Chapter 1
Biomass from Wood in the Tropics

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1.1 Woody Biomass – An Antiquated or a Modern Source of Energy?

Bioenergy production from wood is one of the oldest forms of energy and it was for a long time considered a primitive energy source in many industrialised countries. However, it is currently experiencing an increase in attention worldwide. Considering its importance and history, it is astonishing that the widespread cognizance of wood as an important energy source in modern times is a recent phenomenon. It has been mainly driven by the pressure of diminishing fossil fuel resources in industrialised countries, as well as the wish to become more independent from nuclear power and its risks in some developed countries. In addition, amongst other renewable energy sources, bioenergy was identified as an alternative to

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fossil fuels, which could also help to prevent furthering an anthropogenic climate change by attempting to reduce greenhouse gas emissions. Currently, two different development routes are recognizable, which appear to go in opposite directions and result in competition for land resources in tropical countries. One route is driven by developing countries and the other by developed countries. Globally, wood is the most important source of renewable energy and is used to produce more energy than all other renewable energy sources combined (ren21 2013; FAO 2011). According to (FAO 2011), the global annual woodfuel consumption, which comprises fuelwood, charcoal and other wood based energy sources, sums up to 1.87 billion m^3. Of this amount, 13 % are consumed in the tropical and sub-tropical regions of America and the Caribbean region, 30 % in Africa and 30 % in Asia and the Pacific region. In total, almost three quarters of the global woodfuel consumption occur in tropical countries.

1.1.1 Wood Based Energy in the Developing Countries

The strong contribution to woodfuel consumption by tropical and subtropical countries is not surprising since they account for a majority of the two billion people worldwide who are dependent primarily on firewood for cooking and heating (Mathews et al. 2000). The correlations of population growth, wood fuel demand and deforestation are well known (Allen and Barnes 1985; Barnes 1990). As an example for this process the Southern African Development Community (SADC) region in sub-Sahara Africa should be given, where the dependency on biofuel and charcoal is bigger than in most other regions of the world (Hall et al. 1994). Figure 1.1 illustrates the correlation between population growth and deforestation in the SADC countries. SADC has one of the fastest growing populations in the world and as such faces the challenge of increasing food and fuelwood demands (Barnes 1990; Hall et al. 1994). This has inevitably resulted in large forested areas being cleared or sequentially degraded. Non-sustainable fuelwood use is the second biggest cause of deforestation in that region (FANR 2011). The relatively limited access and high cost of electricity and fossil fuels in rural areas, where over 70 % of the population reside, and in urban areas worsens the situation (FANR 2011).

Due to a lack of methodological knowledge and financial means, biomass conversion to energy in the tropics comprises mainly of low-tech fuelwood use and charcoal production. With industrial growth in many tropical countries, there is a growing movement from traditional firewood use to coal and other fossil based energy sources. This change is furthered by the fact that the natural ecosystems are often not capable of sustaining the supply of fuelwood for the growing population, and thus demand. These challenges and trends are similar to those previously experienced in developed countries during the industrialisation process two centuries ago.

