forest and non-forest lands[2] (FAO, 2004).

2 For the purpose of this project, "traditional" (unsustainable) fuelwood and charcoal production will not be considered.

PART ONE
THE BEFS ANALYTICAL FRAMEWORK

CHAPTER 1

INTRODUCTION

Recent years have witnessed a renewed interest in bioenergy both within the developed and the developing world. Bioenergy, and particularly liquid biofuels, have been promoted as a means to enhance energy independence, promote rural development and reduce greenhouse gas emissions.

Bioenergy potentially offers poor countries many advantages. Firstly, bioenergy developments offer the opportunity for enhanced energy security and access by reducing the dependence on fossil fuels and providing a localized solution. Increased energy security in turn can have positive effects on food security. Secondly, a bioenergy sector can create a new market for producers as well as offer new forms of employment that will positively affect agricultural and rural incomes, poverty reduction and economic growth. Thirdly, bioenergy has the potential to contribute to environmental objectives including the reduction of greenhouse gas emissions. Not surprisingly, bioenergy has been placed high on the policy agenda of developing countries.

However, recently bioenergy developments have also become a cause for deep concern. The reason for this lies with their actual social, economic, and environmental viability due to the potential negative impacts on food security and on the environment caused by food production and natural resource competition and intensive agriculture production.

For the first time since 1970, the number of hungry people has been increasing climing over the one billion of hungry and undernourished people as stated in the FAO report *The State of Food Insecurity in the World* 2009. Two main factors explain the increase in food insecurity. First, 2005-2008 witnessed the first major global food crisis in 30 years which saw the prices of basic staples increase several fold. While prices have fallen since their peak in 2008, they remain at a historical high and subject to ongoing volatility. Second, the financial crisis in 2009 meant that developed countries cut back significantly on development assistance, with implications for food security in particularly vulnerable countries. In this context, bioenergy has been recognized, although to a varying degree, as one of the additional pressures on agriculture production and since the 2008 food crisis, serious concerns have been raised as to the extent of opportunities afforded by bioenergy because of the competition the sector creates for resources used for food production and environmental preservation. Moreover, bioenergy developments expose countries to new sets of risks related to the industry that derive from domestic changes in natural resource use as well as international changes in bioenergy policy, both of which could affect food security.

These crises have made governments understand more firmly the very essential role played by agriculture in supporting the food and livelihood needs of the poor. This has been accompanied by a clearer understanding that the agricultural sector in a large number of developing countries requires a new "revolution" to regenerate the sector in a *sustainable* way.

Initially the rush to develop bioenergy has tended to take place in the absence of a wider understanding of the full costs, benefits and impacts of bioenergy. The question now faced by governments is whether the investments brought in by bioenergy can be channelled to ensure that bioenergy developments are viable and sustainable and that ultimately they become a vehicle for much needed agriculture growth, food production enhancement, rural development and poverty reduction.

The BEFS analysis demonstrates that the impacts of bioenergy, and more specifically biofuels, on food prices, economic growth, energy security, deforestation, land use and climate change vary by feedstock, by the method and location of production, and centrally hinge on the management of the sector. This illustrates that it is difficult to draw *general* conclusions about the net impacts of bioenergy for countries, particular groups and households. Sustainable biofuel development relies on accurate management of the sector and of the trade-offs that may arise from the development. Consequently, sound bioenergy policy development needs to be the outcome of a context or country specific analysis of the net costs and benefits.

In order to assist governments in this and in developing a broader understanding of the issues at stake, the Bioenergy and Food Security (BEFS) project developed the Bioenergy and Food Security Analytical Framework (BEFS AF). While there are a number of issues that surround bioenergy, the central focus of the BEFS AF is to examine how bioenergy development can be implemented without hindering, and potentially enhancing, food security.

In this context,

1. **The BEFS Analytical Framework** (BEFS AF) identifies four areas of analysis required to examine the relationship between bioenergy and food security;

2. **The BEFS tool box** comprises the analytical tools needed within the four analytical areas supporting the understanding of the dynamics of the bioenergy and food security interface through a quantitative analysis.

