

OPPORTUNITIES AND CONSTRAINTS OF TRADITIONAL AND NEW
AGROFORESTRY IN SOUTH-WESTERN BURKINA-FASO

Quentin GAUSSET

*Institute of Anthropology - University of Copenhagen
Frederiksholms Kanal, 4
DK-1220 Copenhagen K., Denmark
E-mail: quentin.gausset@anthro.ku.dk*

Anders RÆBILD

*Danida Forest Seed Centre
Krogerupvej 21
3050 Humlebaek, Denmark
E-mail: ARE@sns.dk*

Jean-Marie Kilea KY

*Centre National de Semences Forestière
01 BP 2682 - Ouagadougou 01, Burkina Faso
E-mail: kkilea@caramail.com*

Bassirou BELEM

*Centre National de Semences Forestière
01 BP 2682 - Ouagadougou 01, Burkina Faso
E-mail: belbass@hotmail.com*

Søren LUND

*Department of Environment, Technology and Social Studies
Roskilde University
Hus 10.1, Postbox 260,
DK-4000 Roskilde, Denmark
E-mail: slund@ruc.dk*

Emma Lucie YAGO-OUATTARA

*Centre National de Semences Forestière
01 BP 2682 - Ouagadougou 01, Burkina Faso
E-mail: ouattaralucie@hotmail.com*

Joachim DARTELL

*Center for African Studies - University of Copenhagen
Købmagergade, 46
1150 København K.
E-mail: dartell@mail.dk*

Abstract

The present article discusses the opportunities and constraints relating to agroforestry in South-Western Burkina-Faso. Two agroforestry systems are studied. The first is a traditional system found in parklands, in which indigenous trees such as *néré* and *karité* trees are intercropped with cereals. The second is a new system based on large-scale plantations of mango or cashew trees, in which intercropping happens mainly while trees are still young. The article compares the impact that different constraints - pertaining to the local use of the trees, investments, commercialisation, gender, land-tenure, labour, bushfire management, agropastoral management - have on the agroforestry systems, and discusses how these systems influence soil fertility and biodiversity. It concludes that the two systems concern different economic strategies (subsistence or market oriented), different types of trees (indigenous wild trees or exogenous planted trees), different primary beneficiaries (women or men), different tree management (low or high density; communal or private ownership), different types of problems (labour or tree tenure security on the one hand, land-tenure security, pastoral management, or investments on the other) and that the two systems are therefore complementary. The combination of these two types of agroforestry systems helps farmers to optimize agricultural production, given the existing constraints.

Keywords: *Néré* (african locust bean), *karité* (shea), mango, cashew, livelihood strategies.

INTRODUCTION

The present article discusses the opportunities and constraints in promoting agroforestry in South-Western Burkina-Faso. The discussion is based on interdisciplinary research conducted by the Petrea team, which was composed of scientists having different backgrounds (development studies, anthropology, forestry, biology). A wide range of methods were used: questionnaire survey, semi- and unstructured interview, participant observation, Participatory Rural Appraisal (PRA) ranking and problem-trees, participatory mapping, ethnobotanical survey and forest inventories (¹). This article uses the results which can contribute to a better understanding of the local problems relating to traditional agroforestry (parklands) and modern agroforestry (large-scale plantations). The comparison of traditional and new agroforestry does not intend to judge which option is the better, but intends to understand the strengths and weaknesses of each system to see the interaction and complementarity between the two systems. We will argue that the traditional and new agroforetries constitute rational, sound and important aspects of the local livelihood strategies, and that future projects should try to find solutions to the existing constraints that impede the development of the present agroforestry. Here, we will argue that some of the main constraints of the development of agroforestry in Peni are land- and tree-tenure (access to land and trees), commercialisation, agro-pastoral conflicts, and soil fertility. The identification and understanding of these constraints was the first step in the Petrea project. It will allow the research team to orientate its future research to find locally acceptable solutions in overcoming the problems that impede the development of agro-forestry in the region.

REGIONAL INTRODUCTION

The research was conducted in Peni, a small town which counted 4234 inhabitants in the census of 1996. This town is situated 35 km from Bobo-Dioulasso on the main road going to Banfora, in the Houet province (south-western Burkina Faso). This region is part of the south-sudanian bioclimatic zone, with annual rainfall exceeding 1000 mm. The number of dry months with rainfall below 50 mm is approximately five. The original vegetation in the zone is tree savannah or seasonal forest (Fontés et al. 1994). At present, land use in Peni comprises the following major categories: fallow land; different sorts of agroforestry parklands with food crops; fruit and nut tree plantations, home gardens (mainly in town), a sacred hill (on which Combretaceae and Caesalpinaceae dominate) and a few gallery forests without cultivation. Slash and burn systems are also present with both short and long-term fallow areas. The main crops produced for consumption are maize, sorghum and millet. The main cash crops are cotton, hibiscus flowers, mango and cashew (groundnut is present but less important than the other crops). It is important to realise that the town is situated on top of a cliff, which divides two areas with relatively different land-uses. On the top of the hill, investments in fruit plantations are very important. Down hill, however, fruit and nut tree plantations are much less significant and cotton and cattle herding are the primary source of income. This article focuses on the part of the village territory on top of the hill where animal browsing is less important.

The land use practices have a large influence on the number of trees and species, as will be described in more detail below. Based on mapping of the vegetation and botanical inventories carried out as transects, we estimate that the land use in the area surrounding Peni town is roughly equally distributed between fallow land, parkland with annual crops and plantations. Although the population density is still relatively low compared to other parts of Burkina Faso (11 hab/km² compared to more than four times this number in Mossi land) population pressure (migration and population growth) has brought an increasing amount of land into cultivation.

The Tiefo, a Diula speaking group, traditionally dominates the area. However, this group has welcomed large numbers of migrants which constitute about 2/3 of the population living in Peni. Most of these migrants come from neighbouring communities in South-Western Burkina Faso. Those who come from further away are mainly Mossi and represent about 20% of the total population (see also Atampugre 1993; Drabo 2000) (²).

OPPORTUNITIES AND CONSTRAINTS OF OLD AND NEW AGROFORESTRY

Agroforestry is a collective name for land use systems and technologies in which woody perennials (trees, shrubs, etc.) are deliberately used on the same unit of land as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence, and in which the woody and non-woody components interact (Nair 1993: 13-14, see also Kessler and Boni 1990).

Although trees tended in agroforestry cover a very wide range of uses (firewood, construction material, timber, medicines, food, fodder, ritual uses, etc.), people in Peni usually focus on fruit trees. They are not interested in planting trees for other reasons, although they recognise the importance of other uses (as was evident during the PRA exercises). Most trees (more than 90%) are planted and tended in order to produce food; only few people plant trees for timber and almost none plant tree for firewood. Although many local activities - beer brewing, preparation of soumbala (sauce ingredient based on néré

fruits), shea butter or food, construction, etc. - require large quantities of wood (Broutin and Laura 1992; Gattegno and Muchnik 1994; Journe 1997; Pare 2001), trees in the bush and on fallow land seem to satisfy the local demand for timber and firewood. Few people identify this as a current problem.

The four most valued trees all produce fruits and nuts. Women and men, old and young, autochthonous and migrants, everybody in Peni is interested in harvesting products from at least one of the four following species: *Parkia biglobosa* (Jaqp.) G. Don. (English: African locust bean, French: néré), *Vitellaria paradoxa* C. F. Gaertn. (Eng.: Shea nut tree, Fr.: karité), *Anacardium occidentale* L. (Eng.: cashew, Fr.: anacarde) and *Mangifera indica* L. (Eng.: mango, Fr.: manguier). In the following, we will refer to these trees as karité, néré, cashew and mango tree.

In the following, we will focus on agroforestry relating to these fruit trees. In this respect, we will distinguish between two different types of agroforestry which are practised on large scales. On one hand, traditional agroforestry concerns wild indigenous trees such as néré and karité, which are symbolically important in the local cultures (Kabore 1987). These trees are not planted, but are actively protected and tended. On the other hand, what we will call the "new agroforestry" concerns exotic trees such as cashew and mango trees. These plantations are mainly oriented towards export, although mangoes are an important food complement during the hungry period. We therefore review the strengths and weaknesses of the different forms of agroforestry concerning these species, in order to analyse their potential for development and the obstacles associated with them.

1) Nutrition

In Peni, planting trees for timber (such as *Eucalyptus sp.* or *Tectona grandis*) remains a relatively marginal activity, and planting trees for firewood is not practised at all. The main trees which are planted or tended are néré, karité, mango and cashew, and they all produce fruits and nuts consumed as food. These trees are also the object of ownership claims and account for more than 90% of the planted or tended trees (³).

Traditional agroforestry: The néré tree produces fruits whose seeds are rich in protein (41,8%) and in calcium (see Ouedraogo, M.A. 1987b: 207; Ki 1994; Ouedraogo, A.S. 1995). The seeds are dried, cooked and fermented in order to make "soubala", used as the basis of tasty sauces which accompany the main meals. The fruit also produces a yellow powder, which is poor in protein but rich in sugar (42,2%, see Ouedraogo, M.A. 1987b: 208), and which is either eaten by children, sold as cakes, or given to cattle. It can also be prepared as doughnuts, or prepared together with couscous of finger millet. In Peni as elsewhere in Burkina Faso, néré also plays a symbolic role in rituals (Ki 1994; Ouedraogo, A.S. 1995).

