Environmental Viewpoint of Fuelwood Management

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Abstract. The introduction of fuelwood production into the regional patterns of energy production and consumption is controversial and imperative. Subsequently, the global policies upon sustainable use of fuelwood necessitate an integrated and systematic coordination upon environmental and anthropogenic issues. This study provides a literature overview upon the environmental perspectives of forestry management, while focusing on an overview upon the environmental features of a contemporary fuelwood market. Conclusively, the study reiterates the determining issues of foodwood management, signifying those issues that determine the environmental perspective of a contemporary fuelwood market.

Keywords: environmental sustainability; forest protection; forestry management; fuelwood prosperity; renewables.

1 Introduction

Nowadays, there exists a large-scale utilization of land and water resources that intensifies the local environments threatening. Particularly, 30% of the earth's land is used for crops and pastures, and 70% of all abstracted freshwater is directed towards irrigation, aiming to produce a stable food supply for people and livestock. In parallel, excessive and indiscriminate use of fertilizers –mainly derivatives of phosphorous and nitrogen and other chemicals in agriculture– are burdening the pollution of air, water, and soils, putting at risk both pristine terrestrial and marine ecosystems downstream, as well as human health (Food and Agriculture Organization of the United Nations, 2013).

A literature overview within the last three decades of analysis revealed that Asian countries are among the most well-investigated regions upon the issues of fuelwood

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Proceedings of the 7th International Conference on Information and Communication Technologies in Agriculture, Food and Environment (HAICTA 2015), Kavala, Greece, 17-20 September, 2015.

policies (Gazull and Gautier, 2015), fuelwood exploitation for heating purposes – mainly in third world (Zafeiriou et.al., 2011; Arabatzis et.al., 2012; Arabatzis and Malesios, 2013; Arabatzis et.al., 2013), endemic and exotic forestry species taxonomy/characteristics/chemical composition, as well as wood biomass yields, in the main socio-economic conditions (Specht et.al., 2015) and environmental perspectives (He et.al., 2009; Wang et.al., 2012). Moreover, there are abundant studies regarding the India context (Goel and Behl, 1996; Goel and Behl, 1995; Dunkerley et.al., 1990; Maikhuri, 1991; Bhatt et.al., 1994; Jain, 1994; Jain, 1993; Amatya et.al., 1993; Negi and Todaria, 1993; Jain, 1992; Garg, 1992).

In a worldwide context, fuelwood policies have been focused on forestry management upon energy production. Particularly, most biofuels are used for residential cooking and heating, mainly in Africa, Asia and Latin America. It is noteworthy that almost 90% of the wood removals in Africa are used for fuel. In countries that form the Organization for Economic Co-operation and Development (OECD), in many developed countries –such as Austria, Finland, Germany, and Sweden– biofuels are increasingly used for the production of electricity, attracting huge investments in wood-energy industries (International Energy Agency, 2005). Moreover, in the United States about 3% of energy demands are supplied by biomass. Much of this is exploited by the paper and pulp industry, which burns large quantities of fuelwood and paper milling wastes to supply energy for its needs. Other substantial consumers of forestry biomass include households that burn fuelwood as a primary source of heat (about 5% fall into this category) and another 20% occasionally burn fuelwood in a stove or fireplace), commercial industries and establishments that burn fuelwood as a source of energy. Such indicative energy uses from fuelwood feedstock are for space-heating purposes and for waste-to-energy facilities that burn municipal solid waste.

Additionally, outlook studies by the International Energy Agency indicate that renewable energy sources will continue to increase their market shares in the energy mix (International Energy Agency, 2005). While heating and cooking will remain the principal uses for fuelwood and charcoal in developing countries, the use of solid biofuels for the production of electricity is expected to triple by 2030 (International Energy Agency, 2005).

In the following Figure 1 the forest profile and characteristics –in a worldwide context– is presented for the reference year 2010, accordingly.