The BEFS AF and its tool box provide the means for examining the many varied consequences of bioenergy developments on food security, poverty reduction and rural development in specific country contexts. The information generated by the tools is key in providing information to policy makers to ensure that bioenergy policy development is evidence based and in line with the above.

The main endeavour throughout the analysis in BEFS is to identify a management system that is smallholder inclusive, food secure, and vulnerability safeguarding in order to ensure that countries reap the benefits of bioenergy developments but manage and are aware of the risks involved.

The BEFS AF was implemented in Peru, Tanzania and Thailand and supported biofuel policy formulation and implementation in these countries. The BEFS tool box is available for use by other countries in considering food security within the context of bioenergy.

The document is divided into two main parts. Part I presents the structure of the BEFS AF and the underlying rationale. Part II provides an overview of all the tools that support the BEFS AF.

CHAPTER 2

THE BEFS ANALYTICAL FRAMEWORK

2.1 BIOENERGY AND FOOD SECURITY: DEFINITIONS AND LINKAGES

FAO defines bioenergy[1] as energy derived from biofuels (solid, liquid fuels and gaseous fuels). It can come from a variety of sources, including crops like sugar cane and beet, corn and energy grass or from fuel wood, agricultural wastes and by-products, forestry residues, livestock manure and other sources.

The definition of Food Security and its dimensions are listed in Box 1. Food security is usually analysed in terms of its four dimensions: availability, access, stability and utilization. While these dimensions are linked, specific factors can drive the availability of and access to food. These factors then determine the stability in access to food and the way food is utilized for human health benefits. The BEFS AF has focused on the availability and access dimensions of food security[2] but acknowledges the importance of the other two food security dimensions.

BOX 1

DEFINITION OF FOOD SECURITY

"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". (World Food Summit, FAO, Rome 1996)

Food Security has four dimensions:

Food availability: The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).

Food access: Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources).

1 Further background information can be found in Annex 1.

2 A background note on this is contained in Annex 2.

Utilization: Utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security.

Stability: To be food secure, a population, household or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security.

The starting point of the BEFS AF considers the balance between the natural resource base and food security. Three-quarters of poor people in developing countries live in rural areas and rely on agriculture for their livelihoods and food security. More specifically, the poor are heavily dependent on the natural resources used to support the agricultural sector. High levels of poverty and food insecurity can result in natural resources being used in an unsustainable manner. Over time, this leads to a vicious circle of poverty and degradation of the natural resource base.

The evidence in developing countries clearly shows that since the mid-1970s agricultural investment as a proportion of GDP has declined. Cheap global food prices for over thirty years removed the incentives for many poor country governments to focus on agriculture, thereby compounding the vicious circle of poverty and natural resource degradation. It took the food crisis in 2008 to revive interest in agriculture, particularly for food security. However, the current state of agriculture in developing countries is not adequate to support food security.