Karité produces oily nuts which are smoked or fried, crushed, and boiled to extract an oil which, once cooled, is "shea butter". It can be used locally as cooking oil, or it can be exported and used in the cosmetic industry or in the commercial food industry - it can replace cocoa butter in chocolate (Fold and Reenberg 1999). The oil is rich in unsaturated fatty acids (51%, a proportion comparable to that found in groundnuts or sesame oil), which decrease the concentration of cholesterol in blood and can thus help to prevent cardio-vascular diseases (Ouedraogo, M.A. 1987a: 146-7). The flesh of karité is sweet and can be eaten. Néré and karité are also used as traditional remedies for treating illness (see Bognounou 1988, Flahaut 1999, Ki 1994).

New agroforestry: Mangoes produce fruits in April and May. One big tree can produce up to 1000 fruits per year (Von Maydell 1981). In Peni much of the production is sold in local markets (and, from there, exported to the capital or other parts of the country), or is sold directly to co-operatives (which process mangoes or export them to foreign markets).

Mangoes play a very important role in the nutrition of people, especially children, because the fruits mature when other agricultural products are in short supply. But this function is limited to the few months of production. Cashew produces a red fruit to which a nut is attached. The fruit is sweet, rich in proteins and in vitamins (Agnoloni and Giuliani 1977), and is eaten by people or animals, although it is usually not commercialised on a large scale. The valuable part is the cashew nuts which, after being roasted and taken out of its shell are exported and sold on the international market.

In short, *néré* and *karité* have a very important role in providing women with valuable nutritional ingredients all year round. When the production of *soumbala* and shea butter does not cover family needs, women have to buy *soumbala* or stock (such as “*maggi cubes*”) and cooking oil on the market, lest the food prepared is nutritionally poorer ⁽⁴⁾. Mangoes are an important source of food, but only during two months per year. Cashew plays a very marginal role in the local nutrition, as most of the production is sold on markets and is thereafter exported.

2) Investment and commercialisation

Apart from being an important source of food for households, tree fruits are a very important source of income - 1/5 of the total average income of households in Peni ⁽⁵⁾. The fruits, either raw or processed, are sold on local markets. They can be consumed locally, nationally, or exported and sold through a long chain of traders on international markets.

Traditional agroforestry: *Néré* and *karité* grow in the wild and are therefore not actively planted. They are relatively resistant to fire, and do not require any special precaution to protect their growth. *Soumbala* is one of the most popular ingredients for preparing traditional sauces. Shea butter is used as cooking oil, as oil for lamps, or for local soap. Supply does not satisfy demand, as only a minority of households seem to be self-sufficient (see also Helmfrid 1998: 25, 29).

New agroforestry: In the 1980s, the region witnessed a boom in mango cultivation. The state co-operatives bought, transformed and commercialised mangoes and mango products. Mangoes began to be exported to European markets. Thousands of hectares were transformed into mango-plantations. In recent years, several co-operatives have gone bankrupt. Mangoes used to be transported to export destinations by air, but this has proved expensive, and they are now transported by boat. Many of the varieties of mango produced in Burkina Faso are not suited for this kind of transport, causing a decline in sale for the co-operatives. The big problem for mango cultivation is its short shelf life. It is a fresh product that easily spoils. Moreover, the production of mango is very seasonal. As a result, when the mangoes ripe, there are a lot of these perishable products on the market, and it is difficult to commercialise them (supply outnumbers demand, transport is a major problem, especially for isolated areas, etc.). A possible solution would be to develop post-harvest processing, such as producing mango chutney, dried mango slices, mango jam, etc. Although some of these products can be found in big towns, their production is still marginal and does not have a significant impact on the regional market of mangoes. Today, the region faces a new boom in agroforestry in cashew production. The price of cashew nut is unstable, but can be very high some years, and has so far never been below a threshold under which production is uneconomic. The problem of cashew is that it requires a lot of labour for processing before it can be consumed. As a result, cashew nuts are usually sold unprocessed, and there is no locally added value to the product. Mango and cashew are actively planted in large quantities. Cashew seeds, coming from the nuts sold on local markets, are cheap and easily planted but mango seedlings are expensive and are usually bought from a local seedling specialist. The creation of mango and cashew plantations also requires a high investment in labour for

clearing the land, planting the seeds or seedlings, and weeding the young plantations for a few years in order to prevent bush fires. Moreover, mango plantations need to be grafted, a technology which is not known by everybody.

To sum up, the *nééré* and *karité* do not have a major problem of investment or commercialisation, since they grow in the wild, *soumbala* and shea butter can be conserved for a long time, and since the demand is mainly local and is not totally satisfied by the supply. The creation of cashew or mango plantations requires a higher investment in term of labour (planting trees, weeding), cash (buying seeds and seedlings, hiring labour), and technology (grafting mangoes). The cashew nut market does not have major problems, except for the instability of prices which introduces uncertainty in household income. Only mango has acute problems of commercialisation, as the local supply outnumbers the local demand, and due to the difficulties of finding a foreign market. As a result, a significant part of the local production is wasted, or sold for a token price. A general problem is the existence of a long chain of traders and intermediaries, which keeps the benefit low for the local producers.

3) Income and gender

In Peni, men are generally the heads of households and make decisions relating to farming strategies. A man usually keeps most of the income of the household, and is responsible for providing the staple food, clothes, medicine, transport and school fees for the children (although he sometimes let his wife hold part of or all the money, especially in monogamous families). The wife has to work together with her husband in the households' fields, although she can, in addition, cultivate extra fields and earn an income from selling the products. She is responsible for taking care of the children, cleaning the house, collecting firewood and preparing food, and for providing ingredients for the sauce accompanying meals (cultivating or gathering vegetables, buying or producing cooking oil, spices, etc.) (see also Helmfrid 1998: 9-10; Thorsen and Reenberg 2000: 50).

Traditional agroforestry: Women are responsible for most of the activities linked to *nééré* and *karité* (Fold and Reenberg 1999; Helmfrid 1998; Khouw and Golane 1987). Men may participate in the harvest especially for harvesting *nééré* fruits, which often requires climbing trees, and in transporting the fruits home. But women are fully in charge of all the different steps in transforming the fruits into *soumbala* or shea butter (collecting firewood, fuming, drying, crushing, boiling, filtering, etc.). As a rule, when men are interested in *nééré* and *karité*, it is to sell the fruits as raw goods on the market. When women are interested in *nééré* and *karité*, it is on the contrary in order to produce *soumbala* or shea-butter, i.e. a product which has a use-value (Yago *et al.* 2003). In some families, the woman shares the harvest with her husband, eventually buying the husband's part to process and sell it. In others, the husband leaves all the harvest to his wife, so that she can prepare good sauces in the household. If a woman does not produce enough *soumbala* and shea-butter (if her husband does not leave her enough fruits), she will have to use her own money to buy the products or equivalents on the market, and is likely to prepare food of a much lower quality. It is therefore in the interest of the husband that his wife has access to enough *nééré* and *karité*, so that he can eat good food, although the co-operation between husband and wife varies according to the different families.

In Peni, the production of raw *nééré* and *karité* fruits accounts for about 8% of the average total household production, when given a monetary value. To this, one should add the important income that women derive from producing and selling *soumbala*, shea butter or soap made out of shea butter. Women often buy raw *nééré* and *karité* seeds and nuts on the market (sometimes from their own husband), to prepare *soumbala* and shea butter which is sold at approximately double the price of the raw fruits - but the cost of processing includes a

lot of fuel wood and time. This is one of the main economic activities of women, which accounts for a significant part of the household income. Women usually use this money to meet their obligations i.e. to buy ingredients for cooking, or to make up for their husbands' failure to live up to his responsibilities (buying clothes, medicine, staple foods, paying school fees for children, etc.) Soumbala is often given to visitors, and it helps women to maintain good social relations with kin, in-laws and relatives living in town. The importance of *nére* and *karité* for women was confirmed in our PRA exercises, as they rank these species much higher than men do.

New agroforestry: Mango and cashew trees are most often planted and owned by men as a cash crop. The income derived from mango and cashew is quite significant, and constitutes more than 10% of the total average household income in Peni. Men keep the money of cashew, and sell mangoes in big quantities to traders coming from town. Women and children are enrolled in the maintenance of the plantation and in the harvest of fruits, and can sell the mangoes that are left after the harvest, in small quantities along the road or at the market. Since women do not own land, they cannot create their own tree plantations. If widows or divorced women may sometimes create plantations, they do this in the name of their male children. Or they organise themselves in co-operatives, which makes it easier for them to create a collective plantation (Yago *et al.* 2003) Young men are more interested in mango and cashew, as they are usually interested in activities generating income. The new type of agroforestry can thus become an interesting alternative to migration to the Ivory Coast.

