# AGROFORESTRY SYSTEMS AND FOOD SECURITY IN THE SAHEL: THE CASE OF TOUKAR, SENEGAL

by

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THESIS ABSTRACT

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Title: Agroforestry Systems and Food Security in the Sahel: The Case of Toukar, Senegal

Communities in the Sahel region are confronted with problems such as depletion of soil fertility, food insecurity, and climate change, which exacerbate poverty and malnutrition for the inhabitants. The farmlands in Toukar, Senegal, are rapidly denuded of native trees, mainly *Acacia albida*, that provide myriad benefits. Agroforestry systems, or the intentional use of trees in croplands, have become a potential vehicle to transform the capacities of subsistence farmers to achieve food security. The purpose of this study is to determine farmers' attitudes about agroforestry, who seems to practice it and support it, who is unsure about its values, and who seems opposed to it.

I find that farmers who practice a more intact historic version of the Serer farming system are the most supportive of agroforestry and tend to be wealthier, while people who are seemingly more modern are less likely to adopt it and tend to be poorer.

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To Amsatou, Kaan, Fatou and Mouha

TABLE OF CONTENTS

Chapter Page

Chapter Page

LIST OF FIGURES

Figure Page

LIST OF TABLES

Table Page

# CHAPTER I

## INTRODUCTION

This thesis asks who supports, who opposes, and who is not sure about agroforestry techniques in the village of Toukar, Senegal, a community of 3,800 people in the Serer region, the west central peanut basin. Agroforestry in this thesis refers to planting and protecting trees in farmlands, practicing toss (fallows and pasturelands), maintaining living fences around farms, crop rotation and mixed-cropping. This study finds that 17 out of 43 interviewees support these new techniques to mix trees with crops; 15 out of 43 are unsure; and 11 out of 43 are against agroforestry systems. The study proceeds to examine the underlying explanations for why some people tend to adopt agroforestry more readily, why some are uncertain, and why some tend to oppose the technique.

I examine agroforestry adoption because, given the many socioeconomic and environmental benefits associated with the technique, agroforestry can give people new tools to improve their livelihood. The more we know about the underlying motivations and characteristics of adopters, opponents, and those who are indifferent, the more we can understand how to advocate for agroforestry techniques that clearly can improve agricultural conditions and standards of living, and can alleviate rural exodus.

I further examine whether characteristics like wealth, female gender, agropastoralism, and economy of subsistence versus economy of commodificaton correlate with adoption of agroforestry. First, concerning the wealth issue, I expect wealthy people to adopt agroforestry because they have many assets (including livestock) that are dependent upon the practices of agroforestry such as trees in farms to provide fodder in the dry season. Second, I examine conventional wisdom about gender in regard to use of forests, and specifically the claim that because women need firewood to prepare household meals, they cut trees and oppose agroforestry (Eckholm, 1975; Gorse, 1985; RdS 1993, cited by Ribot, 1999). By this logic, which I find flawed and will refute, women will criticize the practice and adaptability of agroforestry. Third, I expect agropastoralism to correlate with agroforestry practices because agropastoralists need fodder and *toss* (grazing lands) for their livestock. Lastly, I also analyze a correlation between the pattern of adoption for agroforestry techniques and the degree to which a farmer's economic activity is more subsistence oriented, or more oriented toward commodification. I would expect modern people or people working within a more externally- oriented commodified economy to adopt agroforestry because they have more outside income opportunities. As it turns out, the wealthy do support agroforestry more, but women are also supporters. Agropastoralism does correlate with agroforestry, but not with economic commodification. This thesis examines questions of adoption, presenting an unexpected correlation among traditionalism, agroforestry, and wealth in Toukar, a correlation that calls into question a number of truisms about development in this part of the world.

With regard to patterns of adoption, this thesis shows that supporters are people who are more attached to the traditional farming systems, and that people who are seemingly more modern (e.g., more educated and more in contact with the outside economy and outside world) are less likely to adopt agroforestry. Interestingly, people who are wealthy in this society tend to be those with the most traditional profiles in terms of lifestyles and economy. Here, wealth goes with traditionalism and support for agroforestry, while poverty goes with being more modern and being more opposed to agroforestry. In the Serer region of Senegal, agroforestry is not new, but rather, part of historic, traditional, deep cultural values and practices tied to ancestors and even to the local religion. These findings suggest that agroforestry techniques are culturally embedded and socially compelling strategies that farmers can utilize to increase food supply and rural incomes as well as ameliorate soil conservations measures.