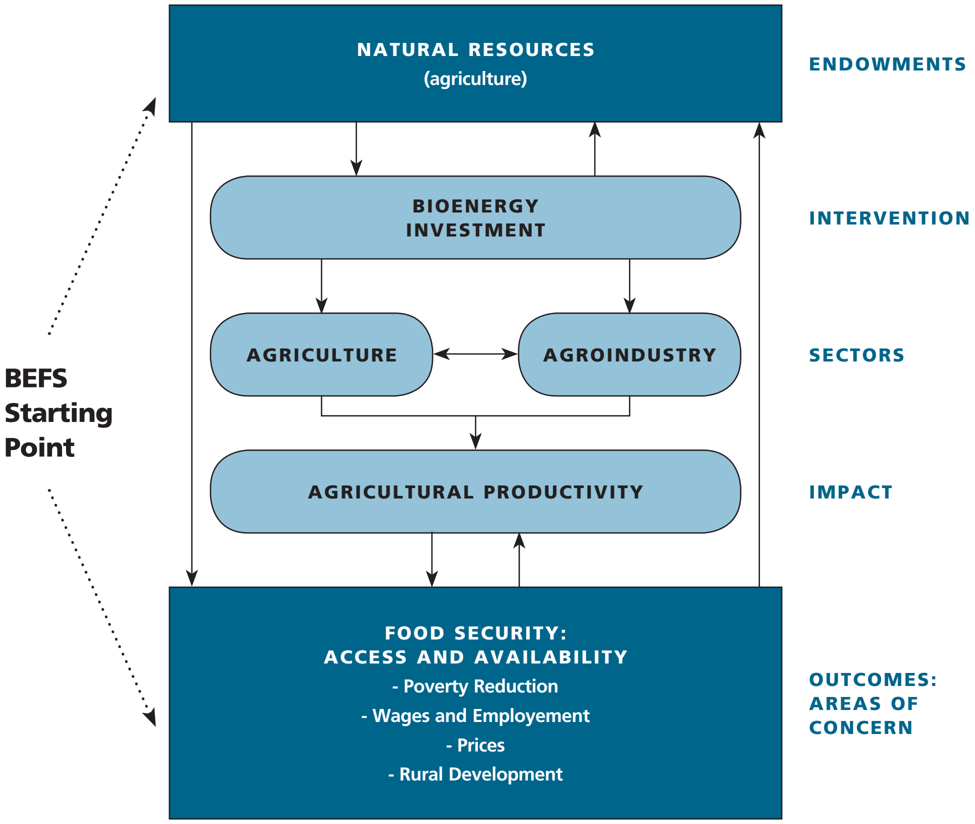
Agricultural development is critical to achieve long-term sustainable food security. The core objective of the BEFS AF is to identify to what extent bioenergy interventions can play an instrumental role in improving agricultural performance for food security. A priori, it cannot be determined whether bioenergy has a positive or a negative impact on food security. The issue is a complex one.

The BEFS AF illustrated in Figure 1 describes this complex relationship between bioenergy development and food security. The BEFS AF is not fully comprehensive in considering all the dimensions for food security and all forms of bioenergy. It has for analytical clarity confined itself to key issues surrounding food security and bioenergy.

Figure 1 shows that bioenergy interventions affect food security through two principal channels. First, they compete for many of the same natural resources used to support food production. Second, the structure of bioenergy interventions can have an impact on agricultural productivity and affect food security outcomes. Each of these channels is considered separately in sections 2.2 and 2.3.

Figure 1

The BEFS Analytical Framework



2.2 Bioenergy, Natural Resources and Food Security

Bioenergy interventions, through their effects on the use of natural and agricultural resources, affect food security in a number of ways. Environmental constraints already limit the biophysical and technical production of food crops in many poor countries. Bioenergy developments can put additional pressure on the use of natural resources and could compete with food production.

The main issues for food security may arise from the following:

- **Land displacement and degradation**
  Bioenergy could displace food production in the use of land. Any reductions in food output could be accompanied by higher prices for staple food crops. Shortfalls in domestic production could require increases in food imports, with implications for the public purse. Where bioenergy feedstocks are grown to service an export market, pressures may increase on small farmers to sell their lands. Bioenergy feedstock production tends to be resource-intensive, which could affect long-term soil quality and therefore land productivity. Different crops and methods of production affect

land quality in the long term. In order to maintain its output levels, the bioenergy industry might have to further increase its use of land at the expense of agricultural land used for food. If land displacement occurs, food producers may have to move to new lands where soil quality may be lower. This can be the case where land previously used for livestock grazing is brought under crop production, since grazing may negatively affect soil quality.

- **Water resource management**
  Agriculture already uses more than 50 percent of all available water in many developing countries. Many poor regions of the world are water scarce and climate change may worsen the situation. Bioenergy interventions compete for the same water resources used for agriculture. Depending on the bioenergy feedstock, water demand by the sector can be very high further depleting water stocks. If a system of water pricing is put in place that reflects water scarcity, small farmers could be priced out. The bioenergy industry is likely to be developed under an intensive system of agricultural management, with widespread use of agrochemicals and fertilizers to boost yields. Excessive use of these inputs reduces water quality. This affects food security through reduced agricultural productivity and adverse health effects associated with clean drinking water and sanitation.