4) Ownership of Trees and Ownership of Land

Land is traditionally controlled by land chiefs ("*chefs de terre*"). These chiefs are in charge of distributing the land, and to conduct the traditional rituals needed to maintain fertility and avoid agricultural misfortune. As a rule, land can not be sold. It belongs to the first settlers in the area (in Peni: the Tiefu), and it is inhabited by the spirits of the ancestors, who would disapprove and mystically punish any selling of land. But another general rule is that one cannot refuse a piece of land to somebody who asks for it to cultivate for his own consumption (see Hagberg 2001). People must be hospitable and cannot let anybody starve. Until recently, migrants could receive as much land as they could farm. But today, all informants (both Tiefu and migrants) insist that land is getting scarcer because of immigration and demographic pressure. They take as a proof that it is becoming much more difficult to borrow a piece of land, and that recent newcomers have had to be satisfied with much less land than earlier immigrants. Our survey shows for example that if the size of the fields cultivated is relatively comparable in all informants' categories, the size of land left fallow is significantly lower for non-regional migrants (⁶). Additionally, the land given to recent immigrants is of poorer quality, or situated further away from the main road and Peni town. The land which is offered to migrants is leased. It still belongs to the owner and the borrower cannot sell or give it to somebody else.

Many problems arise when leased land is improved, such as when heavy bush is cleared, or when cashew or mango trees are planted. Migrants who have invested in the land are reluctant to leave without being compensated for their investments (see below). Originally, land was leased for as long as the migrant farmed it. If the migrant left the land, it returned to the chief (*chef de terre*), and could be given away to other people. But if migrants stayed long enough in the same place and farmed continuously on the same piece of land (without planting trees), they would become integrated into the local community and would be de-facto owners of their land. They would then be able to plant trees, and their children would inherit the land. However, more recently, due to land shortages and due to tenure

conflicts, the land used by new migrants tends to be leased on a temporary basis, for a few years, before it is taken back. The recent crisis in the Ivory-Coast has made the problem even more acute, as many Tiefo men come back to their area of origin and reclaim some of their (family's) land to secure themselves a livelihood.

Traditional agroforestry: Néré and karité are indigenous to Burkina Faso and regenerate naturally in the fields of Peni. People usually avoid cutting néré and karité when clearing fields, so that they can harvest fruits. When a piece of land is left fallow, the fruits are still harvested. People can also protect the new seedlings or transplant them to other fields (Kabore 1987, Maiga 1987). The tenureship of these trees varies from place to place (see for example Helmfrid 1998; Remy 1972). In Peni, these trees are owned by private individuals. When an owner leases a piece of land to a migrant, he usually makes a special agreement concerning the néré and karité trees which grow on it. Either the owner retains the full ownership of all fruits, or he shares the harvest of fruits with the migrants who use the land and harvest the fruits. However, this private ownership is generally challenged by women on the ground that there is free access to wild products, like game or wild vegetables (Yago *et al.* 2003). As a result, néré and karité fruits are often "stolen" because they are considered a "wild product", especially if they are situated far away from inhabited areas or on fallow land (i.e. closer to the bush). Some owners of néré trees attach charms to their trees in order to dissuade other people from "stealing" their fruits (see also Ki 1994). Although it is a net loss for the owner, the theft of néré and karité has the effect of democratising access to this important resource for all women in the area. In short, ownership of trees and fruits is ambiguous because the trees are considered to grow in the wild, and yet it is found on private fields and sometimes considered a private value.

New agroforestry: Mango trees are either planted close to the home, to satisfy the needs of the household, or they are planted for commercial purposes in rows in large plantations, covering entire fields. Cashew is always planted in big plantations as a cash crop. From various interviews, it is clear that one of the major reasons for creating plantations (apart from making money) is the declining yield of annual crops. When a piece of land does not produce enough output compared to the input invested, people can choose to invest in fertilisers and more intensive forms of farming. However, they seldom can afford this solution. They can choose to leave the land fallow for a few years hoping to restore productivity, or they can transform it into a plantation of mango trees or cashew. To leave the land fallow is making possible lease requests from a relative or a foreigner, or it can provide a good excuse for the owner to take land back, if the land is borrowed (see also Helmfrid 1998: 8). Therefore, when yields become too low, people don't like to leave the land fallow and usually plant trees (mango and cashew). Planted trees are usually considered, in both the traditional and modern law, to belong to the person who has planted them. The advantage of this is that the fruits belong unambiguously to the owner of the trees. Their "theft" on a large scale (7) is much more disapproved of than "theft" of néré or karité fruits. The negative aspect of this is that in the case of migrants, people own the trees that they have planted, but not always the borrowed land on which the trees are planted. This makes it difficult for the owner to take back the land and easier for the leaser to stake a claim to the land. Some of these conflicts were taken to the district officer for resolution. The district officer gave the land to the migrants who had invested in trees. One principle of modern Burkina Faso law is that anyone has the right to harvest the fruits of their labour. Therefore, owners now specifically forbid migrants to plant any trees on leased land. When an owner sees that the leaser has planted trees, he will/can take back the land immediately, before the trees grow old, or force the migrant to uproot all the trees. The result is unfortunate, as it leads to a short-term and unsustainable exploitation of land (Ouedraogo, M. 2002, Gausset *et al.* 2003). The owner

does not want the migrant to invest in the land because the migrant would have a stronger claim on the land. The borrower does not want to invest in the land because he is afraid that he won't be able to benefit from his own investment. This is a vicious circle in which the insecurity of the owner and of the leaser feed one another, and which lead to a short-term exploitation of land, detrimental to both parts (Gausset *et al.* 2003).

In summary, autochthonous people own more trees than the migrants (especially the non-regional migrants), both when it comes to traditional and new agroforestry⁽⁸⁾. Néré and karité are seldom the centre of land-tenure conflicts, but are the object of tree-tenure conflicts. The owner of the fields or fallow on which they stand claims their ownership (when the land is borrowed by someone, the harvest is usually shared with the owner). But as nobody has planted these trees, women claim that they belong to no-one and that they can have free access to them. The fruits are therefore "stolen", and this practice is not seriously/strictly condemned, especially if trees are situated far from town or on fallow land. The ownership of planted trees, on the other hand, is unambiguous, but it may render the ownership of land ambiguous when the owner of the tree is the not the owner of the land. This leads to serious conflicts as well as to unsustainable farming strategies which prevent farmers from addressing the problem of declining soil fertility over time.

5) Availability of Labour

Labour is one of the main constraints of agricultural production (Bolvig 2000, Helmfrid 1998, Remy 1972: 116; Thorsen and Reenberg 2000: 52). It plays an important role in defining the opportunities and constraints of agroforestry.

Traditional agroforestry: The néré fruits mature, are harvested, and are processed into soumbala in April-May, i.e. before planting and soil preparation begin. At this time there is no labour shortage. However, the karité fruits mature and fall from trees in June-July, i.e. at the beginning of the rainy season, when heavy agricultural work (planting, sowing) has already begun. It is important to harvest and dry the fruits quickly, lest they rot. This requires a fair amount of labour at a time where it could be used elsewhere (June is a month with intensive work in the fields). This is an important constraint. Processing nuts into shea butter is done mainly in August-October, when women have more free time (after weeding and before harvesting the main crops), although it can also be done all the year round.

New agroforestry: the use of labour in new agroforestry is almost optimal because the harvest of the fruits happens when there is no other major agricultural activities (after the harvest of staple crops, and before field preparation). The labour invested in this agroforestry is therefore not taken from other agricultural activities - see the table in note⁽⁹⁾. Moreover, almost anybody can participate in harvesting mango and cashew fruits. Children and elderly people cannot participate in heavy agricultural work, and cannot go far into the bush to harvest néré and karité fruits but can participate in mango and cashew harvest. As there is no local market for processed mangoes and cashew nuts (and as processing these products requires a high investment in terms of technology and labour), they are not locally transformed. Some people have consciously created plantations as a kind of "retirement benefit", which will secure them an income even after they are too weak to work in fields. The new agroforestry is therefore a good complement to agriculture, as far as labour is concerned.

6) Intercropping and bush fire management

Bush fires occur mainly during the dry season, after annual crops have been harvested (Nielsen and Rasmussen 2001). Although the authorities in Burkina Faso forbid bush fires, they occur widely. Slash and burn is practised when fallow land is taken into cultivation and

sometimes fire escapes to other areas than that intended. Early fires are to protect houses and fields from later, more serious, fires. The later fires tend to be more serious because of lack of moisture in the vegetation and because of the fuel build-up from crops. Pastoralists can also light early fires in order to hasten the regeneration of grass, and fires can be started for hunting purposes. Some of them are due to conflicts and are lit in order to harm others. They can also be lit accidentally, for example by smokers who throw their cigarette away.

Tree responses to fire are complex, and some species may actually benefit from fires (e.g. Sawadogo and Nygård 2000). However, fires may also cause serious damage to trees, especially when they are still young. To avoid damage, fields must be cleared of grass at the beginning of the dry season. This requires a lot of labour, which can be expensive if labour is hired. However, when annual crops are planted between trees, weeding the annual crops helps to keep the tree plantation free from dry grasses. Apart from optimising maintenance labour, inter-cropping can also optimise the production of a piece of land through combining crops and fruits outputs.