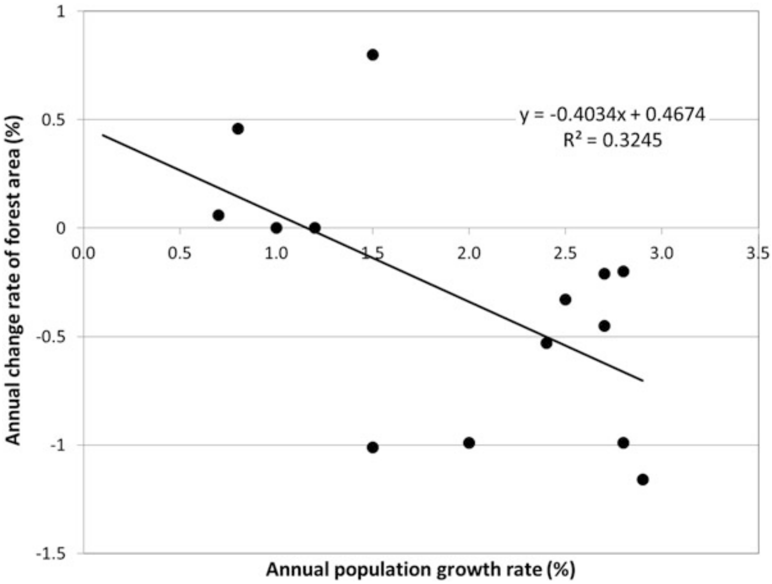

Fig. 1.1 Correlation between annual population growth rate (2010) and percentage forest loss in the SADC countries (excluding Zimbabwe) from 2005 to 2010, based on data from FAO (2010)

1.1.2 Wood Based Energy in the Industrialised Countries

Energy development in many industrialised countries shows a reverse trend, turning away from fossil fuels and nuclear power towards regenerative energy sources. International commitments towards clean development mechanisms, such as the Kyoto protocol, increasing fossil prices due to a dwindling supply, and the general aversion to nuclear energy in many developed countries, lead to a dynamic development of alternative energy sources in the past two decades. The European Union, which may serve here as an example for the industrialised nations, has defined the goal to increase renewable energy in their energy portfolio from the current value for the year 2011 of 13 % (Eurostat 2013) to 20 % in the year 2020 and is planning to move beyond that mark (European Commission 2010). About 70 % of the current European renewable energy production was from biomass in 2011 and about 70 % of that biomass was based on wood and wood residues (Eurostat 2013). In the last decade the amount of wood based biomass used for energy has increased by more than 50 % (Fig. 1.2). In the same time frame (2002–2011), net imports of biofuels have increased by a factor of ten, indicating that the import of solid and liquid biofuel is part of the strategy to transform the energy portfolio in the European Union. Due to restricted access to land and high production costs, industrialised

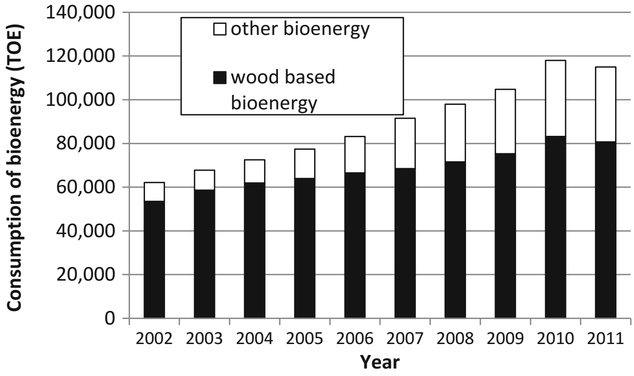

Fig. 1.2 Consumption of bioenergy and wood based bioenergy in the EU countries (EU27), measured in Thousand Oil Equivalents (TOE)

nations increasingly try to source their biofuels from tropical countries, preferably in the form of easily transportable fuels such as oils, fatty acid distillates, bioethanol or solid pellets, all of which can facilitate co-firing in power plants or be blended in fuel for motor vehicles.

However, to embark on commercial bioenergy projects for the mitigation of climate change might be a two-edged sword. Non sustainable practice, in particular with palm oil production, have raised concerns about the suitability of biofuel production for mitigating climate change since it may degrade existing natural resources and may further increase climate change due to deforestation and the deterioration of natural ecosystems, especially in tropical countries (Wicke et al. 2008; Butler et al. 2009). Many of these concerns are valid, particularly in the tropics, where conversion from one land-use to another is quite common, where it is often loosely regulated and controlled and land tenure is frequently unsolved. Conversely, if bioenergy is produced sustainably, it offers the potential to provide an energy resource, sequester carbon and at the same time alleviate poverty in many developing countries in the tropics. In this context it is important to see both aspects of current bioenergy use. The traditional low-tech fuelwood aspect for everyday cooking and heating that is prevalent in most developing countries, and the high-tech approach of many industrialised countries, which will also be realised mainly in the developing countries of the tropical and sub-tropical areas. Some tropical and sub-tropical countries have embarked on commercial bioenergy production, driven partly by local demands and by the increasing resource needs of the industrial countries of the Northern Hemisphere (Mathews et al. 2000; Wright 2006).