**Importance of Agroforestry**

Agroforestry has the potential to address Africa's contemporary agricultural crisis. Adding trees to farms can restore soil fertility, produce animal feed, facilitate the integration of livestock into croplands, secure organic fertilizer in the form of manure, alleviate the fuel wood shortage, mitigate deforestation and climate change, and above all, improve agricultural yields and incomes, ensuring more secure livelihood for Africa's poorest.

In Senegal, West Africa, farming is the mainstay of the economy. About 77.5% of the population (CIA World Factbook, 2013) are farmers who depend on rain-fed agriculture and cultivate peanuts (*Arachis hypogaea*), cotton (*Gossypium barbadense),* and vegetables as cash crops for export, as well as pearl millet

(*Pennisetum glaucum*), sorghum (*Sorghum bicolor*), maize (*Zea mays*), and other food crops for consumption. The country is located in the Sahel region, where an estimated five million hectares have been lost to the desert in the last fifty years (Rodale, 1991). Today agriculture in Senegal, which primarily depends upon the limited rains that fall in the three-month period from July to September, faces a formidable challenge. Impoverished soils and land degradation, due in part to over-intensive agriculture, climate change, and over-grazing, have become prevalent and have undermined people's ability to grow adequate subsistence crops. Thus, food security is in jeopardy, both because modern types of agriculture have superseded traditional systems, and ironically, because for more than a century the state has promoted a peanut cash-crop monoculture for export to boost its revenues without providing real economic incentives or better alternatives to farmers to produce nutritious, diverse, and culturally-appropriate food crops.

The village of Toukar in Senegal, like many communities in the Sahel region, is confronted with soil fertility depletion, food insecurity, deforestation, and climate change. These problems exacerbate poverty and malnutrition among inhabitants. Farmlands are rapidly denuded of native trees, especially *Acacia albida* that provide myriad benefits to the inhabitants. Fallow periods, which regenerate soils by allowing nutrients to accumulate in the topsoil and help prevent soil erosion (Baumer, 1990; Pelissier, 1966), are diminishing in Toukar as a result of extensive peanut production (farmers' main income provider), and a growing population. Widespread desert-like conditions in the village can be blamed on the decline of rainfall and human-made deleterious agricultural

practices, such as deforestation for firewood and reduction of vegetative cover. These dire conditions have prompted many farmers in the village to out-migrate to the cities or abroad in search of better opportunities and to provide for their poverty-stricken families.

Agroforestry systems, a set of sustainable land-use management practices centered around planned and managed interactions between trees, shrubs, crops, livestock, and other factors of agricultural production (Bishaw, 2012), have become a potential vehicle to transform the capacities of subsistence farmers to achieve food security in the Sahel. Agroforestry is simply defined as a modern term for a set of ancient practices throughout the world (Nair, 1982, cited by Hyde, 1995).

Although considerable research has been devoted to agroforestry—especially in East Africa (Garrity & Verchot, 2008)—less attention has been paid to the decline of tree density, hesitancy of certain famers to plant trees, and the patterns of agroforestry adoption in West Africa. My research not only contributes to the existing large body of information pertaining to the potential benefits and sustainable use of agroforestry, but provides evidence for why some farmers are more likely to adopt, why some are not sure about agrogroforestry, and why others seem more opposed. While agroforestry techniques have traditionally produced desirable results in this village, use of these techniques has dwindled considerably in recent years. The Acacia parklands' contribution to poverty alleviation and natural resource conservation in the Serer region (Pelissier, 1966) is disappearing rapidly. The purpose of this thesis is to determine farmers' perceptions about agroforestry, to determine who practices it

and supports it, who is unsure about its benefits, and who appears to be against it, as well as provide the underlying reasons for these patterns of adoption.