Traditional agroforestry: Intercropping is more or less built in the traditional agroforestry system. The number of *néré* and *karité* trees is controlled by the farmers because the space taken by the trees and the shade that they produce can impede the production of annual crops (Maiga 1987: 49, see also the 9th point in this article), although the loss in production can be mitigated by the cultivation of shade-tolerant crops such as sweet potatoes. The intercropping of *néré* and *karité* in agricultural fields produces therefore additional income from the fruits, but it is allowed only in so far as it does not inhibit the production of annual crops excessively. Moreover, *néré* and *karité* resist fire relatively well ; bush fires might disturb their production, but seldom kill trees themselves. Bush fires are more serious in areas that are left fallow than in areas which are cultivated, as the weeding and the harvest (and, perhaps, the roaming of cattle eating the stalks remaining in the fields that have been harvested) mitigate the intensity of subsequent fires in cultivated fields.

New agroforestry: The crown cover of the trees is much higher in mango or cashew plantations than in *néré* and *karité* parklands. In new agroforestry, intercropping of trees with annual crops produces additional income, but is practised only as long as the trees do not shade the crops too much. In young plantations, the seedlings are very weak and sensitive to drought, cattle grazing and trampling, and bush fires. To prevent damage from drought, the seedlings are planted at the beginning of the wet season, and can eventually be watered in the rare case where water is available nearby the field. As for bush fires, the best way to keep them under control is to intercrop trees with annual crops. In young plantations, any crop can be planted (maize, sorghum, groundnuts, etc.). Later on, as trees grow, their shade severely limits the possibility of practising large-scale agriculture. But they still allow the practise of small-scale agriculture. Intercropping seems to become very difficult in the case of cashew plantations, for reasons which remain to be analysed (see under point 9).

In summary, intercropping can mean very different things. In the traditional agroforestry, the focus is on annual crop production and trees are secondary. In the new agroforestry, the focus is on tree production and annual crops are secondary. Although very important when plantations are still young, the yields of annual crops decline when trees grow older. Intercropping in the two agroforestry systems is an excellent strategy to maximise both labour and output, since the necessary maintenance and weeding of trees is done through producing annual crops.

7) Agropastoral conflicts

Nomadic or semi-nomadic pastoralism is a rational strategy which maximizes the production and health of cattle through taking advantage of extremely variable geographical

opportunities (see for example Swift 1977; 2000). However, when considering the constraints linked to agroforestry (especially mango and cashew), the unchecked mobility of cattle represents a problem. In the past 20-30 years, pastoral Fulani have established themselves in increasing numbers in the region of Peni. Since there was no cattle prior to their arrival, the new situation has inevitably brought new problems (see also Tiemtore 1997; Oksen 2000), including problems for agroforestry. During the wet season, the Fulani cattle are usually carefully herded in the bush, out of the farming zone. However, during the dry season, when vegetation is scarce, cattle invade the agricultural space to eat the stoves left in the fields, and frequently browse or trample young trees. Agriculturalists often blame Fulani people for not looking carefully after their cattle, unlike agriculturalists themselves who usually keep their cattle at home at night and follow them everywhere when they go out.

Traditional agroforestry: The *néré* and *karité* which are found in fields are usually old and strong enough to resist pastoral pressure during the dry season. It is unclear whether wandering cattle eat and destroy young seedlings. However, even if this is the case, nobody complains about cattle preventing these trees from growing, because they are not actively planted.

New agroforestry: Cattle can damage big cashew and mango plantations in different ways: through eating the fruits and through eating the seedlings. Here, it is important to distinguish between the situation on the top of the hill and down hill. On the top of the hill, most cattle are looked after at all times, and are prevented from entering plantations. There are, therefore, not so many problems. Down hill, however, things are very different. Most of the cattle stay there during the dry season because they have better access to water. Although herders look after their cattle carefully during the wet season and prevent them from invading the fields during the farming time, they let their cattle wander around during the dry season and do not see plantations as something valuable needing protection. Even when cattle are caught damaging a plantation (eating and destroying the seedlings in young plantations, or eating fruits of older plantations) and the herders brought to court, they often refuse to pay any compensation for the damages. This is a major constraint that discourages people down hill from investing in planting new plantations.

8) Vegetation and biodiversity

Despite the important nutritional and monetary outputs that result from the species used in the agroforestry systems, trees that are considered less important or are less frequent may still produce important products for the local people. Trees are used for firewood or for construction; bark, flowers, roots and leaves are used for medicinal purposes; wild fruits and leaves are used in salads and sauces (Chweya and Eyzaguirre 1999; Mertz and Reenberg 1999; Mertz et al. 2001; Lykke et al. 2002). The uses are manifold, and the “new” species cashew and mango trees can only supply part of these services. The range of outputs and services produced by all the trees present introduces flexibility and a range of choices in the daily living.

By means of transect studies and registration of the botanical composition, the vegetation and biodiversity of the traditional and modern types of agroforestry were described and compared with fallow land (Ræbild et al. in prep.). The whole system is dynamic as farmers convert land from one land-use to another (e.g. from fallow to parkland or plantation, or from parkland to plantation), and the vegetation changes accordingly. Only insignificant differences were found in the woody biomass between young and old fallows, traditional agroforestry systems and plantations. Even though old fallows on average had the highest basal area (which is indirectly a measure of biomass), there were no statistically significant differences between the basal area found in the different land-use categories

(young and old fallow, plantations, and traditional agroforestry systems). Thus it seems that there is no reason to believe that the introduction of fruit plantation will mean that less wood will be available for such purposes as firewood (Ræbild et al. in prep.).

As regards species richness, we found no differences between the karité and néré parklands and the plantations. The number of species, both for young and larger trees, was about the same in the two systems, and the number of trees expressed on a per-area basis were higher (but not significantly different) in the plantations than in the parklands. It is interesting to note that in the parklands and plantations, many species were present as young trees, but not as old. Only few tree species grow to maturity, presumably because they are cut down during preparation and tending of fields. It is when comparing parklands and plantations with fallow land that large differences were revealed. Both the number of trees and the number of tree species were considerably higher in old fallow than in the other land-use categories. Most of the benefits from a high diversity of tree species are thus to be found in old fallow fields. If tree diversity is a concern, the net conversion of fallow land into orchards or parkland is therefore much more of a problem than the conversion of parkland into fruit orchards.

9) Soil fertility and productivity

Many farmers claim (in our semi-structured interviews), that plantations are often created in fields which have a declining soil-fertility resulting from continuous cultivation. This allows farmers to secure long-term benefits on degraded land. It is unclear, however, how much tree plantations can replenish soil-fertility. In parklands, soil nutrient concentrations under trees are often found to be higher than in the open (Boffa et al. 2000, Kessler 1992, Tomlinson et al. 1995), but it is not always clear why. Concentration of nutrients under trees could be caused by re-translocation of nutrients, carried by the roots from outside the canopy to the tree, but could also be because trees intercept dust from the atmosphere, and because animals deposit their dung underneath trees when they seek shade. Furthermore, many leguminous trees may have nitrogen-fixing capabilities, but in a study from Burkina Faso, néré (the only leguminous tree of the four species we are dealing with here) does not seem to have this ability (Tomlinson et al. 1995). The degree to which the four species are able to concentrate nutrients is not known. The farmers in Peni claim that cashew trees deplete the soil of nutrients, making cultivation of other crops difficult. However, it will take an experimental approach to confirm whether this is really a matter of soil fertility or if it is because the trees shade crops excessively, and whether cashew is different from other species.

Trees have important effects on their environment, such as reduction of wind speed (thereby reducing wind erosion and transpiration of crops), but also compete with annual crops on water, light and nutrients. Interactions between annual crops and trees are difficult to describe, because of a high degree of complexity. The tree/crop interface depends on a number of factors, such as tree and crop species, tree density and size, but also on environmental factors such as soil type, fertility, and climate (which may vary from year to year), and on the applied agricultural techniques (including crop variety and application of manure or chemical fertiliser). Most studies are limited to investigating one site in one or a few growth seasons, and the results may seem contradictory (Boffa et al. 2000, Kessler 1992, Wilson et al. 1998).

However, for trees such as Néré and Karité, it is commonly observed that the yields of crops grown underneath the trees are lower. Sorghum plants are smaller and produce less than in the open with no shade. Although a single study showed that the presence of medium sized trees increased sorghum yields, other studies indicate that trees cause lower yields in

annual crops (Boffa et al. 2000, Kessler 1992, Maïga 1987, Ouedraogo, A.S. 1995, Senou and Bagnoud 1998; Wilson et al. 1998). Thus, it appears that in most cases the farmer has to make a choice between crop yield and the products from the trees – the more trees in the field, the smaller his harvest of cereals. Data for the interaction between crops and cashew and mango in West Africa is scarce. Farmers in Peni only intercrop these species during the first years of plantation, indicating that the competition from trees inhibit the development of annual crops when the trees grow old, in contrast to the parklands that are cultivated throughout the lifetime of the tree.

Our studies of soil properties in the lands of Peni showed that the soils were poor in organic matter, nitrogen, potassium and especially phosphorous (Ræbild et al. in prep). The nutrient concentrations were highly variable between samples, and there were significant differences between sites within the territory of Peni. Even so, nitrogen and phosphorous were always in the medium to low range. The variation was not associated with land use, and we found no significant differences between fallows, traditional agroforestry systems and plantations. We cannot exclude that the different land uses affect the soil properties differently, but given the variation between sites, much more detailed studies are needed to verify this. It is likely that such differences will become manifest only after many years.