2.3 Bioenergy, Agricultural Productivity and Food Security

The second channel through which bioenergy interventions affect food security occurs through the impacts on the agricultural and agro-industrial sectors. Agricultural production of bioenergy feedstock constitutes an input into the agro-industrial sector. In turn, the agro-industrial sector driven by a profit-maximizing motive will exert strong influence on the way the agricultural sector is organised for bioenergy. This involves both the crop choice, the type of agricultural management system and the scale of operation used for production. Private investors could favour large scale production because they entail lower production costs.

Meeting the requirements of a bioenergy agro-industrial sector in developing countries necessarily involves increasing production and productivity within agriculture, if bioenergy is to be a serious alternative to fossil fuels. Increased agricultural productivity may positively affect poverty reduction and food security either because small and poorer farmers are able to benefit from productivity gains improving their incomes, and/or because agricultural productivity may increase food productivity, reducing food prices. Strong arguments exist for the role bioenergy interventions may play in enhancing agricultural productivity but without careful management of the sector the poor may be bypassed in accessing any benefits. There is concern that productivity gains may accrue only to large scale farmers with very little trickle down effects on small and poor farmers. Second, increased agricultural productivity may actually be associated with increased food prices, if feedstock production competes with food production.

The case to support the development role of bioenergy needs to be validated with careful analysis. The food security dimensions of access and availability are driven by a number of factors relating to prices, employment and incomes, rural development, and poverty reduction in general. Bioenergy interventions in principle could have an ambiguous impact on each one of these factors, as discussed below:

- **Incomes and prices.**
  Bioenergy can impact on food security through changes in incomes and food prices. Income is an important element in the food security status of the poor. Income influences both the quantity and quality of food purchased by households. The exact effects of food prices on food security are more complex and require an understanding of whether households are net food producers and net food consumers. In general, higher food prices hurt net food consumers but farmers who are net food producers are likely to benefit from higher prices and increase their incomes, other things being equal. Some people will find they are better off while others are worse off.

- **Employment.**
  Bioenergy investment can create new forms of employment. Opportunities could arise in the areas of biofuel production, processing, transportation, trade and distribution. There could be positive employment spillovers both geographically and in related sectors. According to some estimates, the potential for job creation in bioenergy is higher than for other renewable energy sources, and entails lower investment costs per unit of job generated.

- **Rural development.**
  The provision of power generated from biomass sources can contribute to rural development by improving the energy of rural communities that previously may have had inadequate access to electricity. Improved energy access can enhance agricultural productivity, food preparation and education, all of which have direct consequences for food security. However, the success of bioenergy developments very much depends on what happens to prices in the long term in fossil fuel markets. A permanent fall in oil prices, for example, would render the biofuel sector uncompetitive.

CHAPTER 3

THE BEFS ANALYTICAL COMPONENTS AND TOOLS

The impacts of bioenergy interventions are not always clear. In order to influence food security outcomes positively, it is important to consider the relationships between natural resources, bioenergy interventions and food security. Consequently, the BEFS approach identifies four key areas of analysis necessary to examine how food security outcomes are affected. These are

(i) Diagnostic analysis
(ii) Natural resources analysis
(iii) Techno-economic and environmental analysis
(iv) Socio-economic analysis

A set of tools were developed to identify the key issues affecting food security, poverty and rural development within each area of analysis called the BEFS tool box. The diagram in Figure 2 illustrates how the tools developed support the BEFS AF and the instruments are listed in Table 1 below.

