CHANGES AND LOCAL ADJUSTMENT IN THE *FAIDHERBIA ALBIDA* USE AS FODDER AND FUELWOOD AMONG THE SEREER, SENEGAL

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ABSTRACT Despite numerous studies on the potential functions of *Faidherbia albida*, farmer's contexts and practices in the tree use are largely unknown. The study described how the Sereer reshaped their techniques of foliage and branch collection for fodder and fuelwood in response to socio-economic changes. Married men turned to fattening livestock to highly increase its cash value, and promoted foliage growth through careful pruning to use as fodder. However, it became prevalent for married women to debark the standing trees for easier fuel collection, which caused the trees to die. Men at first did not make a public outcry, because they appreciated the women's endeavors in fuelwood collection and small retail to provide foodstuffs. Whereas the villagers could not immediately resolve the disharmony between the logics of market economy and subsistence, they eventually coped with the debarking problem by applying the national Forest Code, which lead to a new method of outer bark collection, which was easy but also kept trees alive. Paying attention to people's attempt against resource scarcity and emerging problems among the different social actors is important to understand the dynamics and sustainability of farmed parklands.

Key Words: Farmed parkland; Resource scarcity; Technical evolution; Debarking problem; Social potential.

INTRODUCTION

A landscape, the so-called farmed parkland, where specific useful trees are scattered over agricultural fields, is widespread throughout the West African savanna. The trees inside parklands have been encouraged to grow by farmers at the time of land clearance, and have been maintained for a long time as a resource for livelihoods (Pullan, 1974; Boffa, 1999; Bayala et al., 2011).

Out of more than 40 major tree species in parklands (Pullan, 1974; Boffa, 1999), one of the most studied is *Faidherbia albida* (Del.) A. Chev, which is currently distributed widely from the Sahel to Guinea savanna (Barnes & Fagg, 2003), although the natural habitat is limited to sandy soil with low groundwater level (Wood, 1992). This widespread distribution is closely related to the wide-scale expansion of agriculture and livestock raising (Chevalier, 1928; Chevalier, 1934; Wickens, 1969; Trochain, 1969). The unique and specific characteristic of *F. albida* is its reverse phenology (Roupsard et al., 1999) through which it can improve soil fertility and serve as fodder in the long dry seasons. Appreciating these benefits, many societies have established *F. albida* populations in agricultural fields and developed intensive farming systems that combine crops with livestock raising (Pélissier, 1966; Pullan, 1974; Seignobos, 1980; Lericollais, 1999;

Gray, 2003; Hirai, 2005). The *F. albida*-parklands are acknowledged as evidence to counter the stereotypical view of human-induced desertification, because conversion of natural vegetation to parklands does not necessary entail a loss of plant productivity (Mortimore et al., 1999; Mortimore & Turner, 2005).

However, the farmers' perspectives and practices in tree use have largely been unknown (Sop & Oldeland, 2013), while the potential tree function, utility (Louppe, 1996; Bernatcheza et al., 2008; Hadgu et al., 2009) and rapid degradation of parklands (Gijsbers et al., 1994; Wezel & Lykke, 2006; Belem et al., 2011; Bayala et al., 2011) have been documented in large numbers. Careful study of the people's relation with trees (Dépommier, 1996; Petit, 2003) may more likely identify the farmers' interests and potentials in developing their own way of resource management. In addition, these findings will be essential to connect the global environmental issues including climate change and carbon sequestration (Woomera et al., 2004: Tschakert, 2007; Nyong et al., 2007; Takimoto et al., 2008; Bayala et al., 2014) with local interests.

In examining local potentials for resource management, it is useful to pay attention to diachronic changes in resource use and to problems that emerged from the changes. West African savanna regions have experienced rapid changes in ecological and socio-economic environments during the last decades, including serious drought, demographic growth as well as infiltration of and stagnation in market economy (Mortimore & Turner, 2005). In the process of adaptation to these changes, people have revalued indigenous trees for historically new contexts, and reshaped techniques and rules in tree use.

Based on long-term field research with the Sereer in Senegal, this paper reports (1) how the contexts and practices in *F. albida* use by local people have changed in accordance with decades of ecological and socio-economic environmental transition, and (2) what problems arose among the villagers and how they overcame these. The paper consists of four parts. First, I describe how the people, particularly men, engaged in livestock raising have revalued *F. albida* as fodder under the changing internal and external factors. Secondly, I describe the development of modified pruning techniques during the same period. Thirdly, I describe the women's use of *F. albida* branches and bark for fuelwood to cook, and thereby disharmonious uses of the tree arose between the men and women. Finally, I examine how the different actors belonging to the same household or village interpreted this problem, and how they attempted to overcome it.

STUDY AREA AND METHODS

I. Study Area

(1) Livelihood and household

The field research was carried out between 2002 and 2013 totaling 25 months at Ndondol village inhabited by the Sereer in the Rural Community (Communauté Rurales) of Touba-Toul, Thiès Region (Fig. 1). The village is located in the transition between Sahelian and Sudano-Sahalian climatic Zones. The annual precip-

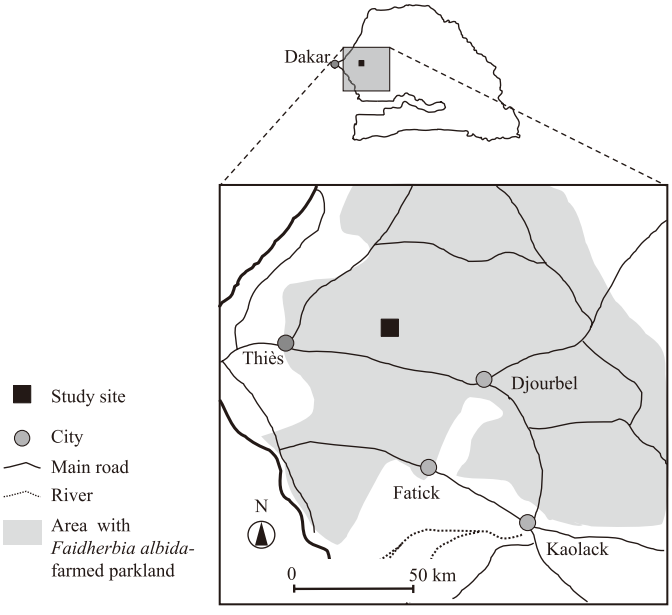

Fig. 1. Study site.

itation ranges 300–800 mm, with no rain in the 8-month period from October to May. Annual mean temperature is around 27°C, and the temperature rises to 40°C from April to May. Although the lowest average temperature is around 16°C from December to January (The World Bank, 2014), fuel is usually not used for warmth.

