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Local People's Perceptions of Baobab (*Adansonia digitata* L.) Technologies in Senegal

Tamsir Mbaye[1, *], Mahani Cisse[2], Katim Toure[3], Ababacar Ndiaye[1], Marième Fall Ba[1], Dioumacor Fall[1], Fatou Gning[1], Daouda Ngom[4]

[1]National Centre for Forestry Research of the Senegalese Institute for Agricultural Research (ISRA-CNRF), Dakar, Senegal

[2]WorldVision Senegal, Fatick, Senegal

[3]Department of Rural Economy and Sociology, National Superior School of Agriculture (ENSA), Thiès, Senegal

[4]Plant Biology Department, Cheikh Anta Diop University (UCAD), Dakar, Senegal

Email address:

tamsirmbaye76@gmail.com (T. Mbaye), agrotoure@yahoo.fr (K. Toure), hanima90@hotmail.fr (M. Cisse), ababacar84ndiaye@gmail.com (A. Ndiaye), bfma09@yahoo.fr (M. F. Ba), dioumacorfall@yahoo.fr (D. Fall), toufa0809@yahoo.fr (F. Gning), ngom_daouda@yahoo.fr (D. Ngom)

[*]Corresponding author

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Abstract: This study analyses the perceptions of beneficiaries on market gardening and horticultural grafting technologies of *Adansonia digitata* L. (baobab). The study involved a representative sample of 106 individuals. The methodological approach adopted consisted of individual surveys, group interviews and statistical estimations. The Chi-square and Pearson's test of independence were used to test the dependence of perceptions on certain socio-economic characteristics (gender, source of income, etc.). Correspondence factor analysis (CFA) analyses and the non-parametric Krusall-Wallis test were applied to the frequency data matrices to relate the perception groups to the extended technologies and villages. The results showed that management style (p=0.003) and beneficiaries' access to high trees (p=0.04) differed between sites. However, the level of accessibility determines the satisfaction of fresh leaf needs which also induces the level of adoption of the technologies by the beneficiaries. In addition, it is shown that the reasons for adoption such as ease of collection, proximity, fruiting of large trees (p=0.04), depend significantly on gender and justify some of the changes made such as the reduction of time spent searching for leaves in the bush. The results obtained will be used in future campaigns to introduce grafting and baobab market gardening technologies. Indeed, the socio-economic determinants found will be mobilized to increase the adoption rates of baobab technologies and, more globally, of reforestation campaigns in Senegal.

Keywords: Perception, Market Garden Beds, Horticultural Grafting, *Adansonia digitata* L., Kolda, Sédhiou

1. Introduction

For more than three decades, the world in general, and West Africa in particular, have been confronted with the exacerbation of the effects of climate change [1]. These climatic events make rural populations vulnerable, as their agricultural production and incomes are greatly reduced. As a corollary to the exacerbation of the effects of climate change, wood resources are being significantly reduced as a result of successive droughts, hydro-agricultural developments, illegal logging, abusive pruning, pressure from livestock on plant resources and bush fires [2, 3]. This situation has not spared Senegal, which is facing a degradation of its natural ecosystems due to the combined effects of the long drought of the 1970s and the population explosion. This unfavorable situation inexorably leads to a decrease in biological diversity [4]. At the end of the 1970s, the FAO formally recognized the importance of trees in the rural economy, particularly for their multiple uses in human nutrition, by setting up a special action programme, "Forestry for local communities" [5].

For rural people, trees are an important and vital part of their landscape and living environment. The baobab, *Adansonia digitata* L., a multipurpose woody species, plays a major role in the diet of rural populations in Sahelian countries. It is a source of food, fodder, fiber and medicinal products [6]. Unfortunately, this species is now becoming increasingly threatened.