Table 1

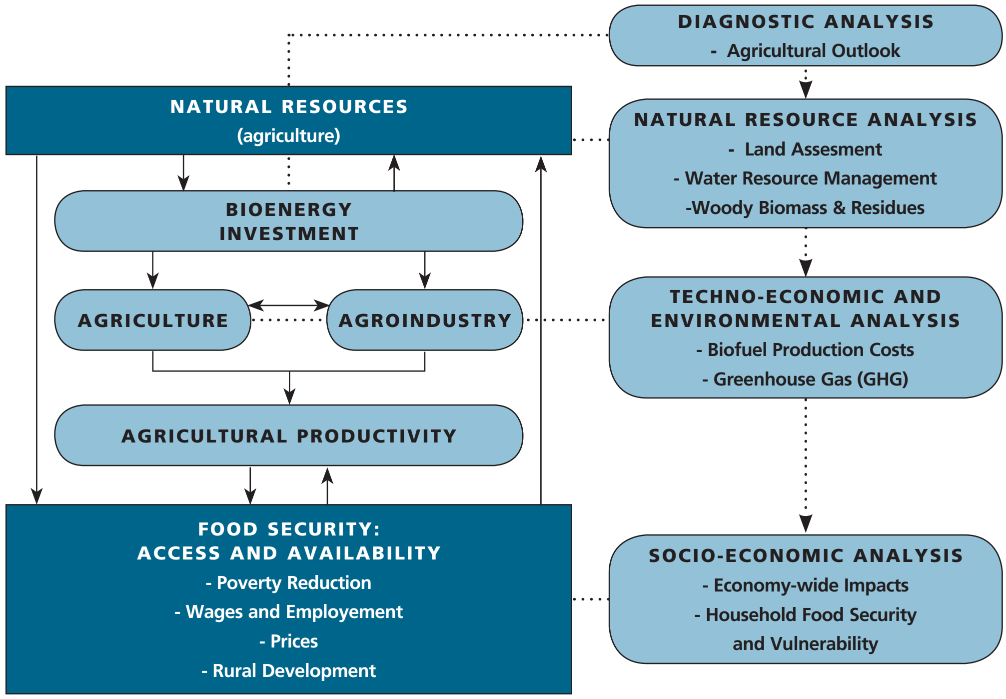
The BEFS AF: Areas of analysis and relative analytical components

AREA OF ANALYSIS	TOOL
Diagnostic	Agricultural outlook
Natural resource	Land assessment
	Water resource management
	Woody biomass and residues
Techno-economic and environmental	Biofuel production costs
	Greenhouse gas emissions
Socio economic analysis	Economy wide impacts
	Household food security and vulnerability

The BEFS tool box considered a number of instruments to understand the critical interactions and trade-offs between food security, natural resource use for bioenergy, and the structure of the bioenergy industry.

Figure 2

Supporting the BEFS AF through the BEFS tool box.



Each of these tools was identified as being important for supporting bioenergy policy in Peru, Tanzania and Thailand- the BEFS project countries.

3.1 Diagnostic Analysis: Agricultural Outlook

The agricultural outlook component uses the OECD-FAO Agricultural Outlook to develop projections for production, utilization (i.e. consumption in the form of food, feed, fuel or fibre), imports, exports, stocks and prices for the main agricultural commodities and biofuels of the countries influencing world agricultural markets. The study identifies the pressures on domestic agricultural markets over time with respect to a set of macroeconomic conditions, trends and current agricultural policies employed in countries influencing world markets.

3.2 Natural Resource Analysis

3.2.1 Land Assessment

The analysis undertaken in the land assessment component identifies the suitability of a specific area of land for bioenergy crop production under a stated system of management. Land suitability is assessed considering climate, soil and site factors that can affect potential productivity. Filters are used to identify the amount of suitable land that is available for bioenergy feedstock production by excluding areas already under agricultural production for food crops or areas that are designated protected regions such as forests.

3.2.2 Water Resource Management

The AF considers two water analysis tools to evaluate water implications and bioenergy development.

A software tool called the Water Evaluation and Planning system (WEAP). WEAP examines the water resource and socio-economic implications of bioenergy crop expansion. This tool is used to create simulations of water demand and supply taking into consideration runoff, evapo-transpiration, reservoir operations, and other variables to examine water usage for biofuels using different feedstocks.

An additional tool to asses the implications of water resources and bioenergy is the water footprint assessment. This tool assesses how water resources are being used by various sectors in an economy and serves as a screening tool. The results generated by the analysis can then be used to identify areas i.e. "hotspots" that required a more comprehensive analysis.