Similar to the majority of the Sereer distributed in the Region of Thiès, Djourbel and Fatick with a population of approximately 714,000 (Lericollais, 1999: 43), livelihoods in the study village consist of crop cultivation and livestock raising. The villagers have cultivated pearl millet, sorghum and cowpeas for subsistence, and peanuts for both subsistence and major cash income. Cattle were the most common livestock until the 1970s, but the number has declined, leading to an increase in sheep and goats. The villagers sell livestock at the local market held weekly near the village, which is famous as one of the largest livestock market in Senegal. Many buyers visit the market from urban areas including Dakar, and this provides opportunities for the villagers to earn cash.

A unit family, called *ngak*, consists of a husband with one or several wives and their children. It can be considered as a household unit (Lericollais, 1999: 195–207). The household shares in crop production and fuelwood collection for cooking, whereas peanut and livestock sales are handled principally by personal transaction. In 2002, there were approximately 72 *ngak*s in the study village.

(2) Population growth

The population of the village grew from approximately 450 persons in the 1960s, to 520 persons in 1976, reaching 1,300 persons, nearly 2.5 times larger than the 1960 population in 2007. Because the population growth has been dra-

matic, the land and resources available to each household continues to decrease. The Sereer society has already been known for its historically high population density (Pélissier, 1966), but the recent population growth has accelerated this trend even further. As a result, almost all the area between Ndondol village and neighboring villages is covered with permanent cultivated fields without fallow periods.

(3) *Faidherbia albida*-farmed parkland

Faidherbia albida is an indigenous deciduous leguminous tree, which grows to a height of 30 m with a trunk diameter of up to 2 m (Wood, 1992). It exhibits vigorous regeneration of foliage after pruning. Its leafing and fruiting season is completely contrary to other species, shedding leaves during the rainy season, and growing leaves and bearing fruit during the dry season.

According to Hirai (2010), who observed 4,548 trees with 20 cm or more of diameter at breast height, comprising 25 species, in a total area of 243 ha of fields owned by Ndondol villagers, *F. albida* accounted for as much as 90% both in terms of number of stems and basal area. In order to establish such a *F. albida*-farmed parkland, the villagers have protected the seedlings that occurred in the fields, and encouraged growth of the seedlings. This practice is called *yar*. It is evident that the *yar* practice has considerably increased the woody biomass in the fields, which steadily provided fertilizer, fodder, and fuelwood for cooking. However, the people ceased the *yar* practice around the 1970s due to various reasons. The most direct reason was the widespread introduction of plows drawn by horses. The people began to embrace this method in order to make up for agricultural labor shortages resulting from a rapid increase in migrant work. Seedlings were removed, because their sharp and long thorns could injure the expensive horses (Hirai, 2005). As a result, the number of trees has declined at a rate of 1.06% per year (Hirai, 2010).

The usufruct of *F. albida* shared widely among different households of the village, while every tree is attributable to the landowner. The people can access any tree to collect fodder and fuelwood, as long as they use the trees in a manner that does not lead to tree death (Hirai, 2010). Since the tree is considered as a common resource of the villagers, all stakeholders are inevitably involved in the process of conflict resolution over the tree scarcity.

II. Survey Topics and Methods

(1) Livestock raising and fodder collection

I recorded the species (cattle, sheep and goat) and the number of livestock owned by household, as well as their feeding system (either pasturing or confined rearing) in 2002, 2006, 2009, 2010 and 2011. The sample sizes were 57, 19, 72, 72 and 21 households, respectively. To compare livestock raising in the past and present, I selected villagers over 40 years old (N = 57), and asked the numbers and species of livestock owned at memorable time points such as marriage, birth of a child, death of a father, etc. The data was summarized by decade by household. Land use and diverse activities related to livestock management in the past

were also documented. As for fodder collection, I conducted direct observations of techniques of foliage cutting since 2006.

(2) Household economy

In order to clarify the contribution of livestock to the household economy, I recorded the sale price of each livestock raised and sold by household (N = 3) in 2002. Also recorded with interviews and direct observations were the number of livestock by species, length of the feeding period, fodder composition and feeding practices, and how the money gained from the sale of the livestock was used. In addition, amounts of peanut harvest and its sale prices were recorded for 56 households in 2002.

In 2006, I conducted a diet survey to examine the food composition for both staple and secondary foodstuffs. Procurement of the foodstuff, whether self-supplied or purchased, were also investigated for a typical household with 15 members headed by AS. In 2006, the family consisted of AS in his 50s, his two wives, their 11 children (of whom, five were under 10 years old) and a wife of AS's son.

The number of migrant workers were recorded for 57 households in 2002 (where N = 30 men in their 40s, 22 in their 50s, 14 in their 60s, 12 in their 70s and 2 in their 80s). I interviewed the elderly members aged over 60 (N = 28) on their experience as migrant worker, including the year they started, the total period, and the average duration.

I also counted the women in every household who engaged in small-scale retail in the village or in the local market.

(3) Fuelwood collection for cooking

Interviews were made with elderly women ($N \geq 30$) in 2006 about the fuelwood collection in the past, major fuel materials, and land types where fuelwood had been frequently collected. Their own explanations about the correlation between fodder cutting and fuelwood collection were also recorded.

To study the present fuelwood collection, direct observations were made in 2006 and 2009–2011 for detailed records of work by women who engaged in collaborative fuelwood collection. The methods and tools employed were investigated, and the collected material weighed by material type. If the branches of *F. albida* were collected, the number and weight of the branches and whether the branches were alive or dead were recorded.

