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ENERGY FORESTRY AND USE OF BIOMASS FUELS IN ETHIOPIA

by

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Energy from biomass counts over 90 per cent of the energy use in Ethiopia. Since the indigenous forests have largely been cut, fuelwood is no more sufficient. Substitute fuels cow dung and crop residues must have been taken in use.

Decimating of natural forests is going on at rate of 100,000 - 200,000 ha/a, which is 10 times above the re-establishment of new forests by planting. To reduce the harmful effects of overcutting the forests for fuel, and of using cow dung and crop residues as substitute fuels, establishment of fuelwood plantations is needed.

Energy forestry with eucalypts is known since 1895 to the dwellers of the central highlands where rainfall is high enough for tree planting. The biggest fuelwood plantations, 19,800 ha planted before the 1975 land reform, grow in the green belt of Addis Ababa. Additional fuelwood plantations of about 14,000 ha have been established with funding from international organizations. The total area of fuelwood plantations in Ethiopia is about 100,000 ha.

Eucalyptus globulus is the main species grown for fuel. Although some doubts of the ecological suitability of eucalypts for plantations exist, the advantages of high production, coppicing and the non-palatability of the leaves for cattle overweigh the disadvantages of low erosion control and high demand for water and nutrients.

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1 BIOMASS FUELS IN ETHIOPIA

Biomass fuels are the most significant energy sources in Ethiopia. They supply over 90 per cent of the energy requirements (Ethiopia ... 1984). As firewood, charcoal, cow dung and crop residues the biomass fuels are mainly used for cooking. Although there is a remarkable potential of hydropower in the country, and fossil fuels are also likely to be found, the biomass will remain as the main energy source in the future. Especially this will be the case among the vast rural population.

Traditionally all fuel came from the forest. In the past fuelwood was abundant and no other types of household energy were needed. The forestry was sustained: the annual forest cut for fuel and other purposes did not exceed the annual growth of the forests neither in a particular area nor in the country as a whole.

It is estimated by the World Bank (Ethiopia ... 1984) that an average amount of energy corresponding to two kilograms of air dry wood per capita per day, is required to sustain traditional Ethiopian cooking and to respect other uses of fire as well, such as heating up and lighting the highland houses, as well as use in small-scale household industry. Only part of this energy equivalence, estimated at 43 per cent, is now derived from fuelwood - simply because in vast highland areas there is no fuelwood available (Fig. 1). Fuelwood has to be substituted by cow dung and crop residues (like maize and sorghum stalks).

Besides these biomass-based energy sources some liquified gas, kerosene and electricity are used in urban households. In Ethiopian context their amount is tiny, under one per cent of the total household energy.

Dried cow dung counts for one third of the biomass energy use. Cow dung is desired fuel among the rural people since it is simple to harvest, light to transport for marketing and easy to burn. Use of cow dung as fuel has, however, a detrimental effect on the soil fertility and on the yields of agricultural crops. In a country with constant threat of famine the proper use for cow dung is fertilization. Especially important this is in Ethiopia where there is no manufacturing of artificial (chemical) fertilizers.

Burning of crop residues, which counts for one fourth of the biomass energy use, has similar, although minor detrimental effect. Instead of burning, the crop residues should be ploughed into soil, or they should be fed to the cattle. In Ethiopia particular users of crop residues are the draught animals, the oxen which are commonly for ploughing.

Fig. 1. Sources of biomass energy in Ethiopia (Ethiopia ...1984, Pohjonen and Pukkala 1988).

The ultimate target of the energy forestry is to meet all the demand for biomass fuels with fuelwood proper. The final aim is to minimize the burning of cow dung and crop residues by substituting them with suitable fuelwood species. Although sustained use of existing forest resources is part of energy forestry, the main emphasis in Ethiopia as well as in many other African countries is on planting enough fuelwood plantations both at smaller and larger scale.