3.2.3 Woody Biomass and Residues

The woody biomass and residues analysis considers how woody biomass and residues, as one component in the bioenergy portfolio, can be developed to create local energy sources for local use. The analysis uses the Woodfuel Integrated Supply/Demand Overview Mapping model (WISDOM), a spatially explicit analysis of the supply and demand of biomass and from residues derived from agricultural production and forest product industry. The results identify areas according to the balance between the supply and demand for biomass residues.

3.3 Techno-economic and Environmental Analysis

3.3.1 Biofuel Production Costs

The biofuel production cost analysis derives production cost profiles for biofuels under different industrial set-ups to examine the degree to which smallholder inclusion in the biofuel supply chain can be competitive when compared to large-scale production. The analysis is carried out for both bio ethanol and bio diesel production using different feedstocks.

3.3.2 Greenhouse Gas Emissions

This component uses a life-cycle analysis to establish a green house gas baseline for ethanol and biodiesel production from different feedstock crops. As liquid biofuels development has been promoted as a means to reduce greenhouse gas (GHG) emissions, it is important that the definition of sustainability includes the impact that possible changes in crop to crop and land-use changes may have on the overall GHG balance in the production of liquid biofuel as this may influence the climate benefit. The analysis therefore considers GHG balances under scenarios that incorporate land use change and under crop-to-crop changes.

3.4 Socio-economic Analysis

3.4.1 Economy-wide Impacts

The economy wide component of the analysis builds on the production cost scenarios constructed in the biofuel production costs component. This component is based on a Computable General Equilibrium (CGE) model and it assesses the effects of specific bioenergy developments on a number of socio-economic variables such as poverty reduction, agricultural growth, GDP growth and employment.

3.4.2 Household Food Security and Vulnerability

The household food security and vulnerability component measures the household welfare effects of increases in the price of key food staples. It is a vulnerability profiling tool that identifies which households are most susceptible to food price increases and where they are located.

Each of the tools developed under the BEFS project is discussed in more detail in Part II of this document where a generic model is presented and its application to the project countries illustrated. For a fuller examination in the precise use of the tools and how the fundamental model changes according to the country context, a country analysis is available for each of the BEFS countries and is referenced in Part II.

Not all the tools were applied in all the countries. The use of specific tools within the BEFS tool box varied across each country according to the bioenergy priority of the country. Table 1 summarizes which tools were used where.

In Tanzania, the main emphasis has been the consideration of liquid biofuels in order to promote energy security. However, there is understandable concern that biofuel development should not compromise the food security goals of the country so the BEFS tools have provided the basis for examining where the policy priorities should lie in pushing for a bioenergy industry.

Peru has already set mandates for liquid biofuels. In addition, the geographic diversity of Peru means that many people do not have access to grid electricity. Thus, finding local energy alternatives for local populations is seen as important to enhance energy security with positive implications for poverty reduction and rural development. In the case of Peru therefore, the BEFS tools have been used to guide policy implementation to support poverty and rural development goals.

Thailand has set an ambitious policy for biofuels and bioenergy in general. The energy plans of the country seek to increase biofuel provision for domestic use but also possibly for international markets. Enhancing energy security lies at the heart of bioenergy policy in Thailand but there is clear recognition that bioenergy initiatives can do much to enhance rural development. The BEFS tools have been largely used to support future policy goals related to bioenergy and rural development.

Table 2

The BEFS analytical components in Tanzania, Peru and Thailand

	TANZANIA	PERU	THAILAND
DIAGNOSTIC ANALYSIS			
Agricultural Outlook	*	*	*
NATURAL RESOURCE ANALYSIS			
Land Assessment	*	*	*
Water Resource Management		*	*
Woody Biomass Residues		*	*
TECHNO-ECONOMIC AND ENVIRONMENTAL ANALYSIS			
Biofuel Production Costs	*	*	*
Greenhouse Gas Emissions			*
SOCIO-ECONOMIC ANALYSIS			
Economy wide Impacts	*	*	*
Household Food Security and Vulnerabilitly[3]	*	*	*

3. Note that within the BEFS Thailand portfolio the household food security analysis was also conducted in Cambodia. This illustrates the use of the tool in the Asian context.