1.2 The Key Concept of Sustainable Production of Bioenergy

Sustainability of bioenergy production from wood in the tropics is mainly endangered by the 'gold-rush fever' phenomenon on the bioenergy market, which sometimes fosters developing projects in tropical countries, without a clear concept of sustainable resource supply. This applies to both traditional and commercial bioenergy production. Tropical countries face the challenge of designing holistic concepts for a sustainable implementation of bioenergy use that is adapted to local conditions. These concepts must embrace all three aspects of sustainability and carefully balance bioenergy production with all other socio-economic and ecologic demands (Fig. 1.3).

It entails that all levels of sustainability have to be met, starting with sustained economic feasibility, long-term beneficial impact on society and the avoidance of negative impacts on the environment. This challenge is best met with an integrated land-use management system, where different land-use forms and eco-system services such as food-production, fibre production, biodiversity conservation, water provision, job creation and biomass production are balanced (Fig. 1.4). A bias of land-use towards a singular objective of biomass production does not meet the sustainability criteria. Unfortunately, decision making support tools to balance land-use portfolios are rare and still have to be developed or adapted to tropical conditions (Fürst et al. 2013; Seifert et al. in press).

Frequently, basic knowledge on the implementation of sustainable systems for biomass production and conversion to energy is also not readily available in many tropical and sub-tropical countries. The vast majority of the current literature on biomass production originates from countries in the temperate and boreal zone of the Northern Hemisphere and due to differences in climate zones; it may not be directly applicable to countries in the tropics and sub-tropics.

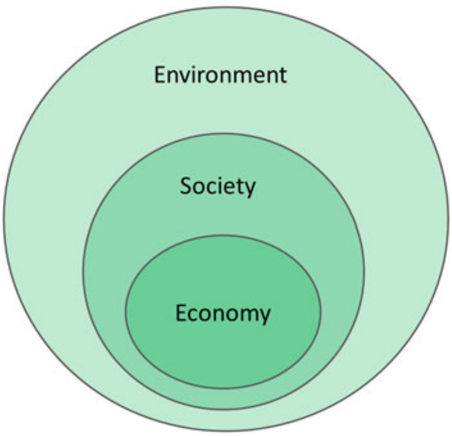

Fig. 1.3 The three spheres of sustainability

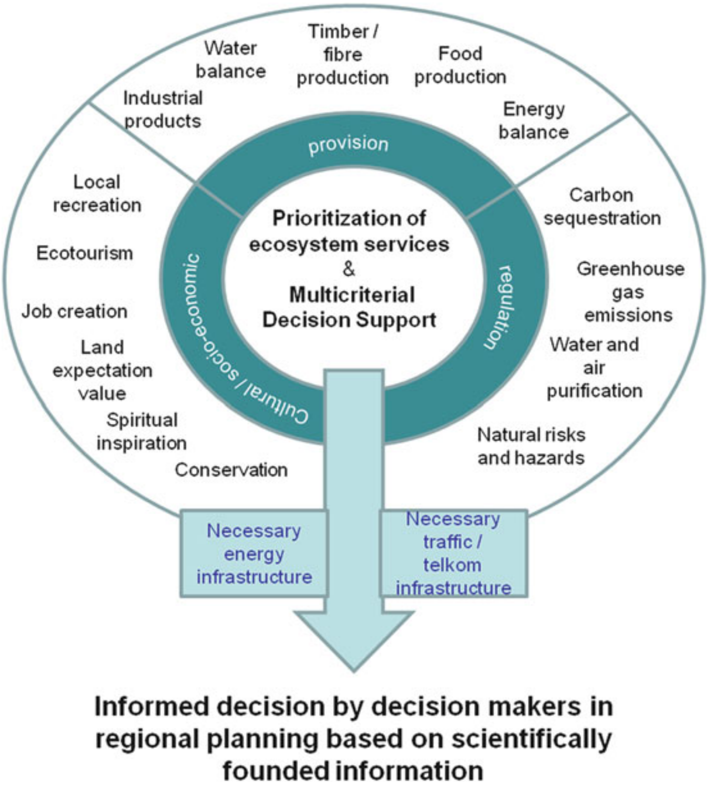

Fig. 1.4 Balancing different ecosystem services, and bioenergy production as one of them, is the major challenge for a sustainable land-use management