2 DRAIN FOR FUELWOOD AND FOREST BALANCE

From the share of wood in the biomass based fuels it can be estimated that the annual harvests for fuelwood (fuelwood proper and harvests for charcoal) in Ethiopia amount at 18.8 mill m3. The annual harvest for construction timber is estimated at about two mill. m3 (Palm 1983). Sawmilling, particle board, fiber board and plywood industry use annually about 165,000 m3 (Melaku Abegaz and Addis Tsehaye 1987). Counting all the uses of harvested timber, the total drain can be estimated to be around 21 mill. m3 per annum.

In sustained forestry the annual timber production of 21 mill. m3 corresponds, for example, to about five mill. ha of well-managed indigenous forests (Mean Annual Increment, MAI about 4 m3/ha/a) or to about one million hectares of fast-growing eucalypt plantations (MAI 21 m3/ha/a). At present such forest resources do not exist in Ethiopia. The remaining forest cover is about 3.2 mill. ha. Even if this area is apparently high it does not tell the whole truth: the main part of the remaining forests grow in the sparsely populated and less accessible western and south-western Ethiopia, not in the central plateau where the main part of the population dwells, and where the timber demand and consumption are highest.

The established plantations (about 310,000 ha, Bowen 1985) cover in statistics about one third of the need, but majority of them does not fulfill the criteria of being fast-growing. The example mean annual increment of 21 m3 per ha per annum is not reached generally but in protected experimental plantations only.

In most parts of the country the forestry is unsustained: the annual harvests clearly exceed the annual growth. This has lead to a serious decimation of the forest resource, the decimation of which is still going on at alarming rate of 100,000 ... 200,000 ha per annum (Bowen 1985, Rehabilitation ... 1986). The annual rate of plantation establishment cannot cope with these figures. In 1980's the annually planted areas have been at their maximum between 10,000 - 20,000 ha. For every planted new forest hectare ten old forest hectares disappear.

Counting on full substitution of cow dung and crop residues, the overall annual fuelwood demand doubles. Similarly doubles the needed area of indigenous forests (into 10 mill. ha) or fast-growing fuelwood plantations (into 2 mill. ha). Taking into account the Ethiopian population growth rate (2.9 per cent), the fuelwood demand rather triples by the year 2000 as well as the corresponding areas: 15 mill. ha for indigenous forests or 3 mill. ha for fuelwood plantations (Pohjonen and Pukkala 1987).

3 FUELWOOD PLANTATIONS IN ETHIOPIA

31 Establishment of Addis Ababa fuelwood forest

Contrary to other Sudano-Sahelian countries Ethiopia has a long experience in energy forestry and fuelwood plantations. Their origin dates back to the end of 1800's, to the times of Emperor Menelik II. The existence of Addis Ababa as a capital was threatened by fuelwood shortage. The natural *Juniperus - Podocarpus - Olea* forest, which had been growing dense on the surrounding mountains of the city, was quickly disappearing. Increasing timber demand for fuel and for poles needed in house building, had resulted in heavy cuttings which the relatively slow-growing indigenous species could no more sustain.

As a potential solution for fuel and timber shortage, eucalypts were introduced in the country. This happened either in 1984 or 1985 when a French railway engineer Mondon-Vidaillet proposed to the emperor a trial plantation of eucalypts (Breitenbach 1961). The proposition was accepted. Seed of 15 Eucalyptus species were imported to the country and trial plantations were established.

The introduction was a success, and soon after the turn of the century, planting of eucalypts for fuel, especially *E. globulus* and at minor scale *E. tereticornis*, was initiated in the surroundings of Addis Ababa. The farmers quickly adapted the new productive and useful exotic tree, "tree behind the ocean" (Amharic: *Bahir Zaf*), like they called it.

