Land Rehabilitation for Food and Energy Production
- A Synergy Policy for the Tropics -

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1 Introduction

The area of degraded tropical land with potential for rehabilitation amounts to approx. 2.000 million ha, while deforestation and desertification continue, ruining soil, decreasing biodiversity and aggravating worldhunger. Indebtedness of tropical countries and economic pressure constrict a sustainable management of resources – therefore socio-economic development must parallel any land rehabilitation effort.

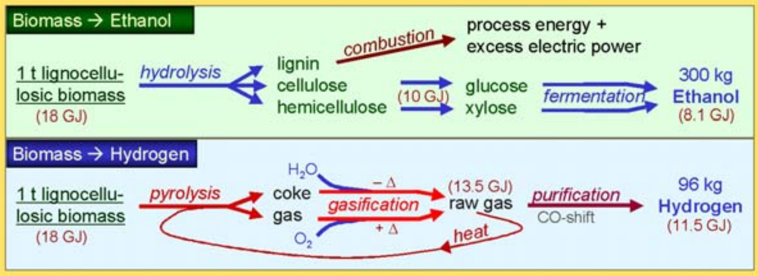
World consumption of primary energy has exceeded 400 EJ/year. Possible effects of global warming are starting to show. Oil and natural gas may be depleted before 2040 resp. 2065. Military conflicts for fossil energy resources already increase. Presently biomass is the only competitive alternative energy source, conforming to established technology and available on a substantial scale. The greatest energy demand, however, comes from industrial countries, while major biomass potentials are found in the tropics.

Consequently there is a high risk of competition between energy demand, nature conservation and world feeding. A synergistic solution, seizing the complementary needs of land rehabilitation and bioenergy production is recommended in this study.

Table 1: *Plant Species for Land Rehabilitation and Bioenergy*

Species	Ecological Requirements	Reported Biomass Yields
leguminous trees		(t / ha·year)
Calliandra calothyrsus	> 20°C ; rainfall 700-4400 mm/year pH 4.5-8.0, low fertility demands	15-40
Leucaena leucocephala	>20°C ; rainfall 650-1500 mm/year sandy soils, pH not too low	19-31
Acacia auriculiformis	>26°C ; tolerates poor soils, sand dunes, extended dry seasons, wide range of pH	7-14
Cassia siamea	rainfall 350-450 mm/year sandy, saline or alkaline soils	6-30
perennial C_4-grasses		(t / ha·year)
Pennisetum purpureum	> 14°C ; rainfall 200-4000 mm/year pH 4.5-8.2 ; tolerates drought, fire, monsoon	2-85
Cenchrus ciliaris	> 13°C ; rainfall 250-750 mm/year ; pH 5.5-8.2 tolerates drought, low fertility demands	1-26

Figure 1: *Major steps of biomass conversion paths*



2 Coproduction of Food and Bioenergy on Rehabilitated Land

Coproducing food and fuel on rehabilitated land minimises opportunity costs, and optimises utilisation of resources. Agroforestry is a common example for multifunctional ecosystems, producing food, energy and other commodities. A study by the FAO (1995) states that average woodfuel productivity of agroforestry systems in asia is 13-19 t/ha·year in the humid resp. half of that in the subhumid tropics.

Agroforestry systems are suitable for land reclamation and allow sustainable management. In various environments an important function is assumed by leguminous trees, which add nitrogen and organic matter to the system, provide erosion control and shelter for smaller crops, can be browsed by livestock, and are major producers of woodfuel. Costs of reforestation, e.g. in India (1996), are quoted in the range of 600,- € / ha.

Perennial grasses that follow the C_4-photosynthetic pathway have a high water efficiency, can provide good erosion control and high biomass production in semi-arid or dry regions. Food use is possible by temporal grazing.

Table 1 indicates the biomass potential of some species suited for land rehabilitation as well as for coproduction of food and bioenergy. Traditional biomass utilization is mostly inefficient (combustion). Conversion to high grade fuels could release an energy surplus.

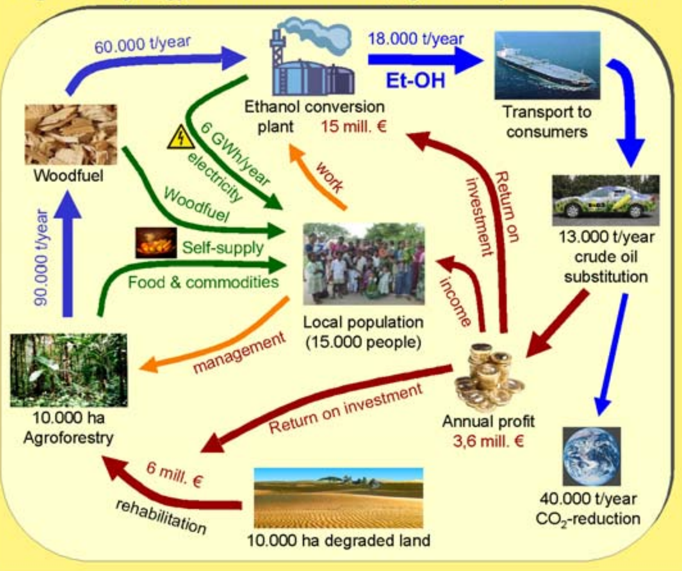
3 Conversion of Biomass into Ethanol and Hydrogen

Combustion engines for ethanol are state of the art, infrastructure requirements are low, and the biochemical production pathway allows recirculation of organic residues. Ethanol production from lignocellulosic biomass like wood or straw (*Figure 1*) promises a decline in ressources consumption and costs.

Hydrogen is the energy carrier of the future. It represents the interface of all solar energy sources (storage by electrolysis) and potentiates clean energy of highest efficiency by the use of fuel cells. The gasification of lignocellulosic biomass (*Figure 1*) is the most cost-efficient solar production pathway of hydrogen.

Total auxiliary energy required for conversion, transport, etc. is in the range of 1,5% (EtOH) to 6% (H_2) of the biomass input. Variable costs for production and distribution are estimated at 150,- € per tonne ethanol resp. 700,- € per tonne hydrogen. A sales revenue for fuel applications of 350,- € per tonne ethanol resp. 1300,- € per tonne hydrogen can be expected. Both numbers account for a gross revenue of 60,- € per tonne biomass. Investment costs for conversion plants will be in the range of 0,5 mill. (EtOH) to 0,7 mill. (H_2) € / MW, depending on the economy of scale.

Figure 2: *Synergy of land rehabilitation, agroforestry and bioethanol*



4 Impact and Recommendation

As illustrated in *Figure 2* by a sample calculation, the on-site production of high grade fuels from biomass coproduced with food on degraded tropical land entails multiple benefits:

- Funding of land rehabilitation by revenue from energy production
- Soil restoration and increase of biodiversity
- Substantial reduction of CO_2-emissions
- Self-supply of local population, additional income and regional development
- Economic production of clean renewable energy
- Promising return on investment

For the exploitation of this win-win-situation more detailed information is required. The concept of a preliminary project is given in *Table 2*.

Table 2: *Projecting the synergy – preparatory task plan*

Analysis of existing land rehabilitation projects
Plant species and potential bioenergy production
Impact on food security and biodiversity
Sustainability and socio-economic structure
Review of general conditions for bioenergy utilization
Substrate requirements of biomass conversion plants
End use options (vehicles, electricity, infrastructure)
Economic scope
Modelling
Appropriate ecosystems
Flow balance of energy, matter and money
Project initiation on basis of the results
Consortium of administration, technical implementation and partner countries

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