1.3 Managing the Value Chains

A supply chain management approach is applicable to biomass to bioenergy conversion processes. The value chain approach allows sustainable linkages between individual solutions in the value chain such as the availability of resources in time and space and transport and conversion techniques to a sustainable concept (Fig. 1.5). As a result the value chain approach provides the basis for the comprehensive analysis of the economic and ecologic consequences of bioenergy production from wood.

The value chain illustrated in Fig. 1.5 shows the bioenergy concept of supply chain management. In this case the chain is initiated with the assessment of the current and future availability of a resource. It goes on to include sound sustainable resource management to maintain production, harvesting and logistics planning and ends with characterisation of biomass and processing. Undelaying the value chain are aspects concerning economic sustainability, socio-economic considerations and environmental impact assessments at both local and global levels (Fig. 1.6).

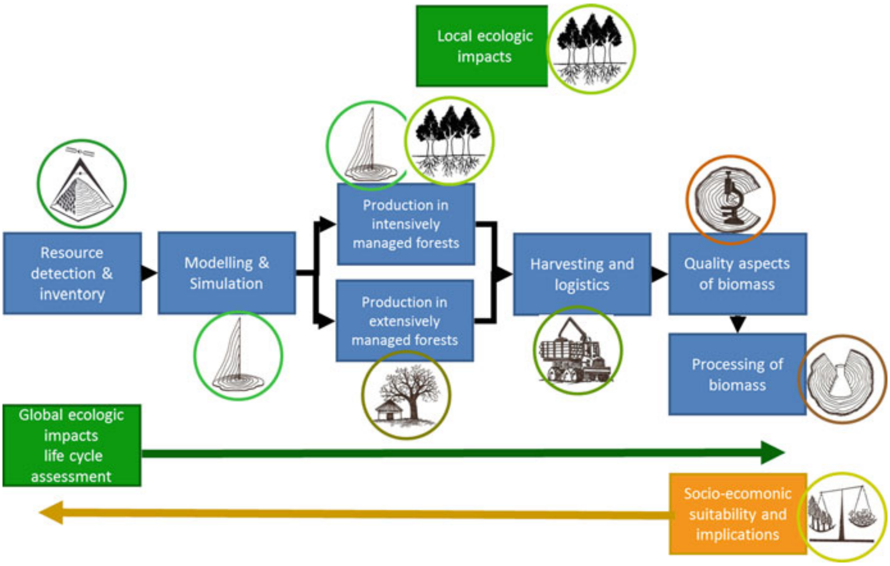

Fig. 1.5 Value chain approach for sustainable biomass production systems

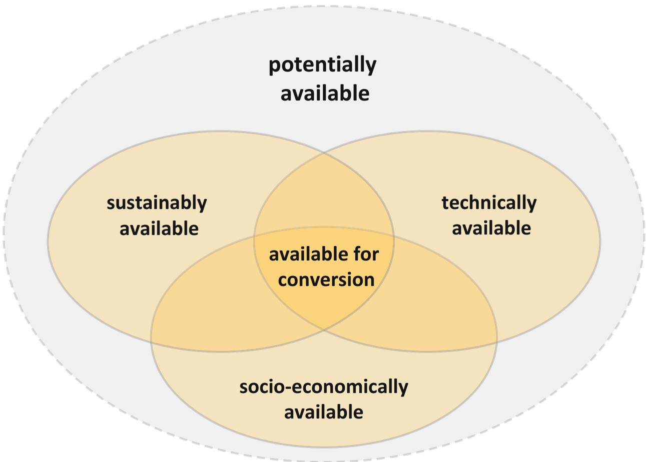

Fig. 1.6 Different constraints for the availability of biomass

In cases where the total supply chain is not taken into account with its technical, environmental and socio-economic constraints in the planning of bioenergy projects the available resource is frequently overestimated. Another challenge to the system is the choice of the conversion processes to match the biomass supply in particular to ensure efficient utilisation of biomass for an end-purpose in mind. Most conversion plants entail large capital investment and stationary biomass is sensitive to transport costs. As such spatial resource localisation planning is a priority at the entry point to any bioenergy project to ensure sustained fuel supply.

The choice of the best method to convert the available biomass and the scale of the operation are often decisive for the success of a project and depend on available biomass. This biomass may be different from region to region as regards quantity and quality. In addition forest based biomass may only be one part of a larger initiative to feed a bioenergy plant. On the other hand the scale of the biomass processing plant is also relevant and must be matched to the potentially available biomass. Another factor to take into account is current and future market segmentation. This concerns more traditional markets for biomass in terms of pulp and paper or particle board, which may inhibit local wood markets.

Ensuring sustainable use of woody biomass for bioenergy strongly relies on a value-chain approach to supply solutions. It is clear from the above that any bioenergy project must involve a multidisciplinary approach from remote sensing and growth and yield modelling to ascertain the extent of the resource; silviculture in terms of biological production; forest engineering and logistics to make the biomass in question available and delivered; environmental aspects and maintenance of biodiversity; socio-economics to consider communities and the financial viability and process engineering for the development of the envisaged products, and finally all relevant step analysed through a life cycle assessment of the system.