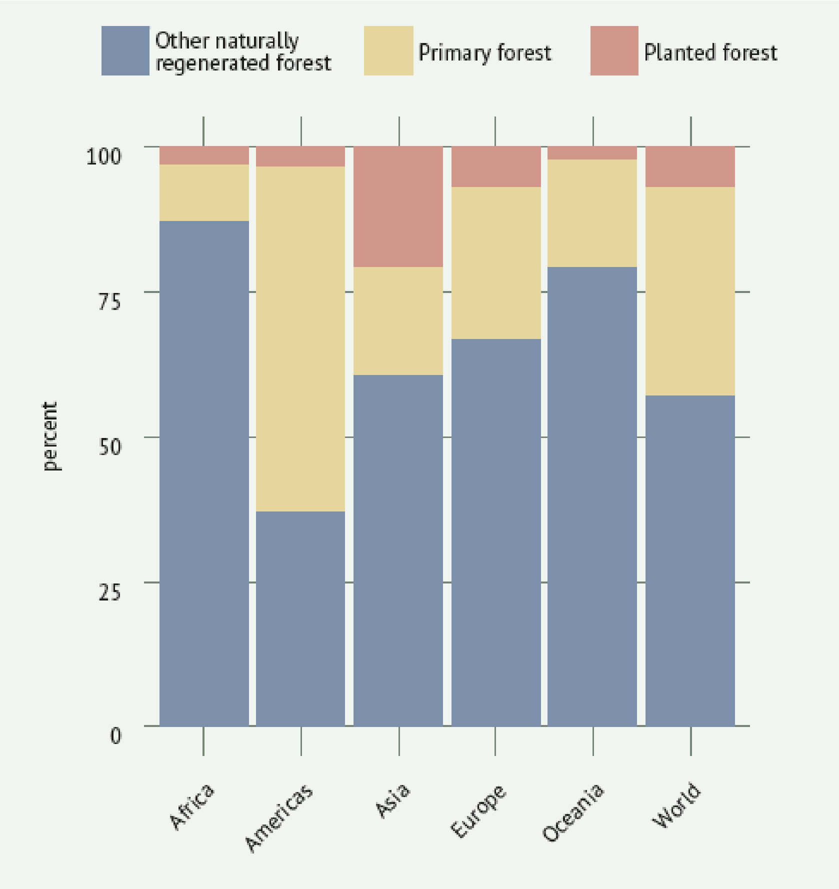

Fig. 1. The forest profile and characteristics in a worldwide context for the year 2010. Source: Food and Agriculture Organization of the United Nations (2013), Forestry Department: http://www.fao.org/docrep/018/i3107e/i3107e04.pdf, p. 204.

2 Fuelwood Features In An Environmental Overview

Environmental aspects of fuelwood production and energy use are expanded over a wide spectrum of applications, from the local land use up to global climate change, and from applications in smoky kitchens to electricity generation up to large-scale power plants. In parallel, environmental impacts of fuelwood production and energy use are valued both as positive and as negative, thus the environmental footprint of these impacts should be an integrated component of any contemporary fuelwood energy scheme upon energy policy making (Western Ghats Biodiversity Information System, 1999).

In the European context there is an extensive literature production upon the environmental perspectives of fuelwood exploitation in mountainous regions (Kyriakopoulos, 2010; Chalikias et.al., 2010; Kyriakopoulos et.al., 2010; Kolovos et.al., 2011). Such studies have expressed the pronounced role of natural forests, those unaffected by humans, which often contain a diverse range of both tree and non-tree species since all forests –even monoculture plantations– are reservoirs of biodiversity. Nevertheless, almost all forests in Europe have experienced more or less strong anthropogenic influences throughout history. Subsequently, even though forest areas are increasing in most European countries, the positive trends exceed the negative ones (European Environment Agency, 2006).

In mountainous forests an utmost importance issue –regarding a sustainable forestry management– is the residues' extraction. In particular, residues' extraction can in some cases be beneficial in terms of forest fires prevention. Woody harvest residues and deadwood constitute a fire risk in Mediterranean countries. Removal of biomass for bioenergy production could, thus, help to reduce the risk of forest fires and facilitate fire extinction. Furthermore, biomass originated from creating corridors of fire protection can be utilized in order to enable an added economic value to this operation. Generally, while the low utilization of annual increment has created positive conditions for biological diversity, some man-made forests have not been thinned. This phenomenon can be attributed to the lack of market demand and low prices. In such cases thinning for biomass utilization could provide an opportunity to open very dense coniferous forest plantations and improve the habitat value of these forests for many species (Chalikias et.al., 2010; Kyriakopoulos et.al., 2010). The main fuelwood features in an environmental overview are systematically presented in the following subsections of this section 2.

2.1 Deforestation

Deforestation is the consequence of the imbalance between the (limited) rate of fuelwood production and the (excess) rate of fuelwood consumption. Therefore, this "fuelwood gap theory" is mainly attributed to the aforementioned imbalance that was introduced at the seventies. In the framework of the "fuelwood gap theory" it is assumed that all fuelwood is produced by forest resources and that fuelwood consumption would increase at the same rate as population increase (Western Ghats Biodiversity Information System, 1999).