The set of tools developed for the BEFS project are not exhaustive and may not necessarily be the critical tools for other countries. The BEFS tool box is adaptable in the sense that for each of the areas of analysis identified by the BEFS AF existing tools may be modified or new tools may be added that reflect the priorities and context of specific countries. For example, environmental objectives such as biodiversity and deforestation have an impact on local livelihoods and thus food security, but this is not considered in the current BEFS analyses. However, existing tools can be modified to capture some of the effects arising from decreased biodiversity and deforestation and/or new tools can be introduced that look specifically at these dimensions.

CHAPTER 4

SUPPORTING POLICY WITH THE BEFS ANALYTICAL FRAMEWORK

The BEFS AF identifies the structure of relationships between bioenergy interventions and food security. The BEFS tool box includes a range of tools which after implementation provides an information set that can directly support the policy machinery in individual countries. The information set generated helps decision-makers in three key ways:

- **Reduces the time governments spend in their various roles as decision-maker and resource allocator when considering the direction of bioenergy developments.**

If governments can use a pre-existing framework like the BEFS AF it allows them to prepare better for the period of change induced by bioenergy developments. By understanding how each tool examines interactions between bioenergy and food security, policy-makers better understand the analytical patterns and how they link to other relationships within the BEFS AF. This helps reduce the time spent searching for solutions to specific concerns.

- **Assists governments in identifying teams of experts that have the correct abilities and skills to carry out the required analyses.**

This is especially important when a particular standard of expertise is required. The skills set needed for each analytical tool are identified within the discussion of the tools.

- **Identifies training needs.**

The BEFS AF can provide the basis for an in-country training plan.

In practice, the experience within each of the project countries has amply demonstrated that these three functions have been endorsed and accepted by relevant stakeholders. The application and use of the tools is subject to the availability of data and the right technical expertise (see Part II for full details for data and skills required to carry out a specific analysis). It is important that countries identify experts, define training needs and consider the required data sources and consider how this may affect the time frame for implementation of the tools. While the use of all the BEFS analysis permits a quantitative identification of the many relationships between natural resources and food security, individual countries may wish to focus on specific relationships. Consequently, countries may be selective in terms of the tools they use in order to reflect the policy priorities of the country.

This discussion is taken up in the policy work for all the countries and has been a theme in the policy training. Even where a country is unable to carry out the analysis, the diversity of the BEFS countries means that the analyses undertaken in one country can provide an important knowledge base for other countries in their consideration of bioenergy developments and the impacts on food security.

CHAPTER 5

THE DIRECTION OF FUTURE WORK AND THE USE OF THE BEFS AF FOR CLIMATE CHANGE ANALYSIS

The BEFS AF and its analytical components and relative tools are a flexible instrument that can be integrated with additional components as necessary. The selection of additional components will depend on the countries' development priorities and strategies and also on the context the BEFS AF may be applied in.

Currently, as discussed, the focus of the BEFS AF has been on food security and food security implications of the bioenergy developments. However, the discipline interlinkages within the BEFS AF are able to accomodate detailed work on the environmental, labour market and climate change impacts of bionergy developments. More details can be added on all of these aspects where the user can decide to detail a specific issue further and focus on that specific side of the problem. With the additions, conclusions on the theme at hand can be drawn out further. For example, the BEFS AF has the capacity to integrate additional environmental information so as to specifically evaluate the green house gas emissions reduction potential of selected biofuel supply chains. On the other hand, if the main focus were rural development and employment, more details can be added on the local use of bioenergy and on local employment implications. Again, all of the analysis has to be crop and country specific and industrial set up specific.