DIACHRONIC CHANGES IN LIVESTOCK RAISING

I. Decline in Cattle Raising and Introduction of Livestock Fattening

According to interviews with men over 40 years old, they were formerly deeply involved in cattle raising. They described its importance to their subsistence as follows: "When we would get near the village after working in the fields, the air smelled of cow's milk." "For dinner we would pour cattle milk on pearl millet."

"I used to climb trees and cut down branches to collect cattle fodder." "At night, I used to sleep out in the kraal with the cattle and keep watch." "Even youngsters from households without cattle used to help out with guarding cattle at night." However, the number of cattle owned by these men has declined dramatically since the 1960s (Fig. 2). At present, cattle herds were owned by only a limited number of households (20–40% of the total sampled households), and, in many cases, herd size grew smaller with 1–2 heads/household, than in the past (Table 1). The elders explained that this decline was due to either drought or death from disease.

Two reasons may account for why the number of cattle did not return to previous levels after the 1950s. First, the communal pasture for cattle was converted into cultivated fields in the early 1970s, due to the increase in population. In the past, calves, nursing mothers, and cattle were kept in a communal pasture near the village on return from their daily pasturing during the rainy season so that they did not eat crops. The loss of the communal pasture made it difficult to keep as many cattle as previously held. Second, more than 50% of young people

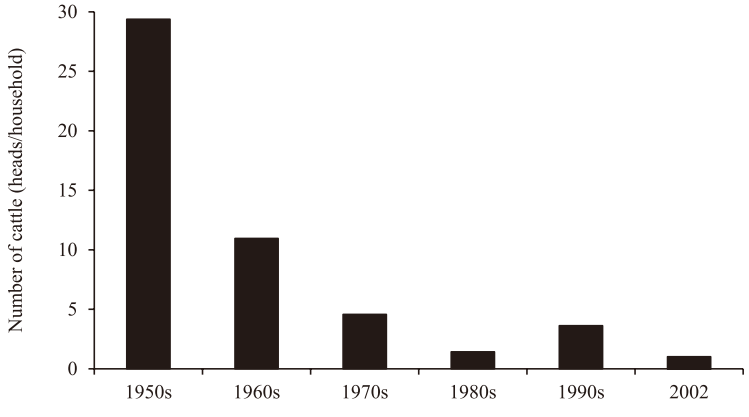

Fig. 2. Change in average number of cattle owned by a household from the 1950s to 2002.

Table 1. Percentages of households owning livestock to the total households in Ndondol village

Year	Sample size	Cattle				Sheep				Goat			
		% of household with livestock	Number of livestock*			% of household with livestock	Number of livestock*			% of household with livestock	Number of livestock*		
			Mean	Min	Max		Mean	Min	Max		Mean	Min	Max
2002	57	28.1	1.1	0	13	71.9	3.3	0	15	57.9	2	0	10
2006	19	47.4	2.3	0	21	89.5	6.1	0	39	31.6	1	0	7
2009	72	22.7	1	0	20.5	63.6	4.4	0	36	38.6	1.5	0	12
2010	72	25.9	0.9	0	12	68.2	5.2	0	25	38.8	2.2	0	30
2011	21	28.6	1.5	0	15	66.7	4.1	0	10	38.1	3.3	1	8

* Calfs, lamb and goatlings were counted as 0.5.

began to go to cities to work since the 1960s (Fig. 3). They would have played important roles in the cattle herd management, including pasturing, milking and night watch.

However, these changes did not end the practice of livestock raising, but rather, a new form of livestock raising has developed. The prominent trend is an increase in keeping sheep and goats, which were rare when cattle raising was widely practiced according to the informants. As of the 2000s, 70–90% of total households owned sheep, while 20–30% owned cattle and 40–50% owned goats (Table 1).

Livestock fattening (*yafal*) had never been practiced before, but became increasingly popular since the 1980s. Intensive livestock fattening is carried out predominantly by married men. Adult women were also involved in raising livestock, but were often responsible for raising goats, which required less labor. Most households engaged in small-scale sheep fattening with five or six sheep to sell at the market. Part of the income earned from the sale was often used to purchase new lambs. This is because high profits can be earned by selling fattened sheep. Households raising cattle have one to three heads of cattle. They purchase calves or heifers during the dry season when the prices are the lowest, and fatten them for approximately six months to a year. These cattle were raised intensively with careful attention to the nutrient quality and amount of feed. In addition, it has become common practice to vaccinate these cattle.

The intensively reared cattle sells at relatively high prices in the market (Table 2). For example, between 1999 and 2002, MG, a married man in his 40s, raised eight cattle, each of which was sold at between 300,000 to 500,000 CFA francs/year (1 € ≒ 655 CFA francs). This price is fairly good compared with selling the harvested peanut, averaging 160,000 CFA francs/household-year (SD = 203,585, N = 56 households) between 2002 and 2003.

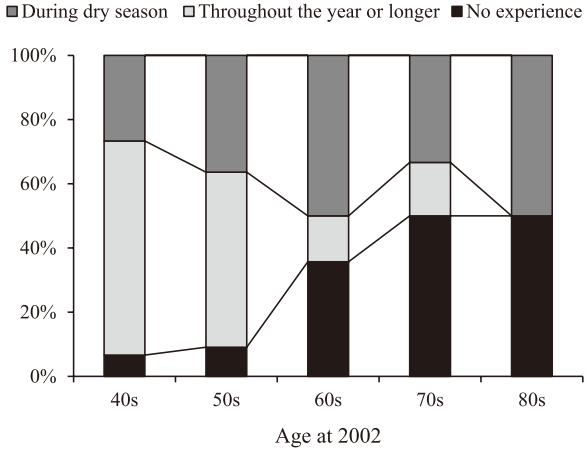

Fig. 3. Percentage of men who had experienced migrant works in their youth.

