1. Introduction

Energy plays a central role in the world economy and changes in energy costs have significant effects on economic growth, especially in oil importing developing countries. Currently, a major shift is underway in the sources from which energy is expected to be derived in coming years. The changes result from three primary concerns:

- high fossil fuel prices;
- perceived risks of fossil fuel dependence;
- increasing greenhouse gas emissions from fossil fuels.

Bioenergy offers the opportunity of reducing carbon dioxide emissions per unit energy production, reducing dependence on energy imports and, together with other alternative fuels, creating a cap on soaring oil prices. Depending on the effectiveness of policy and institutional frameworks, there is also an opportunity for countries to promote sustainable national and rural development through bioenergy expansion. Additionally, many countries have large forested areas, which if sustainably managed can produce large quantities of renewable fuels. A number of countries already have policies in place to encourage the use of wood for energy production.

Bioenergy is derived from a range of feedstocks and through a number of different processes. Some terms used to describe various types of bioenergy are explained in Box 1. A more complete list of definitions is provided in the Glossary. Traditionally, woodfuels, agricultural by-products and dung (referred to as "traditional biomass" in this paper) have been burned for cooking and heating purposes. Large-scale modern facilities, which convert wood and forest residues to power or both heat and power, are often constructed adjacent to wood processing facilities. This power source is considered renewable because new trees or other plants can replace those that have been converted to energy. It is important to note that bioenergy can only be considered renewable if biomass growth exceeds harvest, and carbon dioxide emitted during production, transportation and processing does not exceed that captured by the biomass that was harvested for energy.

There is great variation in the role of wood as a source of energy in different regions of the world. Many developing countries rely heavily on wood as a source of energy for heating and cooking, and wood resources are often threatened by loss of forest cover resulting from increasing population, agricultural expansion and unsustainable forest management practices. Industrialized countries and large rapidly growing developing countries consume a vast majority of the world's fossil fuels and are increasingly making use of wood energy at industrial scales. Some, but not all, have been able to stabilize or increase their forest area.

Recently, the potential of liquid biofuels to substitute for transport fuels has become a strong impetus for investment in the production of bioethanol and biodiesel

BOX 1

Bioenergy terminology

The term "bioenergy" refers to all types of energy derived from biofuels. Biofuels are fuels derived from matter of a biological origin, or biomass.

FAO categorizes biofuels according to the source of biomass used in production – forest, agriculture or municipal – and the state of the product. Thus, biofuels comprise woodfuels, agrofuels and municipal by-products and each of these groups is divided into solid, liquid and gaseous forms of fuels that can be used for heat or power generation. Taking woodfuels as an example, the following main groups are defined:

- solid woodfuels – fuelwood (wood in the rough, chips, sawdust and pellets) and charcoal;
- liquid woodfuels – black liquor (a by-product of the woodpulp industry) and ethanol, methanol and pyrolytic oil (from the thermochemical and biochemical breakdown of wood);
- gaseous woodfuels – pyrolitic gas (produced from the gasification of solid and liquid woodfuels).

The term "agrofuels" refers to biomass materials derived directly from fuel crops and agricultural, agro-industrial and animal by-products. Municipal biofuels include mostly waste products such as sewage sludge and landfill gas as well as municipal solid wastes.

In this paper, the term "biofuel" refers to all fuels of biological origin while the term "liquid biofuel" is used to denote fuels of biological origin that are liquids. This contrasts with the common use of the term biofuel in Europe to denote liquid fuels of biological origin that are used as energy sources for transport – bioethanol and biodiesel. This terminology is not followed here.

Source: FAO, 2004

from plant products. Liquid biofuels are currently manufactured predominantly from food crops including oil-palm, sugar cane, maize, rapeseed, soybeans, wheat and others. In general, first-generation bioethanol is produced from plant sugar or starch and biodiesel from plant oil. As such, the potential for competition between end uses exists, and many claims have been made that food prices have risen as a result of demand for these and other crops in energy production.

In the medium-term, it is expected that technology will become available for an economically competitive production of liquid biofuels from cellulosic material. Wood, agricultural residues and some grasses, such as *Panicum virgatum* and *Miscanthus sinensis*, are the most likely feedstocks that will be used. Because these feedstocks are not used as food sources and because they can grow in areas considered marginal for food production, increases in food prices may be less likely to result from their use.

In the near-term, there is a considerable likelihood that expansion of agricultural production for bioenergy will increase pressure on land and result in increased forest clearance. Although several current and emerging crops used for liquid biofuel production are suited to marginal lands, they often compete for land currently occupied by forest. Because forests store considerable amounts of carbon, replacement with bioenergy crops may result in a net loss of terrestrial carbon. At present, 17 percent of global carbon dioxide emissions are related to deforestation (IPCC, 2007).

As interest in bioenergy increases and possible system impacts are mapped out, a number of similar trade-offs have come to light. In recent research articles, arguments have been raised that down play the role of liquid biofuels in mitigating climate change. The key issue is the degree to which liquid biofuels actually reduce carbon dioxide emissions in comparison with fossil fuels. Because energy is used to grow, harvest, process and transport crops and biofuels, the net benefit may be small in some cases and even negative in others. Second-generation liquid biofuels do, however, offer greater potential. In contrast to current liquid-biofuel use, using wood from sustainable sources for heat and power generation, or for both heat and power production, is highly efficient both in terms of energy conversion and greenhouse gas emissions.

In coming years, global energy use is set to climb steeply and fossil fuels, despite their drawbacks, are likely to remain the most economically viable sources of energy. The extent to which energy sources are likely to change in the future depends, among other things, on energy prices and dependence on fossil fuel imports, the cost and mitigation potential of alternative energy sources and the degree of commitment to climate change mitigation. Political decisions related to agricultural and rural development subsidies will also play a very important role (Wolf, 2007). As the dynamics of energy use evolve in combination with climate change, the consequences for the world's forests will be profound. Demand for energy is clearly one of the most critical issues facing the forest sector in the twenty-first century. There are great challenges ahead. Correct policy decisions offer the opportunity to optimize economic, environmental and social benefits and to spread gains across society and over generations.