Fuelwood Production in Agroforestry Systems for Sustainable Land Use and CO_2-Mitigation

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Abstract
The existence of a fuelwood market is a basic precondition for attempts to develop sustainable landuse systems which integrate trees on arable or pasture land (agroforestry). The Kyoto protocol to the United Nations Framework Convention on Climate Change has opened new chances to finance wood energy and agroforestry projects by the instrument of joint implementation in the next years.

1. Introduction

There are two basic reasons for an increased production of fuelwood:

- On a local level especially in many tropical regions there is an acute scarcity of this form of energy which is a daily need fore more than half of the global population.
- Globally we need a reduction of CO_2-emissions due to the global warming problem. The substitution of renewable energy sources - of which fuelwood actually is the most important one - for fossil fuels is a main strategy in this context. It is closely connected with the possibility of using additional trees as carbon sinks.

In spite of this facts is often very difficult to get more trees on the ground. In Central America e.g. one common argument for not planting trees is the small size of landholding and the long wait until production. This is true for small farms, especially when the production of trees in blocks and with species of long rotation is recommended. In this case agroforestry is a solution. As to be shown here its introduction should be connected with the energy sector and may be funded by greenhouse reduction measures as joint implementation.

2. Agroforestry and fuelwood - two sides of a medal

Agroforestry covers land use systems in which trees and shrubs are grown in association with herbaceous crops, either in a spatial arrangement or a rotation. It has productive functions, such as the capacity of the tree component to produce fuelwood, fodder and fruit, and service functions, chief among which is that of soil conservation. The high potential of agroforestry as a means of achieving sustainable land use - especially in the tropics - has been investigated and promoted since the early 1980s. Its now becoming progressively translated into practice, through the design of sound, appropriate, agroforestry systems and their inclusion in the process of land-use planning (Young, 1989).

In Central America it was experienced that even under the restriction of size it is possible to incorporate a forestry component within small farms by using living fences with fast growing species. The living fence is an agroforestry system and is the advantageous for farm delimitation, protection from soil erosion, prevention of trespassing, and keeping animals away from crops. Also it has low cost of establishment and maintenance, and additional products such as fuelwood, post and materials for construction can be obtained. The introduction of living fences was shown to have a significant positive impact on small farm incomes with an estimated internal rate of return of 28.80% (Reiche, 1991).

Another example for the financial benefits of agroforestry systems can be seen in Table 1. The combination of agricultural crops with trees for fuelwood production can bring a higher profit than pure plantings of either. The same is true for the ecological benefits.

Type of Cultivation		**First Year**	**Second Year**	**Third Year**	**Fourth Year**	**Total Profit in 4 Years**
Maize, traditionally						
Costs	*- Labour*	2104.78	2104.78	2104.78	2104.78	
	- Material	808.02	808.02	808.02	808.02	
Proceeds		5916.00	5916.00	5916.00	5916.00	
Profit		3003.20	3003.20	3003.20	3003.20	12012.80
Maize with Eucalyptus						
Costs	*-Labour*	3083.73	1914.94	390.84	3843.89	
	- Material	2275.31	766.31	120.85	120.85	
Proceeds		4102.80	4102.80	0.00	24869.09	
Profit		-1256.24	1421.53	-511.69	20904.31	20557.92
Eucalyptus Plantation						
Costs	*-Labour*	1837.38	469.208	413.508	3431.61	
	- Material	1012.21	58.21	58.21	58.21	
Proceeds		0.00	0.00	0.00	25145.03	
Profit		-2849.59	-527.41	-471.71	21655.21	17806.50

Table 1: Costs and proceeds for different types of cultivation in El Salvador (values in Colones/ha for 1989) (Juarez, McKenzie, 1991)

The basic precondition for the economic success of fuelwood production systems naturally is the existence of a local fuelwood market. As it was shown in Costa Rica this can be stimulated by the switch from fossil fuel (bunker) to fuelwood in small industries (e.g. saline) (Portilla and McKenzie, 1991). Markets generally have been proven to provide important incentives to tree planting. Thereby the possibility to sell small diameter logs is especially essential, because they are an unavoidable by-product even if high quality lumber shall be produced (Current and Scherr, 1995). So an active fuelwood market turns out to be a valuable tool for any attempts to propagate soil conserving and sustainable agroforestry systems. This aspect has to be kept in mind if an energy system is being planned.