Table 2. Cost, sale and allotment of profit in cattle fattening for three men between 1999 and 2002

Case	Year of * purchase	Expense for rearing (CFA frans)	Rearing period (months)	Sales price (CFA frans)	Margin (CFA frans)	Allotment of profit	
						Purchase of livestock to be reared	Staple food
MG	1999	150,000	6	375,000	225,000	1 male	Rice
	1999	150,000	6	375,000	225,000	1 male	Rice
	2000	150,000	6	370,000	220,000	1 male	Rice
	2000	156,000	6	370,000	214,000	1 male	Rice
	2001	250,000	6	407,500	157,500	1 male	Rice
	2001	250,000	6	480,000	230,000	1 male	Rice
	2002	275,000	6	nd	nd	nd	nd
	2002	280,000	6	nd	nd	nd	nd
DS	2000	140,000	6	250,000	110,000	1 male	Rice
	2001	250,000	6	330,000	80,000	1 male	Rice
	2002	243,000	6	nd	nd	nd	nd
JN	2000	85,000	nd	270,000	185,000	nd	nd
	2001	175,000	nd	275,000	100,000	0	Rice
	2001	30,000	5	170,000	140,000	nd	nd
	2002	110,000	nd	nd	nd	nd	nd
Average		157,000		315,000	163,000		
SD		68,000		104,000	61,000		

* Data from 1999 and 2001 were obtained from interview.

II. Background to the spread of fattening livestock

A number of studies reported that the drought that occurred between 1972 and 1974 throughout the African savanna regions caused not only considerable mortality in livestock herds, but also changes in household structure associated with herd management (e.g., Sutter, 1987; Mortimore & Adams, 2001; Adriansen, 2006; Kazianga & Udry, 2006). The change varied village by village. Gastellu (1981) reported from other Sereer villages that the out-migrant rate of villagers who otherwise would have engaged in herd management, was relatively low at less than 15% (N = 676). Lericollais (1999: 315) found that the fallow field remained at the rate of 10–20% of the total area. Therefore, a considerable number of cattle had been maintained even during the drought period.

In contrast, in the study village, the out-migrant rate was high at 50%, and the communal pasture that had been placed in fallow disappeared due to land shortage, detrimental to maintaining the size of cattle herds. The villagers replaced their cattle, in most cases, with sheep and goats. This continuous livestock raising is above all attributable to the increased importance of cash income for the villagers. Especially, changes in the daily diet required them to purchase staples and side foods.

The author's diet survey revealed that the self-sufficiency rate of millet production had declined dramatically in recent years. The villagers eat three meals a day, but millet is served as the main foodstuff only in the morning and evening (Fig. 4). Even for these two meals, it is not easy for the villagers to be self-sufficient in millet production. In 2002, only 14% of the total households (N = 72) was completely self-sufficient throughout the year. The majority was only able to support themselves for 8–10 months a year, and had to buy food to compensate for the shortage.

The staple food for the midday meal has become rice (Fig. 4). In this region, as the environmental conditions are not suitable for rice production, villagers have to buy imported rice. Men in their 50s explained, "when we were children, we ate rice about once a week or during festivals," and that "rice was so delicious. After eating, we used to smell the aroma of rice left on our hands." This account is consistent with the study by Fraud et al. (1997), which documented a rapid increase in rice imports to Senegal since the 1970s.

The most popular dish using rice is called *ceebu jën*. For AS's household with approximately 15 members, the average meal cost between 1,000 and 1,500 CFA francs. The total cost for a year was estimated as between 350,000 and 550,000 CFA francs, which cannot be covered by the sale of peanuts, because since the 1980s, the peanut market has steadily declined, and the prices fluctuate wildly from year to year (Fraud et al., 1997).

Under this condition, intensive livestock fattening has gained much importance as the major cash income source and become widespread among married men, responsible for procuring staple foods. In fact, before the 1970s, cattle raising was expected above all to provide milk and manure (Lericollais, 1999: 324). The cash income from livestock was only 2% of the total cash income then, while more than 50% came from peanuts (Fay & Fall, 2000). According to Fay & Fall (2000), the percentage of cash income from the livestock has now reached 21%, whereas that from peanut decreased to 17%.

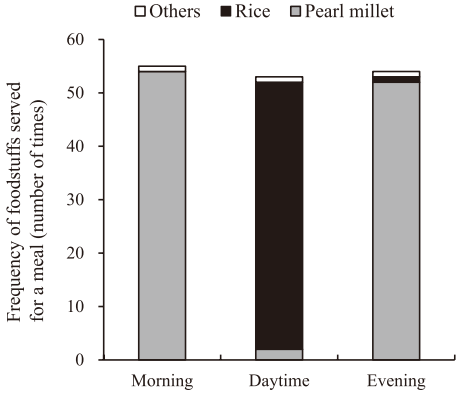

Fig. 4. Carbohydrate foodstuff served in the morning, midday, and evening meals in AS's household. (27 Dec. 2006 to 7 Feb. 2007)

THE INCREASING IMPORTANCE OF *FAIDHERBIA ALBIDA* IN LIVESTOCK FATTENING

I. Feeding Livestock

With the increasing value of livestock as a cash income source, so has that of securing fodder. Fig. 5 shows the seasonal patterns in fodder feeding, illustrated based on the author's observations in 2006. The villagers divide a year into four seasons. The rainy season is called *nawet*. The dry season is divided into three periods, *lëli*, *nor*, and *cooron*, which correspond with changes in fodder source.

Basic fodder during the rainy season is fresh grass and raw leaves from woody plants such as *Adansonia digitata*. In *lëli*, the early period of the dry season, basic fodder for livestock gradually shifts from raw grass remaining in the fields to crop residue, often brought back to the homestead. During *nor*, the mid-period of the dry season, *F. albida* leaves start to develop, the flowers bloom, and fruit (called *ad*) gradually grow. However, the villagers do not collect these during *nor*, but continue to feed the livestock crop residue and dry grass. The men commonly explained that if *F. albida* leaves and fruit were given to livestock too early, they would not eat crop residue or dry grass later. In addition, as the leaves and fruit are not yet "ripe" in this period, feeding these to livestock make their mouths sore.