What are the prospects for increasing the productivity in the different agroforestry systems? This can be achieved either by improving the techniques applied in cultivation, or by changing the components in the systems. From the data on nutrients in the soil it is clear that almost any input of nutrients (e.g. animal manure or chemical fertiliser) will have the potential to increase the yields.

Studies of coppicing of trees suggest that the yield depression of annual crops underneath the crown can be reversed (Tilander et al. 1995, Timmer et al. 1996). However, the effects on tree productivity have not yet been tested, and could vary from species to species. Also, it is clear that the distance between trees affect the productivity of cereals (Boffa et al. 2000, Tilander 1995). Presumably there will be no single optimal combination between trees and crops, because individual farmers may have different strategies.

Possibilities for genetic improvement of trees seem to be relevant mainly for the species that are currently planted (cashew and mango). Only few people will bother to plant improved material of species that regenerate naturally in the fields – a large improvement in the productivity of the trees will be needed to convince people that they should invest in buying plants and take care of them after planting.

For mango, the possibilities for using genetically improved material are obvious. A range of varieties already exists, and is available at nurseries in nearby Bobo Dioulasso. Some of the farmers have experience with grafting, and given the economic incentives in having mangoes that are suited for the export market, it is probably only a matter of time before new varieties flourish in Peni.

Propagated mainly by seed, cashew is closer to being a “wild” species than mango. The source of the seed in Peni is unknown. Nevertheless, efforts are underway in many countries to improve the productivity of the species, and high-yielding dwarf varieties are now available in Brazil. This could also be an option for farmers in Burkina Faso, but the first step (development and testing of new varieties) is beyond the scope of the farmers and obviously requires the input from researchers and larger organisations.

At present, all four tree species appear to be healthy in Peni, and farmers have not reported any problems on this aspect. The native species (nééré and karité) have been on the site for centuries and although some minor diseases exist (see for example Boussim 1991), they are not crucial for the production of the trees. However, there are recent reports from the northern part of the Ivory Coast of mangoes being seriously attacked by a fruit fly that used

to have an African relative of mango as host (Steck 2000). If the fruit fly spreads, it could become a constraint for the cultivation of mango. Similar concerns should apply for cashew: whereas the native species have adapted to the environment and the fauna for a long time, one cannot exclude the possibility of pests and diseases attacking exotic species. This speaks in favour of having a diversified livelihood strategy – if the fruit fly destroys the harvest of mango, there will still be income from cashew, native trees and annual crops.

CONCLUSION

We believe that the different aspects discussed are the main determinants of agroforestry of the *néré*, *karité*, mango and cashew trees. They constitute either the main reason why those trees are planted (for food, income, optimisation of production, labour and land security), or the main constraints impeding further development of agroforestry (land and agro-pastoral conflicts, lack of labour and knowledge, problems of commercialisation and – sometimes – of soil fertility). They are summarised in the following table, in which a plus indicates the comparative advantages of some trees when considering a certain aspect, and a minus indicate comparative disadvantages.

Table 1: Comparison of advantages and disadvantages of traditional and new agroforestry

	Néré	Karité	Mango	Cashew
Local source of food	++	++	+	-
Commercialisation	++	++	-	++
Investment (labour, cash, technology)	++	++	--	-
Income (men)	+	+	++	++
Income (women)	++	++	+	-
Security of ownership of trees	-	-	++	++
Source of land conflicts	+	+	--	--
Availability of labour to harvest and transform	+	-	+	++
Intercropping	++	++	+	-
Agro-pastoral conflicts	++	++	-	-
Vegetation and biodiversity	+	+	+	+
Susceptibility to diseases and pests	+	+	-	-

+ = good or no problem

++ = very good or no problem at all

- = bad or problematic

-- = very bad or very problematic

The table shows that *néré* and *karité* share most advantages and disadvantages. It also shows that the advantages and disadvantages of the traditional agroforestry are very different from, and in most cases, radically opposite to those of the new agroforestry. This is partly because the two systems have different foci. Traditional agroforestry focuses on subsistence agriculture, the new one focuses on cash crops. The two systems concern different types of trees that are managed differently - wild indigenous trees with a low crown cover on one side, and planted exotic trees with a high crown cover on the other. They produce different types of fruits. From *néré* nuts, (soubala and shea butter can be made and preserved for a long time and are locally consumed; mangoes are both consumed locally and abroad but are

difficult to preserve, and cashew nuts are not consumed locally but can be preserved. It seems clear that these two types of agroforestries are complementary. Their co-existence makes sense when seen as a strategy of diversification of households' livelihood strategies whose aim is to optimise agricultural production while taking into accounts all the aspects that constrain it.

Our aim in Petrea is to help local people to find viable solutions to their problems relating to agro-forestry. In Peni, we think that the present local strategy (the investment in néré, karité, mango and cashew) is well suited to sustain the livelihood of a great number of households. We therefore think that our task is to support local people in implementing their strategies, and to help them overcome the constraints that impede on the development of the different forms of agroforestry. As we have shown in this article, many of the constraints are not technical problems, but are socio-economic problems (commercialisation, access to land for migrants, women and young people, security of tenure, availability of labour, and agro-pastoral conflicts), although declining land-fertility is also of serious concern. The next phase of the Petrea research will be to identify possible and sustainable solutions to these constraints. We are aware, though that if the present trend of creating cashew and mango plantations continues unabated, the balance between gender might be upset, and the agriculture might become more risky and less flexible (not to mention the possible loss of biological diversity and of fodder for cattle, sheep and goats). We think that the balance between the traditional and new agroforestry is important, as it secures a diversification of income, and as it addresses the needs of both men and women.

References

- Agnoloni M. and Giuliani F. (1977), *De la culture de l'Anacardier*, Bibliothèque Agricole Tropicale, Florence, Istituto Agronomico per d'Oltremare;
- Boffa J.-M., Taonda S.J.-B., Dickey J.B. and Knudson D.M. (2000), Field-scale influence of karite (*Vitellaria paradoxa*) on sorghum production in the Sudan zone of Burkina Faso, *Agroforestry systems*, 49, 153-175;
- Bognounou O. (1988), De quelques utilisations traditionnelles du Karité, In *Séminaire national sur la valorisation du karité pour le développement national: Bilan et perspectives*, Ouagadougou 15-18 novembre 1988, Ouagadougou, Ministère des enseignements secondaire, supérieur et de la recherche scientifique.
- Bolvig S. (1999), Between nature and society: work among the Fulani Rimaybe in Northeastern Burkina Faso, In Lykke A.M. et al. (eds.), *The Sahel: Nature and Society*, SEREIN - Occasional Paper, 10, 13-33, SEREIN (Sahel-Sudan Environmental Research Initiative), Copenhagen;
- Boussim I. J. (1991), *Contribution à l'étude des tapinanthus parasites du Karité au Burkina Faso*, PhD Thesis, Ouagadougou, University of Ouagadougou;
- BROUTIN C. and LAURA P. (1992), *Artisanat alimentaire et consommation de bois de feu* (3e partie), Montpellier et Nogent-sur-Marne, Altersyal et Association bois de feu (ABF);
- Chweya J.A. and Eyzaguirre P.B. (1999), *The Biodiversity of traditional leafy vegetables*, Rome, IPGRI;
- Drabo I. (2000), Le dynamisme des migrants Moose dans l'Ouest du Burkina Faso. L'exemple du système de production Moaaga dans la province des Banwa, *Annales de l'Université de Ouagadougou, Série A*, XII: 173-201;