1.4 The Scope and Structure of This Book

This book is intended to close the short comings highlighted above. It is fully embracing the value-chain approach for sustainable production of bioenergy from wood. Furthermore it is meant to address all relevant aspects of biomass production and conversion along the production chain, with a particular focus on tropical and sub-tropical countries of the Southern Hemisphere.

The authors admit to bias towards Southern Africa, from where most of the case studies were taken but assume that the examples can be applicable to many other countries in the tropical and sub-tropical zone and in the Southern Hemisphere. The intention of this book is to present the state of the art in bioenergy production from a technical perspective, domestic and global consequences for the environment, economic feasibility and the socio-economic implications. All of these points address typical challenges of a bioenergy production system in tropical countries, considering both intensively managed plantation forestry and small growers and community forests.

This approach addresses all essential aspects of the value added chain of bioenergy production. The book is written for scientists that are involved or want to become involved with research on bioenergy as well as for forest practitioners and forest managers who are looking for an up to date compendium on the topic.

The book may also serve as a concise introduction into bioenergy production for stakeholders and decision makers that have to create the framework for sustainable production of bioenergy from forests and woodlands.

Chapter 2 introduces biomass inventory concepts for the localisation of woody biomass using terrestrial and remote sensing techniques. It is closely aligned to Chap. 3 which is dedicated to modelling and simulation of biomass. In Chaps. 4 and 5 silvicultural management aspects of biomass production for bioenergy in natural woodlands and commercial plantations are discussed. Chapter 6 introduces relevant topics of biomass harvesting, transport and logistics and provides the interface between biological production and biomass processing. The latter is dealt with in Chap. 7, and provides an overview on conversion techniques for woody biomass and their application range. Chapter 8 provides the reader with information on biomass quality testing, which is a prerequisite for establishing optimum conversion techniques. In Chap. 9 an analysis of socio-economic impacts of biomass production is presented, and provides the linkage to society as a major stakeholder when it comes to the implementation of bioenergy value chains. Chapter 10 introduces constraints to the implementation of biomass production systems resulting from potential impacts on water, soil fertility and biodiversity. Chapter 11 finally provides an overview on more global impacts of bioenergy production with a life cycle assessment based on a case study.

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