Recent studies such as those by Cissé and Gning [7] and Ndiaye [8] have shown that *A. digitata* L. parks in the Kolda and Sédhiou regions are facing ageing (90% of the trees studied), poor natural regeneration and a drastic decline in productivity as they senesce. These parks are also strongly threatened by human activities. The study by Cissé and Gning [7] in the Kolda and Sédhiou regions revealed that 46% of *A. digitata* trees are pruned and 76% have been debarked, often resulting in their death.

In order to limit the damage caused to baobabs by intense harvesting pressure, some researchers have been working on its domestication on station [9]. In this sense, the Centre National des Recherches Forestières (CNRF) of the Institut Sénégalais de Recherches Agricoles (ISRA) resumed its research from 2013 to 2016 on market gardens and horticultural grafting of *A. digitata*, but in a peasant environment in eight terroirs in the Sédhiou and Kolda Regions. The market garden beds allow the cultivation of *A. digitata* for the continuous production of fresh leaves and horticultural grafting to facilitate the shortening of its production cycle from 20 to 5 years. The objective of this study is to analyze the socio-economic determinants of the adoption by beneficiaries of market gardening and horticultural grafting technologies of *A. digitata* L.

2. Methodology

2.1. Material

The study sites are the communes of Saré Bidji (Dianabo and Boguel), Sakar (Bougnadou), Ndiamalathiel (Koboyel) and Bogal (Fololo Birane, Sénoba, Saré Modika and Diop Counda) (Figure 1).

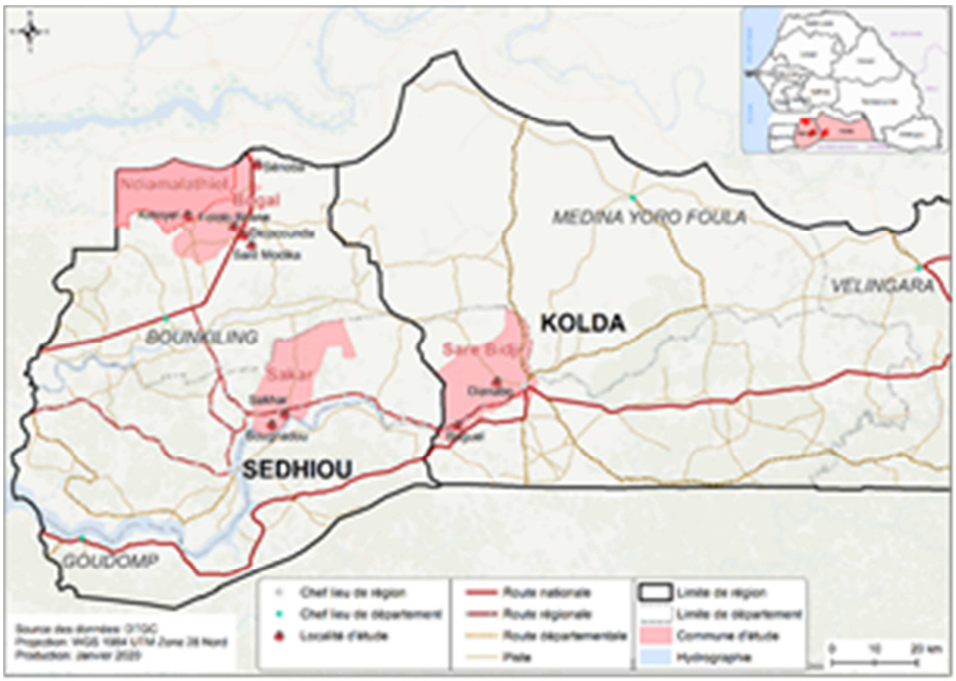

Figure 1. *Location of agroforestry technology introduction sites.*

2.2. Method

Sampling and data collection

Data collection was carried out in 8 sites in the regions of Kolda and Sédhiou. The choice of these sites was based on the presence of baobab parks, the seriousness of degradation phenomena, and the willingness of beneficiaries to collaborate with the project. In total, 106 beneficiaries were surveyed, 46% of whom were men and 54% women. This sample was selected on the basis of the beneficiaries of the technologies. The choice of beneficiaries was based on whether or not they were involved in the management of market garden beds and grafted plants, and whether they were present during the evaluations of the technologies introduced. The beneficiary is defined as an inhabitant (man or woman) of the village who owns at least one baobab tree that produces goods and services. Quantitative data were collected using a questionnaire. An interview guide was used to collect qualitative data.