- Flahaut E. (1999), *Pharmacopée et médecine traditionnelle dans l'ouest du Burkina Faso: Plantes médicinales et soins du couple mère-enfant*, Lille: Université de Lille II;
- Fold N. and Reenberg A. (1999), In the shadow of the 'Chocolate War': local marketing of shea nut products around Tenkodogo, Burkina Faso, *Geografisk Tidsskrift*, special issue, 2, 113-23;
- Fontés J., Diallo A. and Campaoré J.A. (1994), *Carte de la végétation naturelle et de l'occupation du sol, Burkina Faso*, Paris, ICIV;
- Gattegno I. and Muchnik J. (1984), Bois-énergie et artisanat alimentaire: Le cas du dolo en Haute Volta, In Vielajus J.-L. (ed.), *Maîtrise de l'énergie dans les pays sahéliens*, Paris, GREC (Groupe de recherche et d'échanges technologiques), 69-79;
- Gausset Q., Ræbild A., Belem B. and Dartell J. (2003), Land tenure, forest policies and forestry practices in Burkina Faso: some preliminary findings from two villages, *SEREIN - occasional paper 15* (forthcoming);
- Hagberg S. (2001), In Search of Nyo: Lyela Farmers' Perceptions of the Forest in Burkina Faso, *Africa*, 71 (3), 481-501;
- Helmfrid S. (1998), *La cueillette féminine dans l'économie familiale: L'exemple d'un village cotonnier burkinabe*, Rapport de recherche, Ouagadougou, CNRST and IRD;
- Journe B. (1997), *Production, vente et consommation de la bière de mil (dolo) à Ouagadougou (province du Kadiogo au Burkina Faso): aspects économiques, techniques et culturels*, PhD Thesis, Paris, Université de Paris IV-Sorbonne;
- Kabore O. (1987), L'arbre dans la pensée symbolique chez les Moose: l'exemple du néré, du karité et de l'acacia albida, in *Recueil des communications présentées au séminaire national sur les essences forestières locales, tenu à Ouagadougou du 6 au 10 juillet 1987*, Ouagadougou, CNRST, 34-45;
- Kessler J.J. (1992), The influence of karité (*Vitellaria paradoxa*) and néré (*Parkia biglobosa*) trees on sorghum production in Burkina Faso, *Agroforestry Systems*, 17, 97-118;
- Kessler J.J. and Boni (1990), L'agroforesterie au Burkina Faso: Bilan et analyse, Tropical resource management paper, 1, Nature Conservation Department, Wageningen, University of Wageningen;
- Khouw L. and Golane C. (1987), L'importance économique du karité pour les femmes, in *Recueil des communications présentées au séminaire national sur les essences forestières locales, tenu à Ouagadougou du 6 au 10 juillet 1987*, Ouagadougou, CNRST, 150-8;
- Ki G. (1994), Etude socio-économique de la gestion de *Parkia biglobosa* (Jacq) R. BR. EXG. DON (Néré) au Burkina Faso, Ouagadougou, IDR/CNSF;
- Lykke A.M., Mertz O. and Ganaba S. (2002), Food Consumption in Rural Burkina Faso, *Ecology of Food and Nutrition*, 41, 119-53;
- Maiga A. (1987), L'arbre dans les systèmes agroforestiers traditionnels de la province du Bazega: Influence sur les cultures, In *Recueil des communications présentées au séminaire national sur les essences forestières locales, tenu à Ouagadougou du 6 au 10 juillet 1987*, Ouagadougou: CNRST, 47-54;
- Mertz O., Lykke A.M. and Reenberg A. (2001), Importance and Seasonality of Vegetable Consumption and Marketing in Burkina Faso, *Economic Botany*, 55(2), 276-89;
- Mertz O. and Reenberg A. (1999), Building on diversity: pathways to agricultural intensification in Burkina Faso, *Geografisk Tidsskrift*, special issue, 2, 125-37;
- Nair R.P.K. (1993), *An Introduction to Agroforestry*, Dordrecht, Kluwer Academic Publishers;

- Nielsen T.T. and Rasmussen K. (2001): Utilization of NOAA AVHRR for assessing the determinants of savanna fire distribution in Burkina Faso, *International Journal of Wildland Fire*, 10, 129-135;
- Oksen P. (2000), *Cattle, Conflict and Change: Animal Husbandry and Fulani - Farmer Interactions in Boulgou Province, Burkina Faso*, PhD Thesis, Roskilde University;
- Ouedraogo, A.S. (1995), *Parkia biglobosa* (Leguminosae) en Afrique de l'Ouest: Biosystématique et Amélioration. Institute of Forestry and Nature Research IBN-DLO, Wageningen;
- Ouedraogo M. (2002), Le foncier dans les politiques de développement au Burkina Faso: Enjeux et stratégies, *Dossier IIED* 112, London, IIED;
- Ouedraogo M.A. (1987a), Valeur nutritionnelle du beurre de karité, in *Recueil des communications présentées au séminaire national sur les essences forestières locales, tenu à Ouagadougou du 6 au 10 juillet 1987*, Ouagadougou, CNRST, 143-49;
- Ouedraogo M.A. (1987b), Contribution à l'étude de la valeur nutritive de la poudre jaune du Néré et du soumbala, in *Recueil des communications présentées au séminaire national sur les essences forestières locales, tenu à Ouagadougou du 6 au 10 juillet 1987*, Ouagadougou, CNRST, 204-10;
- Pare I.J. (2001), *Logiques sociales, économie du bois de chauffe, énergies nouvelles: Etude du cas des dolotières dans la commune de Toma (province du Nayala)*, MA Thesis, Ouagadougou, Université de Ouagadougou;
- Ræbild A., Dartell J., Hansen H. and Ky J.-M.K. (in prep.), Land use and vegetation in two villages in Burkina Faso;
- Remy G. (1972), *Donsin: Les structures agraires d'un village Mossi de la région de Nobéré (cercle de Manga)*, *Recherches Voltaïques*, 15, Paris, CNRS;
- Sawadogo L. and Nygård R. (2000), Effects of livestock and prescribed fire on coppice growth after selective cutting in the north Soudanian savanna in Burkina Faso, In Nygård R. (ed.), *Productivity of woody vegetation in savanna woodlands in Burkina Faso*, Thesis, Acta Universitatis Agriculturae Sueciae Silvestriæ, 144, Umeå, Sweden;
- Senou O. and Bagnoud N. (1998), Etude de la structure et de la dynamique des parcs à Karité et Nere en zone Mali-Sud, In *Quel avenir pour le karité en zone soudano-sahélienne?* Actes de la 9e session de la rencontre tripartite des structures de recherche forestière du Burkina Faso, de la Côte d'Ivoire et du Mali, Sikasso, 24-26 novembre 1999, Bamako, Ministère du développement rural et de l'eau;
- Steck G.J. (2000), *Ceratitidis cosyra* (Walker), *Entomology Circular*, 403, 1-2;
- Swift J. (1977), Sahelian Pastoralists: Underdevelopment, Desertification, and Famine, *Annual Review of Anthropology*, 6, 457-78;
- Swift J. (2000), Prospects for the Sahelian Economy, *SEREIN Occasional Paper*, 11, 77-88, SEREIN (Sahel-Sudan Environmental Research Initiative), Copenhagen;
- Thorsen D. and Reenberg A. (2000), Marginal producers or breadwinners: Women's cropping strategies and access to agricultural key resources in Boulgou province, Burkina Faso, *Geografisk Tidsskrift - Danish Journal of Geography*, 100, 47-59;
- Tiemtore S. (1997), *La sécurisation foncière de l'élevage dans les zones pastorales du Burkina Faso: cas de Sondre-Est*, Ouagadougou, Institut Panafricain pour le Développement;
- Tilander Y., Ouedraogo G. and Yougma F. (1995), Impact of tree coppicing on tree-crop competition in parkland and alley farming systems in semiarid Burkina Faso, *Agroforestry Systems*, 30, 363-378;

- Timmer L.A., Kessler J.J. and Slingerland M. (1996), Pruning of néré trees (*Parkia biglobosa*) on the farmlands of Burkina Faso, West Africa, *Agroforestry systems*, 33, 87-98;
- Tomlinson H., Teklehaimanot Z., Traoré A. and Olapade E. (1995), Soil amelioration and root symbiosis of *Parkia biglobosa* in West Africa, *Agroforestry systems*, 30, 145-159;
- Von Maydell H.-J. (1981), Arbres et arbustes du Sahel. Caractéristiques et utilisations, Hamurg, GTZ;
- Wilson T.D., Brook R.M. and Tomlinson H.F. (1998), Interactions between néré (*Parkia biglobosa*) and under-planted sorghum in a parkland system in Burkina Faso, *Experimental Agriculture* 34, 85-98.
- Yago-Ouattara E.A., Gausset Q. and Belem B. (2003), Gender and Trees in Southwestern Burkina Faso. Women's needs, Strategies and Challenges, in Mertz O., Wadley R. and Christensen A.E. (eds.), *Local Land Use Strategies in a Globalizing World: Shaping Sustainable Social and Natural Environments*, Copenhagen, DUCED-SLUSE, 341-58.

NOTES

¹ The questionnaire survey concerned 104 households, i.e. about 20% of all the households living in Peni (including Kogoue, Wondjan and Saki sub-villages). On the basis of the census of 1998, we selected every fifth household, found it and interviewed the head of the household. The households which had moved away were replaced by a neighbouring household which was related to the targeted one. Some of the households, as they were defined on the census, worked together in the fields, which means that we lumped them together and we ended up having 89 households defined as agricultural units. In the following, we will distinguish between Tiefo (the autochthonous population), the regional migrants (Diula, Daffin, Tienkan, Senufo, Toussian, Bobo, etc.), the Peul or Fulbe (only 2 households in our sampling - about 20% of the total Fulani population) and the non-regional migrants (mainly Mossi).

The questionnaire recorded data on the composition of the household, on migration of household members; on the species and number of trees owned, on the crops planted, on the number of animals owned, on the out-farm activities, and on the income derived from these products or activities. Cross-checking some of these data with other methods shows that they are very problematic. People have great difficulties evaluating their field size, number of trees and income. However, if we assume that these difficulties are equally spread among all ethnic groups, the data harvested can still provide us with a broad picture of the situation, not in absolute but in relative terms.

PRA matrix ranking exercises were organised with a group of women, a group of men, a group of young men, and a group of migrants, who were asked to rank the trees that they used according to their importance relating to different uses.

About 50 semi- or unstructured interviews were conducted with various kinds of informants (people from various geographical origins, men and women, local authorities, member of local cooperatives or associations, etc.)