Old photographs reveal the steady growth of the *Eucalyptus* forest. By 1906 the first photographs taken in the capital show clumps of *E. globulus* trees around private houses. During the next decade some landowners had covered a few hectares with eucalypts for purpose of selling small poles and fuelwood. Already before 1920 the streets and paths of Addis Ababa began to look like clearings in eucalypt forest, and it was even suggested that Addis Ababa's name (English: New Flower) might appropriately be changed to *Eucalyptopolis* (Berlan 1951).

Establishment of *Eucalyptus* plantations developed steadily. In the late 1930's the size of the forest was estimated to be not less than 4000 ha, probably over 5000 ha (Giordano 1938). In 1957 the first precise forest area determination was possible from the aerial photographs. The forest, excluding the trees in the built-up area, covered a gross area of 17,600 ha, with fully stocked net area of 10,100 ha.

The next area determination was done on aerial photographs of 1964. The gross area had expanded to 24,600 ha and the net area to 13,500 ha (Horvath 1968). The average rate of plantation establishment had been of order 400 - 500 ha per annum since the beginning of the century.

Plantation forestry with *E. globulus* developed steadily still for 10 years, until the revolution and land reform in 1974 - 75. By then the forest area had reached 15,000 ha (Persson 1975). This figure was, however, an underestimate since according to the inventory of 1980, there are 19,800 ha of growing *Eucalyptus* forests to the north and west of Addis Ababa along the Ambo and Gojam roads. The growing stock was estimated at 2.3 mill m3 or 118 m3 per ha (Appraisal .... 1985). This Addis Ababa *Eucalyptus* forest is apparently the largest plantation in the world established mainly for fuelwood purposes.

Similar plantation establishment, although in smaller scale, had spread from Addis Ababa to the surroundings of the other main highland cities and towns. Adding all these plantations to Addis Ababa *Eucalyptus* forest, altogether 91,000 ha, mainly with *Eucalyptus globulus*, were established by the beginning of 1980's. (Henry 1973, Forestry ... 1981).

32 Post revolution development

The revolution of 1974 and the land reform of 1975 ceased the fuelwood plantation establishment in Ethiopia to the end of that decade. The first post revolution fuelwood plantation program was initiated in the beginning of 1980's, when UNSO (United Nations Sudano-Sahelian Office) started the fuelwood projects in the areas of Nazret (Establishment ... 1982), Dese (National ... 1983) and Debre Birhan (Establishment ... 1985). During 1984-1987 about 6500 ha of fuelwood plantations were established in this program.

Besides UNSO-projects there are two periurban, large scale fuelwood projects in the vicinity of Addis Ababa. The African Development Fund has financed (with loan) a project with total target of 15,000 ha (Addis Ababa ... 1981). Out of this target 7600 ha were planted during 1985 ... 87. Another fuelwood project is financed (also with loan) by World Bank. The first planting in this project is taking place in 1988. In 1988 the total area of fuelwood plantations in the country is just over 100,000 ha.

4 ECOLOGICAL EFFECTS

The question of *Eucalyptus* plantations raises strong feelings and ecological argumentation, both for and against them. The displacement of natural, indigenous forest with exotic eucalypt plantations has often been regarded as negative. However, this is rather social than ecological effect. It should affect all the exotic plantation species. In some cases part of the criticism can rather be related to disappointed expectations than to ecological facts. Eucalypts have often been heralded as wonder species that will bring immediate solutions to local wood problems. When such expectations are followed by planting which fails due to unsuitable species, wrong site selection or improperly understood need of management (usually lack of weeding), the blame often falls on eucalypts in general, rather than on the real culprit, which is the bad forestry practice.

The ecological effects of eucalypts are generally said to be negative: disturbance in water and nutrient balance, cause of increased erosion, heavy competition with other species, or toxic effects of eucalypts upon other vegetation. The main criticism that has been launched against eucalypt plantations is that they deplete water supplies and that, on sloping catchment, they do not regulate the flow of water as well as the natural vegetation.