In each site, a focus group was first conducted to analyze individual and collective perceptions of the technologies introduced. Beneficiaries' knowledge of the technologies was also analyzed, including the installation of boards, management and maintenance, the difficulties and solutions recommended, and the positive and negative effects. Beneficiaries' knowledge of the technologies is also analyzed:

the installation of boards, management and maintenance, difficulties and solutions, positive and negative effects.

2.3. Statistical Processing of Data

The respondents were classified, firstly by sociolinguistic group (Peul Cabada, Peul Fouladou, Mandingue, Serere) on the basis of ethnicity according to the classification, and secondly by age and gender categories (men, women) on the basis of the structuring proposed by Assogbadjo and al. [10], which makes it possible to check whether perceptions depend on sociolinguistic groups and age and gender categories. The principle of this structuring proposed by Assogbadjo and al. [10] is that young people are under 30 years old, adults between 30 and 60 years old and the elderly over 60 years old. To study the perceptions of the beneficiaries, the relative frequency matrices were analyzed.

Table 1. *Modalities of the independent variables used for the logistic regression.*

Independent variables	Description
Age	0: Youth 1: Adult 2: Old
Sexe	0: Female 1: Male
Socio linguistic group	0: Serere 1: Mandingo 2: Peul Fouladou 3: Peul Cabada
Access to seeds, water, land	0: No access 1: Access
Source on income	0: No activity 1: Agriculture 2: Vegetable growing 3: Livestock 4: Trade
Household size	1: Less than 3 persons 2: 3 to 5 persons 3: 5 personnes and more
Experience in market gardening	0: No experience 1: Experience

Correspondence factor analysis (CFA) was used to relate the perception groups to the technologies introduced and the villages (Table 1). The Chi-square and Pearson's test of independence were used to test for dependence or otherwise between perceptions and certain socio-economic characteristics (age, gender, etc.). The non-parametric Kruskal Wallis test [11] was performed for the difference between villages based on the number of accessible baobab individuals.

Data were entered into an Excel spreadsheet. All statistical analyses were performed with R (version 3.2.0, 2015-04-16) and XLSTAT software.

3. Results

3.1. Access to Natural Stands

The Kruskal-Wallis test shows a difference in access to large trees of A. digitata between sites (p=0.04). The villages of Bougnadou and Fololo have more access to large trees than Boguel, Dianabo, Saré Modika, Koboyel, Diopcounda and Sénoba (Figure 2).

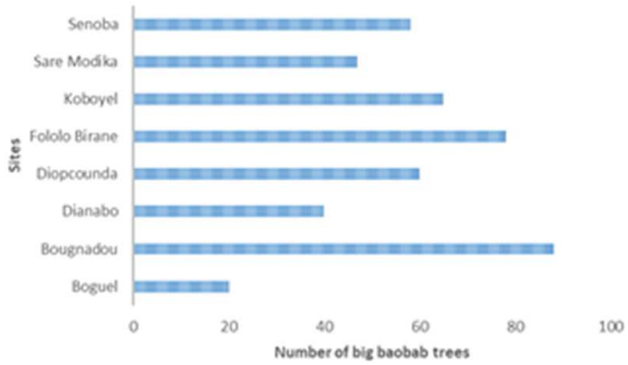

Figure 2. *Access to natural populations of A. digitata at different sites.*

3.2. Satisfying Fresh Leaf Needs

Figure 3 shows that the villages of Senoba, Saré Modika, Koboyel and Dianabo constitute a group that is opposed to Bougnadou and Fololo. The variables most represented on this dimension are 'substitute' and 'purchase' which are opposed to 'stock'. These two groups are then opposed, because the first (Senoba, Saré Modika, Koboyel and Dianabo) does not have enough leaves, while the second (Bougnadou and Fololo) has a stock.