Little crop residue and dry grass remained during *cooron*, the latter period of the dry season. Crop residue and dry grass remaining in the fields at the beginning of *cooron* was 0.14 tons/ha. In contrast, an estimated amount of *F. albida* leaves was 0.43 tons/ha in air-dry weight or 1.42 tons/ha in flesh weight (i.e., in the form that the leaves are consumed). The leaves thus weighed ten times as much as crop residue, thus *F. albida* is typical as fodder in this season. The men collecting leaves and fruit said, "it is like meat or sugar for livestock," "cattle eat the leaves and fruit, and they provide a lot of milk," "the fruits wash out the stomachs of animals," and that, "cattle and sheep eat the leaves and fruit during the dry season, and they will have beautiful fur during the rainy season."

F. albida has become more important in recent years as both a quantitative and qualitative supplement to primary fodder for livestock. The importance of *F. albida* as a fodder has been pointed out in previous studies. According to Cissé

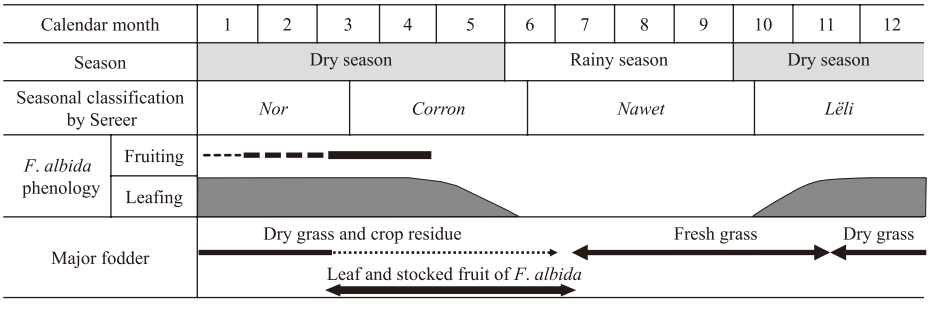

Fig. 5. Seasonal changes in fodder and phenology of *Faidherbia albida.*

& Kone (1992), the leaves, fruit, and seeds have protein contents of 20%, 15%, and 26%, respectively. In contrast, crop residue and dry grass consist mainly of fiber (cellulose) and contain little protein so that livestock have difficulty digesting and absorbing nutrients (Ibrahim & Tibin, 2003). However, if a small amount of protein is provided, the ability to digest and absorb nutrients from crop residue and dry grass increases (Fall, 1978). For example, Fall et al. (1997) suggested approximately 20% of *F. albida* leaf in basic fodder was adequate for feed, because the leaf included tannins that made digestion difficult. Thus, the inclusion of large quantities of leaves in feed is not desirable.

In reality, *F. albida* is fed to livestock with the specific villager recognition that "a little amount is suitable," not always used throughout the period of leaf and/or fruit growth. The men did not collect the leaves or fruit during the early period of the dry season, and kept them until *cooron*, when *F. albida* was in greatest demand. The dry fruit was stored for use in the early period of the rainy season when dry grass was completely unavailable as the cultivated fields were prepared for sowing crop. Given the scarcity of fodder with the increasing cash value of fattened livestock, the villagers use *F. albida* in the efficient feeding pattern.

II. Evolution of the Pruning Technique for Foliage Collection

(1) *Diib*: shaping the tree for denser leaf cluster

Pruning techniques for foliage collection have developed among the people in the research area. The first is called *diib*, which promotes dense leaf clusters. The interviewees stated that, "if the tree were left uncut, branches would grow longer and upwards, and the leaves would grow only around the edge of the crown. When you attempt to climb up this kind of tree to collect the leaves, it is impossible to reach the proper position to cut branches," "instead of hardy growth, leaf is poor and they soon get old," and that, "during strong winds, long branches can break from the main trunk, potentially injuring anyone standing underneath. And branches broken at their base no longer produce sprouts or regenerate foliage." From these accounts, it is evident that the trees not shaped by *diib* are unsuitable for fodder collection. In order to maintain desirable tree shape, the men cut off the secondary scaffold branches coming off primary ones (*bànqaas*), using a machete (Fig. 6). After that, numerous new sprouts emerge around the cut end, eventually producing dense leaf clusters.

(2) *Lonk*: directly picking foliage

Informants pick off foliage with 3–5 cm diameter one by one from the leaf clusters. This technique is called *lonk*. The term *lonk* also refers to a tool used for this practice, an approximately 7 m long bamboo pole with an iron hook at the tip. This technique enables the men to take just the amount of foliage that they need. In addition, because it is done standing on the ground, the older people who no longer climb the tree can participate. The tool became widespread in the 1970s, when many young villagers who would have climbed the trees left the village to work in cities. However, according to the informants, the continu-

Fig. 6. Pruning techniques for fodder collection.
Upper left: *diib*, Upper right: *lonk*, Lower left: *cor*, Lower right: tree with recovered leaf clusters after *cor*.

ous application of *lonk* inevitably makes the leaf clusters smaller with lower leaf density, because it does not promote regeneration of foliage. This is a physiological phenomenon known as apical dominance (Jaremo et al., 1996; Dube et al., 2009; Ky-Dembele et al., 2010).

(3) *Cor*: enhancing leaf clusters

To make up for the *lonk*-induced decrease in foliage, men sometimes climb the trees with little remaining foliage, and cut again from the thicker side of the secondary scaffold branches so that new and denser leaf clusters may develop. This technique is known as *cor* (Fig. 6). With *cor*, the importance of keeping the branches on the top of the crown was emphasized. These branches are called *nuki*, meaning nose, which the villagers consider as the organ by which the tree breathes. They believed that removing the *nuki* made the trees wither and die. The regenerated leaf clusters are again collected with *lonk*. However, the new branches growing just after *cor* have long and sharp thorns not suitable as fodder for sheep and cattle. The thorns become shorter and blunter in three years,

which the informants know so that successive *cor* is carried out with an interval of at least three years.

(4) Trends in the technique for foliage collection

Before the 1970s, when cattle pasturing was widely practiced, the men enhanced the vigorous leaf clusters using the *diib* technique. Also, *cor*, which removed large portions of the crown, was commonly practiced to provide at once a large amount of foliage to feed cattle.

