AGROFORESTRY AND WOODFUEL PRODUCTION:

SOME DATA FROM AGROFORESTRY-SYSTEMS IN AFRICA

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Introduction

In the past, fuelwood production played an important economic role in European agroforestry systems, especially in regions with a high population density, as was the case in the Cevennes in southern France. Wood pruned or pollarded from chestnut, ash and fruit trees was used for heating and cooking. Very little data has been published on the quantities of wood that were produced, but personal communications with older farmers indicate values of about 2.4 t/ha/year (t = metric ton).

In many African countries, farmers harvest most of their fuelwood in their own fields and pastures. Yet although numerous studies have been conducted, some relatively old (CTFT 1989; Depommier and Guerin 1996), and despite recent international scientific recognition of the importance of tree-based bioenergy (Neufeldt et al. 2015), few figures have been published about the actual productivity of African agroforestry systems, in which ecological and socio-economic conditions vary greatly.

With the support of funding agencies such as the World Bank, the French Development Agency (AFD) and the French Global Environment Facility (FFEM), projects are now underway to develop wood energy master plans to supply African cities. Researchers are being asked to provide figures to estimate fuelwood production in the anthropized areas which cover most of these cities' wood energy supply basins. CIRAD and its partners have conducted a number of studies that provide an initial assessment of the productivity of agroforestry systems (AFS) in Africa.

Material, methods and results

Logging planted tree fallows

In many African countries, CIRAD has contributed to the introduction of an innovation which involves planting fallow land with leguminous trees (Peltier and Balle Pity 1993). This improvement of the slash-and-burn system aims to restore the fertility of degraded land and limit forest clearing by farmers while increasing the production of wood energy (Harmand et al 2004). This innovation has had some success in northern Cameroon, with the planting of *Acacia Senegal* (which also produces gum arabic (Harmand et al 2012)) and in southwestern D. R. Congo, with the planting of *Acacia auriculiformis* (also a host of edible caterpillars). In Ngong (northern Cameroon), where 900 mm of rain falls per year, fallow land with ferruginous alluvial soils exhausted by three decades of continuous cropping of cotton and sorghum were planted with 576 *Acacia Senegal* / ha. At the end of 15 years, the production of wood energy was 2.74 t/ha/year. Many farmers have found that income from the sale of firewood (73 €/ha/year) is higher than that from gum arabic, yet the latter is still promoted by research and development services (D'Andous Kissi et al. 2013). On the Bateke plateau in Mampu (DR Congo), an 8,000 hectare forest was planted for the establishment of a sequential agroforestry system (Nair, 1993). The area, with thick sandy soils (400 m) and rainfall of 1,400 mm/year, was formerly occupied by wooded savannah and then degraded by cassava crops. The average production of wood energy in the agroforestry system was estimated to be 10 t/ha/year (Bisiaux et al. 2013).

Pollarding the Sahelian and Sudanian agroforestry parklands

Calculations on small plots with a high density of trees

In northern Cameroon, agroforestry systems are being renovated following the implementation of an Assisted Natural Regeneration policy (Smektala et al. 2005). CIRAD, IRAD and AgroParisTech have studied the fuelwood productivity of *Vitellaria paradoxa* (shea-butter tree or shea) and *Faidherbia albida* (Faidherbia) parklands (Peltier et al. 2007). To enable the production of diverse items (tree fodder, fuelwood, shea fruit, and Faidherbia pods) while limiting shade over crops, livestock owners and tree owners came to an agreement that pollarding would take place on a rotating basis every eight years. The shea tree parkland, which is near the city of Garoua, receives 900 mm of rainfall per year, and is located on ferruginous alluvial soils, has a density of 30 adult trees/ha. Pruning is done late in the dry season to provide supplementary food for cattle (Fulani Zebu) and reduce shade on crops. After cattle consume the leaves (despite its high tannin content, this unpalatable foliage is nonetheless browsed due to a lack of green fodder), wood branches are left to dry and are then collected for cooking. The fuelwood productivity of this agroforestry system has been estimated at 1.07 t/ha/year.

A large Faidherbia parkland is located to the east of the city of Maroua, along the border with Chad. The soils are alluvial and ferruginous, rainfall is 600 mm/year. Trees which retain their foliage throughout the dry season are pollarded to provide a nutritional supplement for the livestock (cattle, sheeps and goats) of Tupuri agro-pastoralists. The leaves of this legume tree, rich in nitrogenous matter, facilitate the digestion of dried grass fodder. Once the foliage is consumed by animals, the branches are left to dry and then are collected to be used for thorny fences or as wood energy. In the village of Sirlawé, for an average density of 30 mature trees/ha, wood energy production was estimated at 3 t/ha/year.

Calculations on very large areas with a low density of trees

In Burkina, Mali and Niger, during the inventories made prior to the drafting of the master plans for the wood energy supply of large Sahelian cities, an attempt was made to estimate the average productivity of large areas occupied by agroforestry parklands with varying tree densities and environmental conditions. For example, in the fuelwood supply basin of Zinder, Niger (CIRAD et al. 2015), the surface of agroforestry areas *lato sensu* was estimated to be 5,108,237 ha, or 85% of the basin. The average biomass of tree crowns was estimated by an inventory carried out on 122 plots of 1 ha each, for a sampling rate of 0.0024%. The average fuelwood productivity was estimated by dividing the tree crown biomass by a theoretical 10-year pollarding rotation and by applying a 50% coefficient of "loss" to take into account the use and loss of pollarded wood. This calculated production to be 0.043 t/ha/year and, at the basin scale, 217,444 t/year, representing 54% of the wood energy produced in the region. The same study showed that wood energy accounts for 94% of domestic energy consumption in the city of Zinder, where wood energy is sold at a retail price of €100/t.

Discussion

This set of data on the productivity of AFS is a first step forward. The data clearly show the socio-economic importance of these systems for the supply of wood energy to African populations. However, precise production figures remain elusive as studies have been carried out either on small plots or over large surface areas on the basis of limited inventories.

Conclusion

In addition to traditional studies of AFS, which often focus on their agricultural and pastoral productivity or on their environmental services (impact on soil fertility, shading, biodiversity, carbon sequestration, etc.), it would be desirable to launch more research on their wood energy productivity. This would help to better understand the interests of farmers, devise more productive and profitable systems, and orientate the energy policies of the South. This research may also inspire scientists working in the North, where the use of wood energy is becoming increasingly topical and where data on the wood energy production of agroforestry systems are very rare.

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