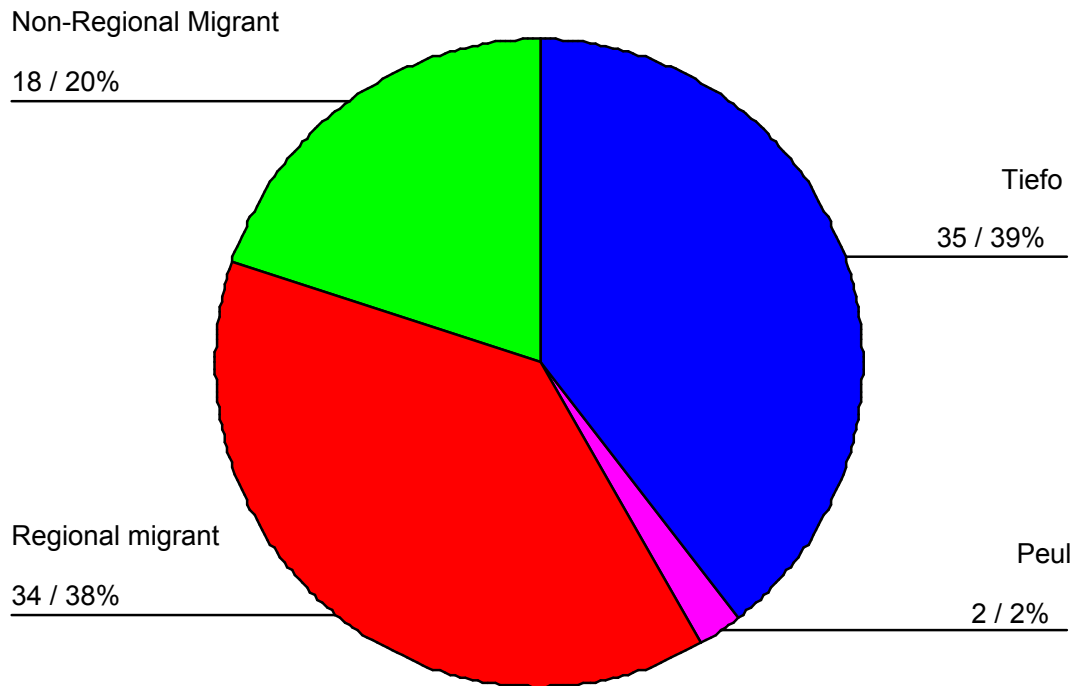
The botanical inventory was made as a stratified sampling, first registering the different types of vegetation (fallow land, plantation, parkland, sacred hill, etc.) and then making a certain number of randomly chosen plots in each type of vegetation. The total number of plots was 31, and the size of the radius was varying between 5 and 40 m, aiming at

having approximately 10 trees on each plot. Within each plot, all tree vegetation was registered. For each tree we noted the species, height, diameter and signs of browsing and cutting. The number of short (<1.3m), young regenerating trees was counted without measuring their height or diameter. In this way we could calculate frequencies of different species, their distribution with respect to different size classes and the degree to which they have been estimated by the observers to be cut and browsed.

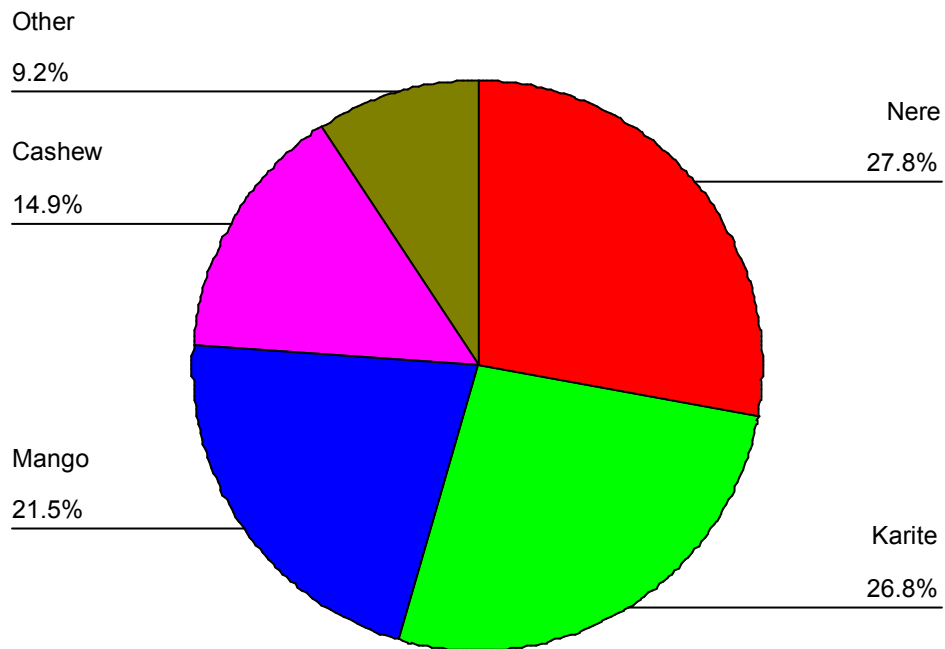
59 soil samples were taken at random within the village territory. The soil profile was described together with the land use system and the vegetation. N, P, K, organic matter and pH was analysed according to standard methods used by Bureau National de Sols, Burkina Faso (see Ræbild et al. in prep.).

Other methods were practiced (such as quantitative and qualitative ethnobotanical survey, remote-sensing, participatory assessment of soil quality), but the present article does not rely on them.

² Figure 1: Composition of the sampling of our questionnaire survey, according to the geographical origin of informants (Tiefo = indigenous people in Péní; Regional migrants = Diula, Daffin, Toussian, Bobo, and so on, i.e. all people coming from the South-West of Burkina Faso; Non-Regional migrants = people coming from other parts of the country, mainly Mossi).



³ Figure 2: Percentage of planted and tended trees which are claimed to be owned by the informants. In the category "other", one finds eucalyptus, teak, lemon tree, tamarin tree, etc.



⁴ Some studies show that introduced products are increasingly favored because they are regarded as modern and prestigious, in contrast to traditional products that are associated with poor and rural way of life. However, they continue to remain an important part of the local diet (Mertz et al. 2001; Lykke et al. 2002).

⁵ Figure 3: Comparison of the different sources of production per household derived from tree products (raw fruits and nuts), crops production , petty trade and salaried jobs (keeping a restaurant or a shop, buying and selling goods, keeping a restaurant, preparing and selling shea-butter, soumbala and soap, etc.), and herding animals (cattle, sheep, goats, chicken, ducks, pigs). This evaluation takes into account subsistence (the production which is consumed by the household). It is based on the evaluation of the total annual production of cereals, fruits, animals or goods, to which an average monetary value is given.