However, the scarcity of *F. albida* became increasingly dire due to demographic growth, demand for fattened livestock, and abandonment of the *yar* practice to protect seedlings, essential to maintaining the tree population. As elderly men explained, *cor* sometimes caused the trees to die. Consequently, the *lonk* pruning became prevalent so as to reduce wastes. In fact, Dépommier (1996) reported that the risk of *F. albida* death was low and tree vigor was maintained with the pruning technique.

However, since *lonk* does not promote the growth of new foliage, *cor* is sometimes practiced for foliage vigor. This complex combination of the cutting techniques is possible only with a deep knowledge of *F. albida* acquired through the long experience in use and observations.

A number of studies carried out in the West African savanna regions pointed out that the increasing population pressure and intervention of market economy lead to land, vegetation and resource degradations (Mortimore, 1993; Dhillion & Gustada, 2004; Gonzalez, 2001; Wezal & Lykke, 2006; Neba, 2009; Bayala et al., 2011). However, these factors do not always bring about crisis. They sometimes induce a technical evolution as described above. Tschakert (2007) also indicated that market-based initiatives have a potential to strengthen the farming systems and foster social and ecological sustainability.

EMERGENCY IN FUELWOOD COLLECTION

I. Change in Fuelwood Collection

Before the 1970s, when cattle raising became widely practiced, men frequently collected fodder from the *F. albida*, as described above, with *cor* as the most common pruning technique. Women were able to collect fuelwood simply by picking up the branches left on the ground from *cor*. Many of the women who lived in these times recounted that, “when I was young, collecting fuelwood was easy. If we went to the cultivated fields, we could find branches that were left over after the cattle had eaten. Today, there is nothing left in the fields.” This suggests that fuelwood collection was not an independent activity, but one supported by livestock raising.

At present, fuel collection relies strongly on residual production from agriculture and livestock raising. As shown in Fig. 7, millet stems and dry cattle dung, rarely used in the past, are primarily employed as cooking fuel from the beginning to the middle of the dry season. These are not so useful as fuel. Millet

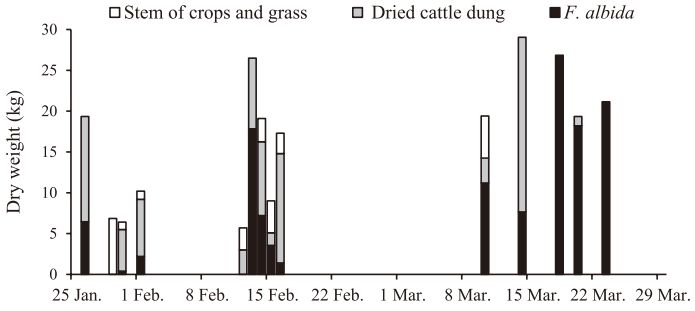

Fig. 7. Composition of fuel materials for AS household (25 Jan. to 29 Mar. 2006).

stems burn out immediately, and cattle dung left in cultivated fields is often crumpled up and mixed into soil before drying, as the dung is intensively used as manure for crops. Therefore, women use *F. albida*, especially from the middle to the end of the dry season, when the residual production is depleted. Near the end of the dry season, women themselves begin collecting foliage from the trees using *lonk*, in addition to the branches left on the ground after *cor* by the men.

II. Stock Typed-fuelwood Collection

In the rainy season, the women depended entirely on the *F. albida* branches stored for fuel. During the rainy season, they avoided entering the cultivated fields, so as not to damage crops. Although gas and fuelwood are sold in the market, most households cannot afford them. Therefore, the women collected branches of *F. albida* during the dry season in advance. Storing fuelwood is called *taxan*. Direct observations in 2009 revealed that *taxan* required a considerable amount of labor and mutual collaboration among women. For example, NG, a married woman in her 40s, formed a group of six women and made more than thirty trips to work in *taxan* every two to three days between March throughout June. Following is the detail obtained from direct observation for 12 trips made between April 20 and June 1.

The group started *taxan* labor between 4 and 5 pm and stopped after 8 pm. The average length of working time was 163 minutes/trip (SD = 27). The members took turns for various tasks, such as searching for dead branches on the trees, handling the *lonk*, collecting branches that fell on the ground, splitting large branches using an axe, bundling the branches for transport, and dividing the collected fuelwood among the members. The group obtained 697 branches from 443 stems of *F. albida* (1–2 branches on average), and most (95%) of the gathered branches were dead and dried. The women sometimes attempted to collect live branches with *lonk*, but often gave up, because the branches were too sturdy to remove. Consequently, they could collect about 50% of the branches on which they attempted to collect. The mean yield amounted to 140.4 kg/trip (SD = 65.9), which was divided evenly among the members. This amounted to, on average, 23.4 kg/person-trip (SD = 19.5), which amounted to fuel for five to seven days

of cooking. NG collected fuelwood in this manner and had stored more than 600 kg of dry branches from March by the beginning of the rainy season. Given that NG's household consumes 3–4 kg of fuelwood/day, the amount she collected could be used for 150–200 days, covering the entire rainy season.

Forming a group appeared indispensable for collecting fuelwood. On each trip, NG's group covered a wide range in the fields (averaged 4.0 km/trip, SD = 1.6), carefully searching for dead branches on every tree dispersed at roughly 20 m intervals (SD = 2). When they found a large dead branch on the tree, some members helped NG to pull it down together. Many hands were needed to operate the heavy and long *lonk* for a long time as well. Given the current scarcity of *F. albida* fuelwood, such intensive labor and collaborative social relationships are essential to securing sufficient fuelwood to sustain households throughout the rainy seasons.

III. Busyness of Women with Retail Business

In 2009, all sampled households (N = 34) cooperated in the *taxan*. However, out of these, eight (23.5%) could not gain sufficient fuel for the rainy season. For example, YS, a woman in her 40s, who carried out eight *taxan* trips with the second wife of her husband during the same period with NG, but gained only 9.4 kg/person-trip (SD = 3.3). The mean time spent for *taxan* was 99 minutes/trip (SD = 27). In contrast to NG's collection, most branches they collected were fresh with thorns, which needed to be removed later. While it is easy to find fresh branches, the return on unit labor input was much lower than that for dead branches.