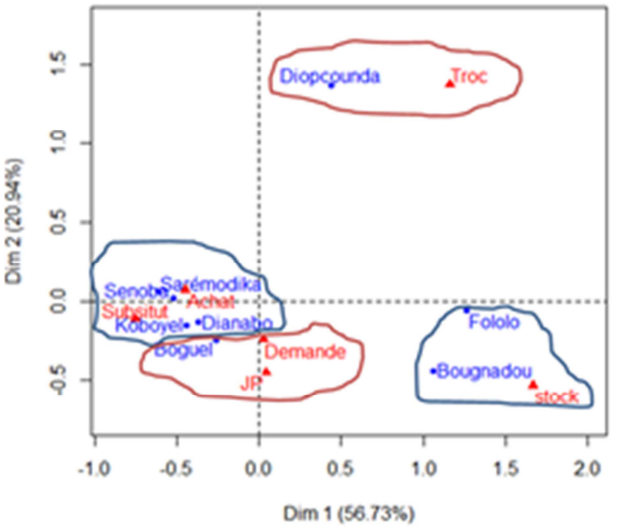

Figure 3. *Fresh leaf requirements by village.*

Substitut= villages that use products that can replace baobab leaves; Achat= villages that buy leaf powder to meet their leaf needs; Stock= villages that have enough leaf powder; Troc= villages that exchange products to get leaf powder; JP= villages that do not have a shortage of leaf powder; Demaned= villages that get leaf powder from others.

On the other hand, the villages of Diop Counda and Boguel contributed more to dimension 2 with 3.36% and 81.07% respectively. On this dimension, the variables 'barter' and 'demand' and 'never shortage' are more represented. It can therefore be said that Diopcounda still needs baobab leaves like most sites.

3.3. Changes Due to Adoption

Pearson's Chi-squared test showed that changes due to technology adoption are not gender dependent (p=0.3). The CFA showed 100% of the total inertia (79.35% and 20.65% for Dim1 and Dim2 respectively, Figure 4), hence a good interpretation of the factorial design. The villages of Bougnadou (15%), Boguel (5%), on the positive side, in contrast to Dianabo (6%) and Koboyel (42%), contribute more to dimension 2. On the positive side, 'no change' is observed. This variable is strongly correlated with dimension 2. On the other hand, the changes induced on the negative side are 'less time searching for leaves in the bush' and 'more time for maintenance'. Taking this dimension into account, 2 groups can be created. Group 1 consists of Bougnadou and Boguel where there is 'no change'. Group 2 consists of Koboyel, where the change is 'more maintenance time', and Dianabo, where the change is 'less time searching for leaves in the bush'.

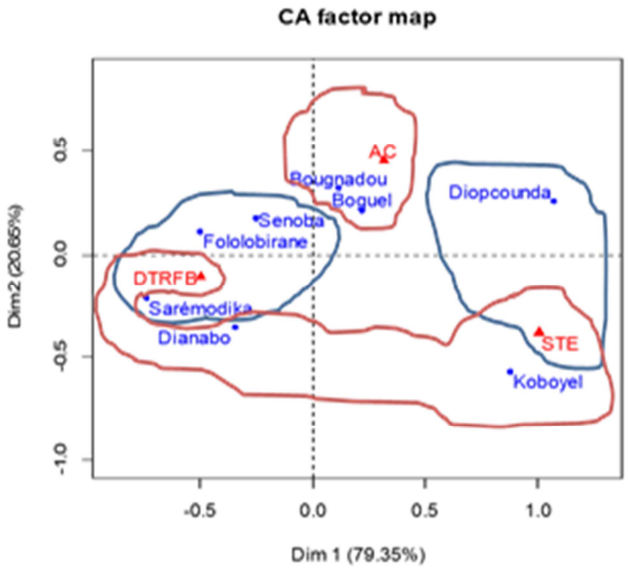

Figure 4. *Changes due to technology adoption by beneficiaries.*

STE = villages that have a surplus of maintenance time with the technologies, AC = villages that have no change with the technologies, DTRFB = villages that have decreased the time spent searching for leaves in the bush,