3. Establishing agroforestry and bioenergy systems by „joint implementation“

This headline is meant ambiguous: First of all it shall repeat, that landuse planning and energy policy should be designed in close cooperation. But secondly it refers to the actual political efforts to reduce greenhouse gas emissions.

At the Third Conference of the Parties (COP III) held in Kyoto, Japan, December 1-10, 1997, a protocol to the United Nations Framework Convention on Climate Change (UNFCC) was signed, which made „joint implementation“ (JI) to a generally accepted political instrument. This mechanism allows companies from the industrialised nations to generate emission credits by investing in projects to reduce, avoid or sequester greenhouse gas emissions in developing countries in a cost-effective manner. In a pilot phase, internationally referred as „Activities Implemented Jointly“ (AIJ) several countries already started projects some of which dealt with forestry, agroforestry and biomass energy. Australia e.g. just in November 1997 created its " International Greenhouse Partnerships“ (IGP) Program in order to find ways to use JI for a cost-effective fulfilment of its greenhouse gas emission target. Another objective of the program is to enhance Australian trade and investment links in environmental technology and services areas in the energy and other relevant sectors, mainly focused Asia-Pacific region.

Host countries will benefit by gaining access to technology that will build the infrastructure needed to meet their development needs while also benefiting the global climate. Accordingly a big German company decided in spring 1998 to invest DM 30 Mio. in a forestry CO_2 -mitigation project. This demonstrates well that after Kyoto there are much better chances to receive funds for agroforestry and fuelwood projects by the mechanism of JI. As it has been demonstrated by scientific calculations (see Table 2; Swisher, 1991) and practical experiences from many pilot projects since 1989 there is a big potential for greenhouse gas mitigation by agroforestry. The increasing use of biomass and its conversion efficiency for producing heat, electricity, and liquid fuels can become a significant factor in the global management of atmospheric CO_2 over the next century (Sampson et al., 1993). Consequently this chances should be used intensively in the interest of a sustainable development especially in tropical countries.

References

Current, D. and S.J. Scherr, 1995. Farmer costs and benefits from agroforestry and farm forestry projects in Central America and the Caribbean: implications for policy. Agroforestry Systems, **30**: 87-103.

Juarez, M. and T.A. McKenzie, 1991. Sistema agroforestal maiz-eucalipto en El Salvador: analisis financiero. Silvoenergia No. 45, CATIE, Turrialba, Costa Rica, p. 4.

Kürsten, E. and P. Burschel, 1993. CO_2-mitigation by agroforestry. Water, Air and Soil Pollution, **70**: 533-544.

Portilla, W. and T.A. McKenzie, T.A., 1991. Un caso de evolution en el desarollo de proyectos forestales. Silvoenergia No. 40, CATIE, Turrialba, Costa Rica, p. 4.

Reiche, C. 1991. Economic analysis of a living fence case in Central America - Development of a methodology for the collection and analysis of data with an illustrative example. Invited paper presented at the Economics of Agroforestry Systems Workshop, Honolulu, Hawaii, July 22-26, 1991. CATIE, Terrible, Costa Rica, p. 22.

Sampson, R.N., L.L Wright, J.K. Winjum, J.D. Kinsman, J. Benneman, E. Kürsten and J. Scurlock, 1993. Biomass management and energy. Water, Air and Soil Pollution, **70** (1-4): 139-159.

Swisher, J.N., 1991. Cost and performance of CO_2 storage in forestry projects- Biomass and Bioenergy, **1** (6): 317-328.

Young, A., 1989. Agroforestry for soil conservation. CAB International, Wallingford. pp. 246

Accumulation and Conservation of Carbon Stores	
Trees in Agroforestry Systems	3... 60
Wooden Products	1... 100
Soil Organic Matter	10... 50
Protection of Existing Forests	0...1000
Sum	***(14...1210)***
Reduction of CO_2-Emissions within 50 Yrs	
Energy-Substitution	5... 360
Material-Substitution	0... 100
Reduction of Fertilizer-Input	1... 5
Sum	***(6...465)***
Total	**20...1675**

Table 2: Estimated CO_2-mitigation effects of agroforestry systems (in $Mg \cdot C \cdot ha^{-1}$ agroforestry land) (Kürsten, Burschel, 1993)

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