The observation suggests that not all women had sufficient time for *taxan*, and it is attributable to their engagement in small-scaled retail. As explained earlier, purchased rice has become a major staple food for the midday meal. The rice dishes constantly included several kinds of foodstuffs such as fish and carrots, which must be purchased. It cost approximately 500 CFA francs per meal, which was purchased by the married women in most cases. In order to cover this expense, most women engaged in the retail at the market, selling peanuts harvested from their fields, diverse foodstuffs, and daily commodities. The survey on the household economy revealed that more than 75% of the married women (N = 98 from 72 households) were presently engaged in the retail business daily and personally.

Given this circumstance, to conduct successful and careful fuelwood collection with sufficient team labor, became much difficult. On the other hand, debarking which is to strip off the bark from a standing tree, can be conducted with much less labor, and became prevalent.

IV. The Debarking Problem

The men have developed the pruning technique to maintain the vigorous state of *F. albida*, while the practice of debarking by married women (Fig. 8) caused the trees to die. The bark used as cooking fuel is hard and thick, e.g., thickness

of the bark is 1–3 cm at the trunk with a diameter of 40 cm. The debarking requires less labor with an iron tool called *xedji*. Meanwhile, elderly women commonly commented, "we never stripped bark for fuel." The debarking started in the latter 1990s, according to them.

The debarking by women introduced a new problem into the community. The debarked trees generally wilted and died, because the cambium layer and phloem are removed along with the bark, as shown in Fig. 9 (Spearman rank-correlation coefficient $\rho = 0.926$, $P < 0.0001$). Especially, if ring-barked, all trees died within one year (Moncrieff et al., 2008; Midgley et al., 2010). A considerable number of the trees were actually damaged and died in the research period. Tree censuses

Fig. 8. Debarking (left) and outer bark collection (right) by married women.

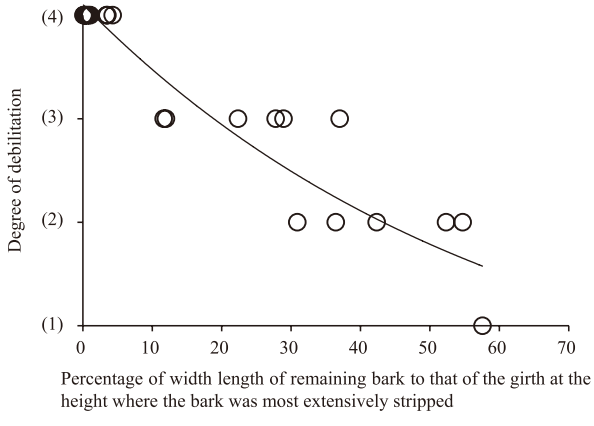

Fig. 9. Impact of debarking on tree vigor.
Twenty-one *F. albida* trees debarked to different degrees were selected, and the debarked width was measured on 15 Feb. 2006. One year later (7 Feb. 2007), degrees of debilitation of the trees were observed based on the following criteria: (1) leaves occurred throughout the crown with similar density with non-barked trees, (2) leaves occurred throughout the crown, but with density lower than that of the non-barked, (3) leaves occurred throughout the crown, but with considerably low density and yellowish color, (4) dead.

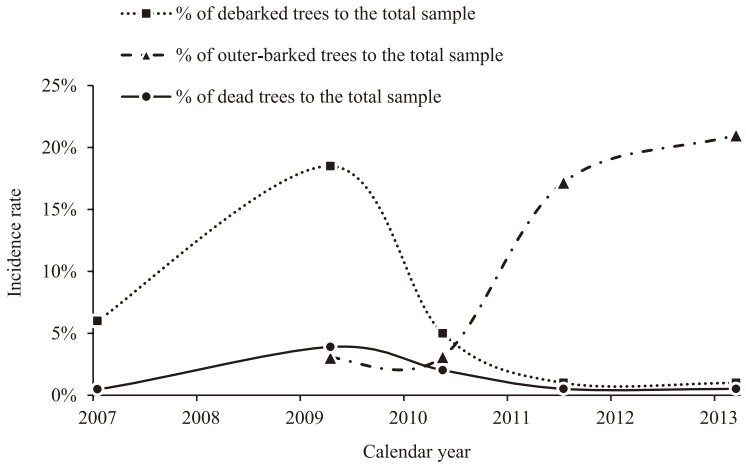

Fig. 10. Incidence rate of debarking and outer bark collection, and the mortality rate of the trees. Sample trees were selected in the fields (N = 205 stems in 2007, 197 in 2009, 193 in 2011 and 192 in 2013), and the number of *F. albida* from which the women collected bark and outer bark were recorded. The dead trees also were counted. The decrease in sample size is attributed to tree death.

revealed that the proportion of debarked trees to the total tree population averaged 9.8% between 2007 and 2010, with a sharp increase to 18% in 2009 (Fig. 10). In addition, a significant correlation was found between the incidence rate of debarking and tree mortality (ρ = 0.956, P < 0.0001). From the tree census between 2002 and 2013, the annual mortality was estimated at 1.06%/year, and was likely attributable, in most cases, to the debarking.

Sample trees were selected in the fields (N = 205 stems in 2007, 197 in 2009, 193 in 2011, and 192 in 2013), and the number of *F. albida* from which the women collected the bark and outer bark were recorded. The dead trees also were counted. The decrease in sample size is attributed to tree death.

RECONCILING THE DISHARMONY IN USING THE TREE

I. Ambivalent Response to the Debarking

According to the interviews, the men engaged in raising livestock expressed their discontent with the women's debarking. Many women also expressed their concerns that the emergence of the debarking practice indicated the village's moral decline. Despite such comments, no public outcry was observed against the debarking problem. O, a man in his 30s said, "we can't criticize the women who practice barking because we eat the food cooked using the fuel that they collected." This statement is meaningful. Among the villagers, there had been an unspoken agreement and customary rule that it was permissible to collect a "small amount" of foliage and branches from any tree, even if the trees had owners and stood in their land (Hirai, 2010). In fact, the women shared the belief that it was wrong

to cut down a living tree just for fuelwood collection.