The question of depletion of water supplies is somewhat trivial. One of the principal justifications for selecting eucalypts for planting is their rapid growth compared to alternative species on the same site. On local species trials eucalypts have produced biomass (fuelwood, poles, pulpwood) per year and per hectare more than the alternatives. The high growth is necessarily associated with a high increased need of water.

Critical evidence is still lacking on the most important question: are eucalypts less or more efficient in their water use compared to other trees species? Compared to alternative species, do the eucalypts produce less or more wood per unit of water used?

Sloppy catchments under forest have a lower water table than those under scrub or grassland. This phenomenon is apparently unique to all forest trees, not only to eucalypts. It is due to deeper roots of trees which take water from deeper levels. On the other hand, forests may regulate better the flow of water from rains into the soil and inside the soil than base ground.

In Ethiopian conditions, the comparison of water table and water flow regulation must be done between eucalypt plantations and bare, deforested lands. Observing the rivers flowing from the afforested mountains around Addis Ababa supports the hypothesis that eucalypt plantations regulate the water table and water movement into and through the soil better than bare land. During the dry season the rivers and creeks flowing from planted slopes have water for longer periods than rivers and creeks flowing from bare slopes.

Eucalypts are not particularly good trees for erosion control. When young, they are susceptible to grass competition, and to obtain good growth, clean weeding is necessary. Bare soil under the trees is undesirable on steep or eroding terrain. Even mature stands may be ineffective in halting surface runoff and overland wash.

Dense eucalypt plantations are not recommended for erosion control in semiarid climates. Even if their litter production could compensate for a light understory, the litter is collected in many places of fuelwood shortage. In such cases the sheet erosion is a serious threat. This effect is often augmented by overgrazing.

The cropping of eucalypts on short rotation basis, especially if the whole biomass is harvested, leads always to depletion of soil nutrients. This is a direct consequence of their rapid growth; it would apply in much the same way to any highly productive crop.

There have been suggestions that certain species of *Eucalyptus* may produce chemicals from their leaves or litter that inhibit the germination or growth of other species. It is a chemical or biochemical effect which is quite different from direct competition for water, minerals or light. Such effect has indeed been recorded under *E. camaldulensis* and *E. globulus*. It is caused by some phytotoxins in fog drip coming from leaf extracts or decaying leaves. The effect, however, is not comprehensive on all plants but selective. A claim that eucalypts will poison all the grass vegetation under them is a myth: instead the grass species composition changes - usually to direction of lower grazing and feeding value. It has also been found out that mosses and epiphytes, common in natural forests, are completely absent under eucalypt forest, and mushrooms have almost disappeared. The most specialized plants are replaced by tolerant weeds.

As a summary on ecological effects of eucalypts it may be stated that both positive and negative effects occur. Keeping in mind that fast-growing eucalypts are no ideal multipurpose nor agroforestry trees but efficient biomass producers, the positive effects might overweigh the negative ones. Especially this is the case with fuelwood plantations. As long as more productive alternatives cannot be found for short rotation energy forestry, eucalypt plantations cannot be omitted due to their negative ecological effects.

5 CONCLUSIONS

Eucalypts were introduced in Ethiopia as fuelwood species almost one hundred years ago. The ecological and economical risks involved in plantation establishment with this species are known for longer period than with any other plantation species. It cannot be entirely coincidental that this introduction led early into fuelwood plantation forestry in practical scale. Although this early introduction was done rather intuitively, its value and correctness has later been verified by forestry research. It has been shown that in Ethiopian highlands conditions the eucalypts are the most efficient converters of solar energy into biomass (Booth 1985).

The *Eucalyptus* wood is well accepted as fuel amongst the rural and urban population; the wood also carbonizes well to produce charcoal. Compared to other potential fuelwood species eucalypts, especially the main species *E. globulus*, has two additional advantages: they coppice after the harvesting and cattle does not eat their bitter leaves. Although economical disadvantages do occur, eucalypts will remain as the backbone of the Ethiopian energy forestry if rapid meeting of the need for the biomass fuels in the near future is needed.

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