This "fuelwood gap theory" was the major consequence upon an overstated "fuelwood crisis" that was introduced in the global environmental agenda from the late seventies. In this extreme statement analysts –such as foresters, economists, and policy makers– in many countries structured erroneous projections of the rapid total destruction of the biomass resource. These projections were usually based on a simplistic supply and demand analysis, the so-called gap analysis that was extremely pronounced throughout most of the eighties. The setting goal of theses projections was the boost of fuelwood supplies without regard to local needs, priorities, or resource potentials-or to the economic viability of the plans (Mercer and Soussan, 1992). Nevertheless, other fundamental issues that enable the sustainable fuelwood management are apparent, such as the substantial supply of wood from non-forest areas and responses of fuelwood users to scarcities, such as fuel switching, change of cooking habits, and development of alternative supply sources (Western Ghats Biodiversity Information System, 1999).

Nowadays the main reason of deforestation is the conversion of forest land into agricultural land and urban areas, due to the undergone growing population and the concurring increased demand for food. Contrarily, localized deforestation and forest degradation are not always considered the determining outcomes of unsustainable fuelwood production, since there are geographical regions, such as in Cebu (the Philippines), where commercial fuelwood trade can lead to the improvement of the local environment because it provides incentives to landowners and farmers and traders to plant trees under environmentally viable policies (Western Ghats Biodiversity Information System, 1999). On the other hand, fuelwood energy policies and programs are still commonly structured upon the aforementioned misconception, which leads to ineffective and even obstructing interventions, such as prohibiting fuelwood gathering from forests, restricting the transportation of fuelwood, and cook-stove programs that merely aim to reduce woodfuel consumption (Western Ghats Biodiversity Information System, 1999).

2.2 Global Climate Change

Serious environmental concerns like global climate change, being related to the use of fossil fuels, have currently revived the interest in fuelwood energy as a renewable, sustainable, and environmentally benign energy source. Therefore, fuelwood energy is a renewable energy source that enables sustainable and carbon-neutral production and exploitation. In particular, complete burning or decomposing of fuelwood emits carbon dioxide, but trees absorb carbon from the atmosphere through photosynthesis. Contrarily, natural decomposition or incomplete burning of fuelwood emits methane, while crop and livestock production alone are responsible for half of the methane and two-thirds of the nitrous oxide emitted into the atmosphere by human activity. Thus, from an environmental viewpoint, burning fuelwood residues from logging and processing is an environmentally beneficial process. Moreover, fuelwood does not emit sulfur dioxide, unlike the burning of fossil-based fuels of coal and oil (Western Ghats Biodiversity Information System, 1999; Food and Agriculture Organization of the United Nations, 2013).

Therefore –while emissions of greenhouse gases (GHGs) from agriculture, forestry, and other land uses contribute to global warming, sustaining comparable contribution to pollution caused by energy production and consumption, and far exceeding total emissions from transportation– energy produced from fuelwood can be used to reduce such greenhouse gas emissions related to energy use, by replacing fossil fuels. Subsequently, contemporary fuelwood energy applications are becoming more and more competitive with conventional applications. Other benefits of such applications are: employment generation, saving on foreign exchange due to reduced oil import, and upgrading of barren and deforested areas by energy plantations (Western Ghats Biodiversity Information System, 1999; Food and Agriculture Organization of the United Nations, 2013).

2.3 Emissions

Most fuelwood production in Asia is used by households in their traditional stoves. These stoves sustain low efficiencies and often burn wood incompletely leading to the emission of pollutants, including carbon monoxide, methane and nitrogen oxides. These pollutants deteriorate the health condition of the nearby population and increase the greenhouse gas emissions. Nevertheless, fuelwood is not valued as a dirty fuel itself that has to be replaced, but that traditional technologies are inadequate and need improvements. Besides, the optimum fuel conservation necessitates improved cook-stove programs that should be oriented to the aspects of health protection and users' convenience (Western Ghats Biodiversity Information System, 1999).

Finally, other negative repercussions on the ecosystems and on humans' well-being, are: soil salinity, aquifer depletion, and land degradation. This environmental depletion should reduce achievable yields and could put at risk farmers' ability to bridge production gaps and improve food security (Food and Agriculture Organization of the United Nations, 2013).