Also, as shown in NG's statement that "there is no one in the village who thinks it is okay to strip the bark and cause the trees to die," debarking was no woman's first choice. The following observation is a good illustration of such account:

> When a pubic road was constructed through the cultivated fields as part of the government's infrastructure, one *F. albida* tree blocking the way was felled just before the midday meal. The sound of the falling tree was heard throughout the village. Despite it being just prior to lunchtime, as soon as the villagers heard the sound, all the women in AS's household rushed to the fallen tree. Women from the others households also ran out to collect the thin branches and bark as fuelwood. (March 2007)

It is bad manners to the villagers to leave suddenly where everyone has gathered for the midday meal. However, etiquette was quickly brushed aside in the above case. This suggests clearly the dire need for fuelwood and how no woman would want to miss any opportunity to collect fuelwood. Because the tree was felled by public works that no one had jurisdiction over, there were no reason for the women to hesitate collecting the bark of the fallen tree.

II. Decline in Debarking

Both men and women faced the dilemma that the debarking caused the death of the trees, but on the other hand debarking conducted for cooking fuel was necessary for their daily subsistence. Therefore, there was no public outcry against debarking within the local community. The situation may have led to a kind of "fuelwood crisis" (Cecelski, 1987; Benjaminsen, 1993; 1997; Dovie et al., 2004; Hansfort & Mertz, 2011).

However in 2006, S, a man in his 60s, who worked hard in raising livestock, went to the village office (Conseil Rural de Communauté Rurale de Touba-Toul) to file a complaint that a *F. albida* tree growing in his field died due to debarking. Subsequently, the officer passed the complaint on to the forester (Direction des Eaux, Fôrets, Chasses et de la Conservation des Sols), as he had jurisdiction over the region and the authority to recommend halting the debarking.

According to the Senegal's Forest Code (République du Sénégal, 1999: 40–41), not only felling trees but also collecting the foliage and branches from the *F. albida* trees is prohibited without authorization in advance. The foresters often patrolling around the villages against branch cutting are hated by the people. Yet, inspired by S's complaint, another man G, in his 50s, native to the village, started assisting the forester (agent auxiliaire des Eaux et Forêts). G did not actually enforce the ban, but just offered some words of caution as often as he could if he found women engaged in debarking. Although G was just a volunteer without legal authority, the women took him seriously.

Eventually, S and G's actions enforcing the Forest Code created an atmosphere that deterred the villagers themselves from engaging in debarking, and discourse

supporting their attempts spread among the villagers. In 2009, an elderly woman C commented, "barking is the same as disrespecting an old woman who ought to be respected." This kind of discourse was accepted even by the women who had to collect fuelwood. For example, a married women SG, in her 30s, responded, "well, it may be okay to bark, but who knows what'll happen after that?" The phrase, "who knows what'll happen?" seemed to imply that the person who does not stop debarking will be excluded from *taxan* groups. As explained above, it is indispensable for any woman to be included in a *taxan* group to secure fuelwood. For them, exclusion may be more threatening than the ban on debarking.

As a result, few incidences of debarking have been observed since 2010 (Fig. 10). This sharp decline in debarking was accompanied by the introduction of a new collection technique called *nyabat* (Fig. 8), by which only the outer bark is collected using the same iron tool for debarking. Because the outer bark does not include the cambium layer, the tree does not die. Consequently, the mortality of the tree has decreased sharply since 2010 (Fig. 10).

CONCLUSIONS

A remote sensing study (Herrmann et al., 2013) reported that tree cover in *F. albida*-parklands over the study village has been maintained, or even increased, since 1968. It considers this state as a success story in good land management by rural communities. However, we should also remember the parklands are at any given time in a dynamic state associated with people's livelihoods. What is important is to understand carefully the social potential against problems arising in the community, by paying attention to the people's knowledge of the resource, practices regarding the resource, and their way of coping with the problems.

This diachronic study on the relationships between villagers and *F. albida* showed that the people's practices in the tree use have largely changed due to internal and external factors since the 1970s along with the dynamics in the transition of livelihoods. It is noteworthy that the drought of the early 1970s, population growth, resource scarcity, and intervention of market economy, non-homogeneously affected the actors who use *F. albida* even disharmoniously: men began fattening livestock for cash income and elaborated foliage growth promotion to use as fodder, women began to depend on the bark of *F. albida* for cooking fuel which caused the trees to die and appeared unsustainable.

This disharmonious tree use generated from different gender roles (Biran et al., 2004; Mukadasi & Nabalegwa, 2007). It should also be noted that the roles represented different logical contexts: the men used the trees based on the economic logic to maximize cash income, while the women used them on the subsistence logic to secure a better meal. Since these different logics coexisted within a household, and the men certainly acknowledged that the women's fuelwood collection was essential for food preparation, the conflict between the two sides did not come swiftly to the surface. Therefore, a long time had to pass before any attempt to deter debarking.

The situation may have represented a vulnerability in local resource manage-

ment. However, the villagers of course have been aware that their livelihoods depended on the resource provided by *F. albida*. With this recognition, the villagers eventually settled the problem by embracing the national Forest Code so as to overcome the vulnerable situation in local resource management. In such a way, the disharmonious tree use between social actors was gently compromised, and the debarking practice gave way to a more moderate one, i.e., the outer bark collection. This process, i.e., the application, or praxis, of an external rule, points to a social potential in local resource management, which Cleaver (2001) called an "institutional bricolage," a process by which local people themselves draw on existing social arrangements to shape institutions in response to changing situations. Eventually, the logic of subsistence, of securing a good meal, was combined with the logic of economics, of gaining good cash income, and the *F. albida* population is maintained and each tree is encouraged to regenerate much foliage. This process represents the wisdom of the community that has contributed to the continuous existence of the parkland up to this day.

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