On the other hand, the villages of Saré Modika, Fololo Birane and Senoba are more at the level of the first dimension with 20%, 11% and 35% respectively. The most represented changes correlated to this dimension are: 'less time searching for leaves in the bush' on the negative side and 'more time for maintenance' on the positive side. Taking this dimension into account, two other groups can be created. Firstly, Group 1 is made up of Saré Modika, Senoba and Fololo Birane, where the determining change is the 'decrease in time spent searching for leaves in the bush'. Secondly, Group 2 is made up of Diopcounda where the important change is the 'increase in time spent maintaining the boards'. It can be said that 'less time searching for leaves in the bush' and 'more time maintaining the planks' are the main changes brought about by the adoption of the introduced technologies.

3.4. Reasons for Adoption

The Chi-2 test of independence reveals that gender is a determining factor in adoption (p= 0.04) (Figure 5). Thus, for women, the determining factors for adoption are ease of picking, proximity to homes, and fruiting of large trees. On the other hand, for men, the adoption factors are more related to the market (the possibility of selling).

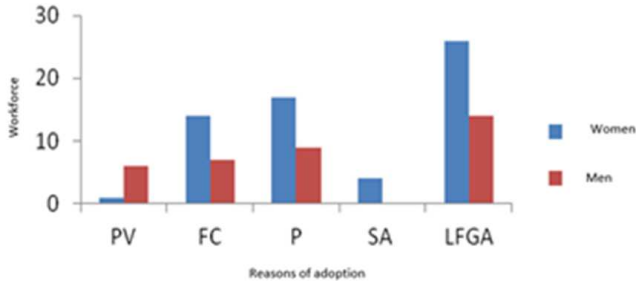

Figure 5. *Reasons for adoption by gender.*

PV=Possibility of selling; FC = Ease of collection; P=Proximity; SA=Food security; LFGA=Let the Big Trees Grow.

3.5. Benefits and Constraints of Technologies

The Chi-square test of independence revealed that the benefits are not related to gender (p= 0.67). For 70% of the sample, the benefits of the technologies were mainly related to food security, for 20% to improved income and for 10% to increased baobab trees. In addition, all respondents felt that the leaves collected from market gardens were of 'good or better' quality than those from mature trees. The adoption of technology helps to reduce the risk of falling from a large baobab tree during harvesting.

With regard to constraints, the survey revealed a lack of knowledge and skills in operating the technologies. According to 62% of respondents, the technologies cannot be applied by beneficiaries without prior training or technical assistance. For 42% of respondents, they are easy to replicate and for only 2%, they require laborious work. For 30% of the sample, the lack of maintenance and follow-up due to the lack of time on the part of the beneficiaries, especially in certain sites (Diopcounda, Boguel, Bougnadou), constitutes a handicap to adoption. In addition to this disadvantage, there is the lack of fencing to reduce the action of roaming animals, and the difficulty of supplying seeds and plants. Also, some plots (Diopcounda, Boguel, Bougnadou) are favorable sites for wildlife. For 50% of the respondents, water problems to ensure good watering are a hindrance to the adoption of the technologies.