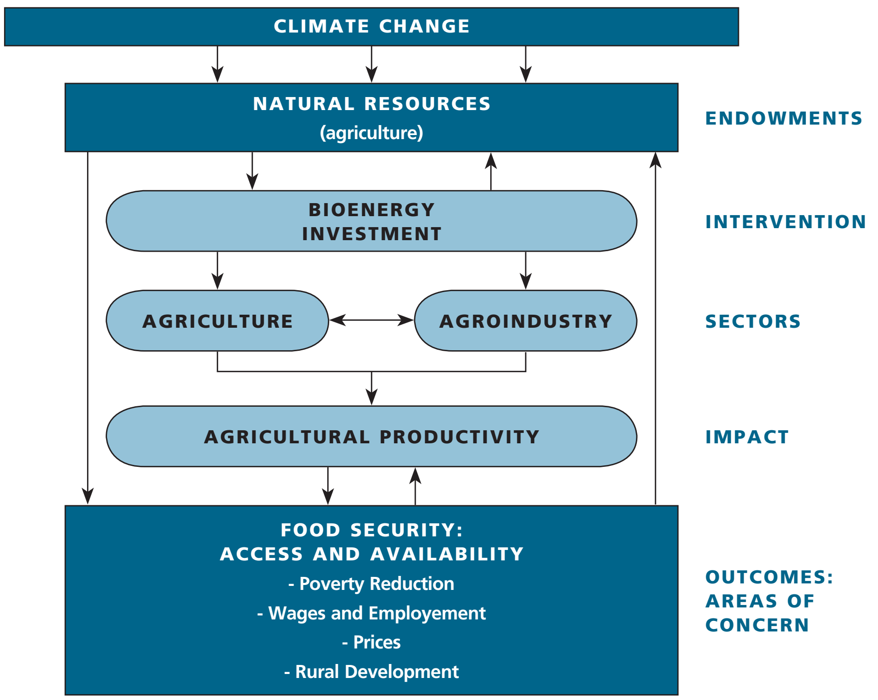
In recent years the issue of climate change has dominated the development agenda. One of the main elements of the climate change thesis rests on how it will affect the natural resource base and what this will mean for poverty and food security. Figure 3 illustrates the importance of the BEFS AF as a building block for a specific climate change analysis. The tools already developed for the bioenergy and food security nexus can be adapted to incorporate specific climate change effects.

Furthermore, within the existing BEFS AF, the core relationship of the BEFS AF is that between natural resources and food security. This is, in the current era, a fragile relationship because past climate change effects and past land use practices have affected the ability of the natural resource base to support livelihoods. Indeed, the ability to reach targets set by the Millennium Development Goals (MDGs) hinge on this very relationship. Moreover, continued poverty tends to result in the unsustainable use of natural resources which has implications for all the other MDGs.

Bioenergy is often seen as a means to offset adverse climate change effects. Incorporating bioenergy interventions within a "Climate Change BEFS AF" will permit a quantitative examination of the interactions between climate change, bioenergy and food security. Such information will be a useful aid to specific policy developments in the context of food and energy security and climate change.

Finally, the focus of analysis in the BEFS project has been on bioenergy interventions but in practice the intervention to be analyzed can be any change that affects the use of natural resources in agriculture. The BEFS AF remains central to the exploration of multiple themes. What will change is the composition of the BEFS tool box as new relationships are identified.

Figure 3
Building on the BEFS AF to examine climate change effects



In conclusions the existing BEFS AF and the underpinning tools can be customised or augmented with additional components and tools to reflect the specific priorities of individual countries.

References

FAO. 2008. *Modelling the bioenergy and food security nexus: an analytical framework,* by D. Dawe, E. Felix, I. Maltsoglou & M. Salvatore. FAO Environment and Natural Resource Management Working Paper Series. Rome.

FAO. 2010. *Bioenergy and food security, The BEFS Analysis for Peru, Supporting the policy machinery in Peru.* FAO Environment and Natural Resources Working Paper No. 40. Rome. (available also in Spanish)

FAO. 2010. *Bioenergy and Food Security – The BEFS Analysis for Tanzania.* FAO Environment and Natural Resources Working Paper No. 35. Rome.

FAO. 2010. *Bioenergy and Food Security – The BEFS analysis for Thailand.* FAO Environment and Natural Resources Working Paper No. 42. Rome.

FAO. 2010. *BEFS Thailand – Key results and policy recommendations for future bioenergy development.* FAO Environment and Natural Resources Working Paper No. 43. Rome.