3 Discussion

An integrated evaluation of fuelwood management for energy production upon forestry sources should involve both environmental and financial viewpoints of analysis. Therefore, in this section it is also noteworthy to further denote the dominated economic entities of energy projects, by succinctly providing the relevant terminology, as follows (Khatib, 2003):

- Equity is an ownership right or risk interest in an enterprise.
- Payback period is the time taken for a project to recover its initial investment in monetary terms.
- Internal rate of return (IRR) is a discounted measure of project worth. The discount rate that just makes the net present worth of the incremental net benefit stream, or incremental cash flow, equal zero.
- Net present value (NPV) is the sum of discounted future benefits and costs at a stated rate of discount. NPV is an absolute measure of project merit.
- Opportunity cost is the value lost by using something in one application rather than another. The opportunity cost of employing a worker in a project is the loss of net output that worker would have produced elsewhere. The concept of opportunity cost is the corner stone of benefit-cost analysis.

Calculation of benefits in the electrical power industry is a complex issue, since a new power station would normally not only increase production, but also contribute towards reduction of the overall system cost of generation. Such infrastructure development should also reduce system losses and delay the implementation of some projects for network strengthening. In parallel, certain energy projects are redundant and are made necessary by the need to ensure security of supply. Moreover, rural electrification is normally a source of financial loss, but has significant economic benefits. Some improvements in power stations –like inhibition of emissions– incur high investment, reduce electrical energy output and efficiency, and yet have sound environmental and economical benefits (Khatib, 2003; Chalikias et.al., 2010; Kyriakopoulos et.al., 2010).

In a financial overview, the guiding principle for the evaluation of such biomass-based energy projects is the maximization of NPV while utilizing, as a discount rate, the opportunity cost of capital. Besides, the IRR is not the only criterion to evaluate projects for investment decisions. Contrarily, NPV with a proper discount rate (reflecting the true opportunity cost of capital) is a criterion. With limited budgeting, a benefit/cost ratio has to be also calculated in order to assist the appropriate selection among all alternative energy-projected choices (Khatib, 2003; Chalikias et.al., 2010; Kyriakopoulos et.al., 2010).

In an environmental overview, the extensive use of coal results in groundwater contamination, land disturbance, changes in land use and long-term ecosystem destruction. Moreover, the dominated air and water pollution reflect the emissions of SO2, NOx, particulates. Such (indicatively stated) pollutants are badly affecting the environmental sustainability, causing air quality implications, heavy metals leachable from ash and slag wastes, possible global climatic change from CO2 emissions, as well as lake acidification and loss of communities due to acid depositions. Focusing the above environmental impacts on forestry biomass sources, it should be further noticed that these energy-projected schemes emit lower levels of SO2 compared to oil-fired or coal-fired projects, but could also sustain higher emissions of potential carcinogenic particulates and hydrocarbons (Khatib, 2003; Chalikias et.al., 2010; Kyriakopoulos et.al., 2010).

4 Conclusions

According to the development of the fuelwood crisis in the seventies, the perspective solutions of the relevant projections were self-evident; if projected fuelwood demands exceeded supplies, the solution was to plant more trees and shift the supply curve outward, or to devise policies to reduce demand and shift the demand curve inward. Nevertheless, most of these efforts failed to have lasting effects on fuelwood scarcity or forest depletion. These failures signified the need of rethinking upon the fuelwood crisis. Although specifications between and within regions are versatile, fuelwood problems should be holistically seen as manifestations of more fundamental failures in rural land, labour, and capital markets, urban energy markets, and failures of governments (local and national) to establish the conditions that would foster efficient and sustainable allocation of land and resources between forest and cropland and wood and food production (Mercer and Soussan, 1992).

Fuelwood problems are currently recognized as rarely generalizable, since these problems sustain inherently complex causes of varied forms. Such problems reflect interactions between local production systems and the environmental resources on which they are based. Therefore, the significance and origins of fuelwood problems are differentiated from region to region, as well as from rural to urban areas within the same district. Besides, these problems reflect changes to economic and environmental relationships that affect local supply and demand; changes that can be (Mercer and Soussan, 1992):

- gradual, such as erosion of local woodlands as a result of land colonization, increased herd sizes in semiarid regions, increased exports of fuelwood to meet growing urban demands, or lower quantities of residues available as fuel, as a result of changing agricultural practices.
- sudden and catastrophic, such as a large-scale deforestation associated with giant development schemes, mass influxes of refugees, and environmental collapse associated with droughts, floods, or other extreme climatic events.

Whether gradual or rapid, these changes are utmost importance aspects of fuelwood problems and constitute the driven forces to effectively grab the open opportunities and effectively confront the arising disputes upon all counterparts involved in contemporary fuelwood policies (Mercer and Soussan, 1992).

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