4. Discussion

The results of this study show that the villages of Bougnadou, Fololo, Koboyel have more access to large trees compared to Boguel, Dianabo, Sénoba and Saré Modika. This can be explained by the fact that in Bougnadou, Fololo, Koboyel there are baobab trees in the hut fields according to

Cisse and Gning [7]. This result confirms Nimaga [12] who showed that access modalities are more or less facilitated by the availability and abundance of quality resources. In general, it is observed that in areas where the natural baobab population exists, the benefits of adopting baobab boards, for the sole purpose of producing leaves, may be limited as shown by Bationa and al. [13]. This observation is basically justified because while resources do not appear to be scarce, the additional need for leaves is low and the incentives for intensification by rural people are low.

The study also showed that most sites do not meet their needs for fresh leaves. Indeed, the villages of Senoba, Saré Modika, Boguel and Dianabo do not have enough fresh leaves because their baobab trees are mostly aged and, therefore, cannot give a good binder. This result corroborates that of Cisse and Gning [7] who showed that more than 90% of the trees studied in the Kolda and Sédhiou Regions were ageing.

Thus, to mitigate this situation, local populations develop alternatives such as the use of other substitute products like *Abelmoschus esculentus* L. or the purchase of baobab leaf powder in weekly markets and bartering. In addition, with the exception of Dianabo and Diop-Counda, the beneficiaries have maintained the FNRAA/Baobab project boards and installed some of them in their home fields, near or within the concessions. On the other hand, the Fololo Birane and Bougnadou sites have a satisfactory quantity of leaves. This would be due to the fact that they have fairly juvenile trees in their home parks with a fairly dense natural baobab population. For the village of Bougnadou, this situation may justify the low level of adoption of the technologies and the lack of success of the market gardens. This result corroborates that of Savard [14] who showed that most of the farmers interviewed (79%) had enough baobab trees in their area to meet their leaf needs. This result is interesting in the sense that it shows that, despite the negative effects of human activities and climate change on plant resources, people are sometimes not very aware of the issue.

The low level of awareness can explain the low level of adoption of the technologies introduced by the FNRAA/Baobab project (25%). This rate of adoption confirms Rogers [15], for whom even if an innovation seems extraordinary, its adoption often remains low contrary to the initial ambitions of the promoters. The most important reasons for adoption, such as 'ease of collection', 'proximity', 'fruiting of large trees', for women, are justified by the fact that, generally speaking, women play the key role in household food security in our study sites. This is in line with Falconer and Arnold [16] who state that women are not only the main collectors, but generally take charge of processing, selling and preparing produce. For men, on the other hand, the reasons for adoption are mainly related to the income they receive from the baobab. In this respect, our results confirm Nimaga [12] who showed that the scarcity of a resource and/or its monetary value leads to a gradual return to its exploitation by men. These reasons for adoption justify some of the changes made. Indeed, most of the sites such as Boguel, Saré Modika, Fololo Birane, Dianabo and Senoba reduce the 'time spent searching for leaves in the bush'. As these sites are among those with the largest amounts of leaf biomass from the plots, the pressure on the large trees has decreased. The opposite is true for Diop Counda and Koboyel, where an increase in 'maintenance time' is noted, and for Bougnadou, where 'no change' was noted. For Diop Counda, this could be due to the repair of their fence, which had been damaged by animals. On the other hand, in Koboyel, the daily maintenance of the planks justifies the large quantity of biomass that is produced. For Bougnadou, the disappearance of their planks could be linked to the lack of commitment of the beneficiaries, especially women, because of the weight of Mandingo tradition.

5. Conclusion

This work has shown that perceptions of agroforestry technologies are multiple. It shows that not all sites have the same level of accessibility to large trees, which determines the satisfaction of fresh leaf needs linked to the level of adoption of the technologies by site.

Furthermore, the analysis of the data collected showed that, although there are a number of advantages (improvement of the taste of sauces, possibility of donations and increased income, availability of leaves in all seasons), constraints (lack of skills and knowledge of the technologies, fencing, animal rambling) in some sites hinder the level of adoption of the technologies by the beneficiaries.

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