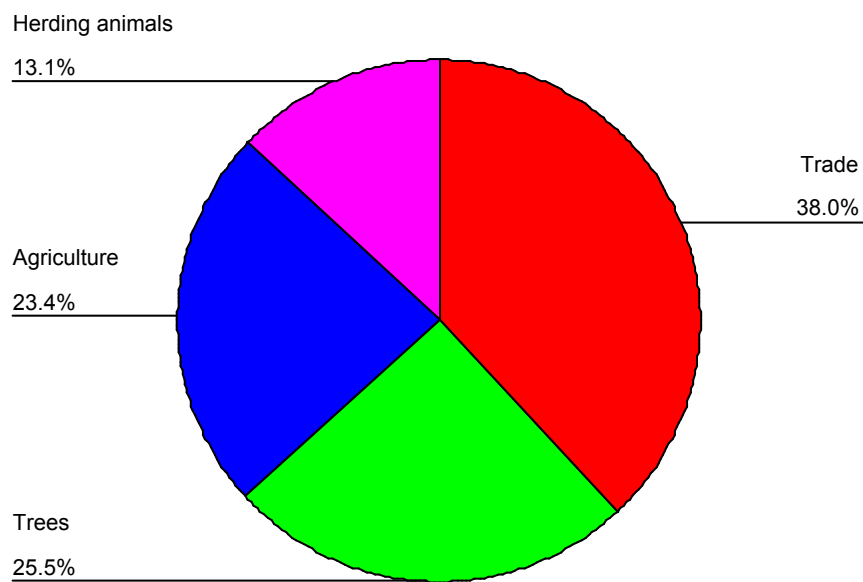
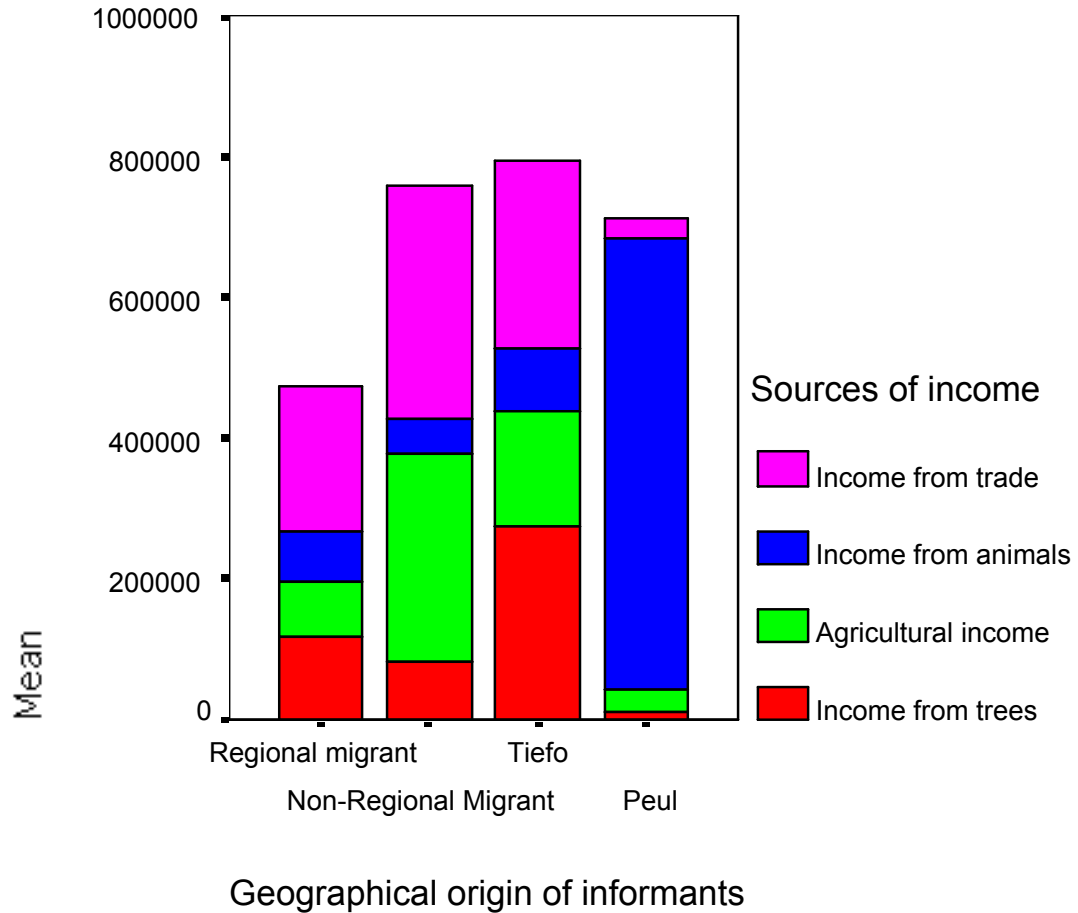
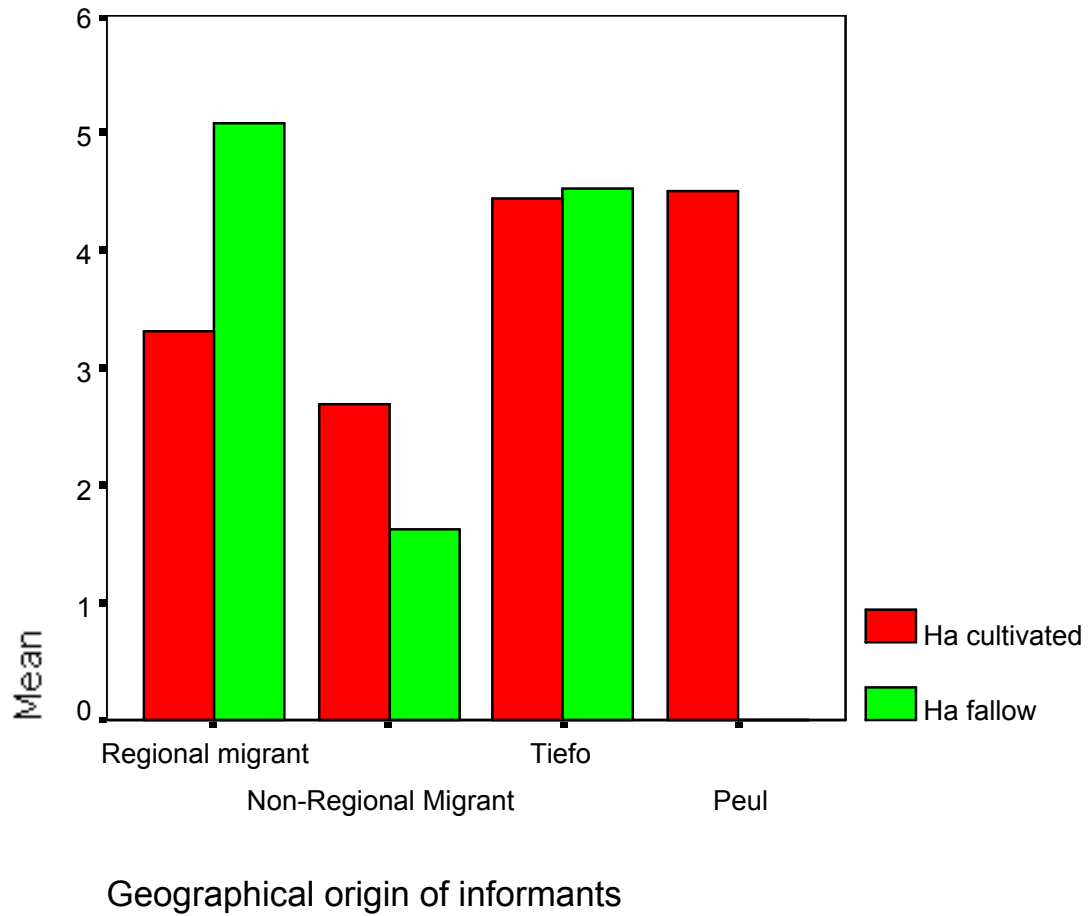


Figure 4. Comparison of the sources of income per household, according to the geographical origin of informants. The income takes into account subsistence (the production which is consumed by the household).

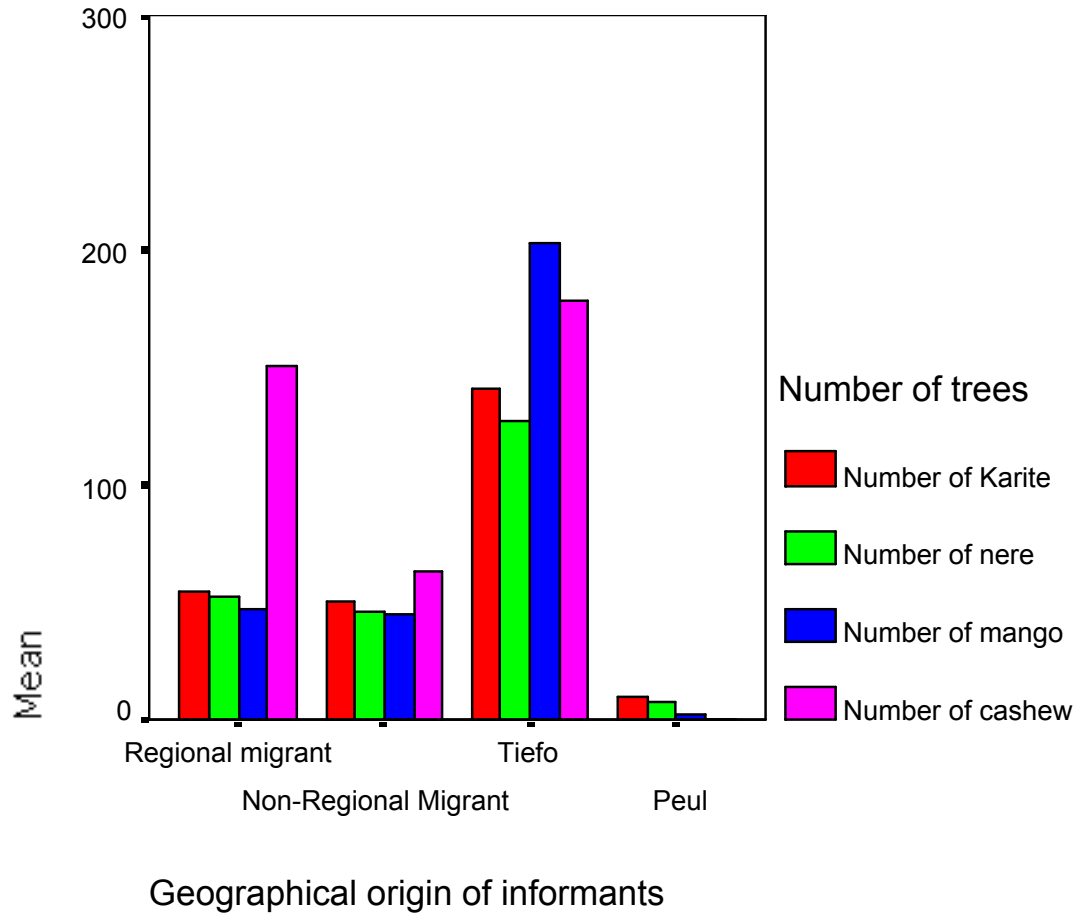


⁶ Figure 5: Areas used for farming and left fallow, according to the geographical origin of informants



⁷ On a small scale, though, anybody is allowed to take a mango in any plantation if it is just to satisfy his hunger on the spot.

⁸ Figure 6: Tree ownership according to the geographical origin of informants (NB: many cashew plantations are still young and do not produce any fruit yet).



For comparison of income derived from trees, see note 6, figure 5.

⁹ Figure 7: Calendar of the main agricultural and agroforestry activities

Land Use Calendar in Pèni Village