Drawing on both qualitative (participant observation using firsthand experiences and personal accounts, interviews and peer literature reviews) and quantitative (statistical data analysis of responses to a survey questionnaire) field research conducted in Toukar, Senegal, I have examined farms with a great quantity of trees and farms with fewer trees to ascertain the rationale behind the opposition or uncertainty in some places, and adoption of agroforestry in places of abundance. I find that farmers with a more intact version of the Serer farming systems are the most supportive of agroforestry (living fences, purposeful tree regeneration, etc.). Even though agroforestry is widely considered a "modern" technology in many parts of the world, it actually is a "traditional" practice in Toukar. Not only do I find that more modern farmers are disinclined to adopt agroforestry, but they tend to be more poor than the more traditional farmers. Understanding this counter intuition is central to this thesis.

The physical and socioeconomic benefits of combining trees, crops, and livestock are enormous, and should allow low-resource poor farmers to increase their survival strategies. But why do many farmers not adopt agroforestry? Traditions fade as people become more educated and more connected to the outside world, and thus become unsure about or even opposed to agroforestry. In response, it is important to understand the obstacles that prevent young and educated farmers from adopting agroforestry techniques.

For example, does inaccessibility to land, or perceived inaccessibility to land, cause some farmers to be uninterested in agroforestry? They may be

underprivileged by the land tenure law (discussed in the background section), and thus own smaller parcel of lands in which they view trees in farms as a constraint to self-sufficient production. Or does the shortage of labor discourage these farmers? The obstacles may also be political, with the state failing to provide support to rural people. Pressed by these difficult circumstances, farmers' response points to an externally- oriented commodified economy (dependent on outside connections) to find solutions to their problems.

I argue that present-day farming needs rebuilding, to benefit from indigenous knowledge systems or ethnoscience that has supported and provided sustained livelihood for people for centuries. It is vital that we revisit traditional agricultural societies, like that of the Serer people, to understand their age-old skills and technical knowledge, before this accumulated knowledge and cultural heritage vanishes. Invaluable sources of information embedded in our ancestors' historic ways of life may be beneficial to young and educated people. Our ancestors developed many techniques to live in this environment. The people today must recover that knowledge and local heritage in order to reclaim locally available remedies to rural development problems.

Traditional agriculture, characterized by low-input, polyculture, and crops and livestock interactions, has been compatible with Toukar's ecological environment, enabling the Serer people to link economic production to their own cultural traditions and management capabilities rather than to foreign approaches to management, which are often contrary to indigenous people's needs. Today the historic pattern is still valid because indigenous farmers who are supportive and practicing this model, are doing much better, with more agricultural assets, than the farmers who are unsure or opposed to it. Hence, soil

fertility management that depends on well-established tree roots to ensure soil structure is still achieved by followers of agroforestry. Adopters and supporters of agroforestry systems continue to benefit from soil erosion control through living fences, vegetative cover, and animal interactions. Meanwhile opponents and unsure farmers continue to miss out on the advantages of agroforestry, especially the important nutrient recycling process by deep-rooted nitrogen-fixing woody perennials (*Acacia albida, A. Senegal*), and on agrobiodiversity (genetic diversity) in farmlands.

This study is significant because the resource-poor farmers have long been exposed to "top-down" approaches to rural development, which have not produced expected results, nor solved their specific problems. They continue to face denuded farmlands, impoverished soils, declining crop yields and shortage of fuel wood. Hence this research may help conserve dying traditions, and also reduce destructive social trends associated with rapid modern practices, by maintaining cultural continuity and increasing the self-reliance of local people (Berry et al., 1984). The study identifies ways for young farmers and entrepreneurs to reconnect with some of the most proven farming practices that have provided food security and held communities together for centuries.

Moreover, the research can also benefit academics, development practitioners, international donors, and policy makers working to improve agricultural production and eradicate poverty in the Sahel. Since Sahelian countries face the same problems of land degradation, deforestation, and climate change, incorporating trees in croplands can improve microclimates, reduce

farmers' risks of crop failure, and thus mitigate climate-change effects across the region.

**Methodology**

I approached the study using qualitative research paradigms that focus on participant observation to gain a close and intimate familiarity with all the respondents. I used first-hand experiences and personal accounts to describe complex rural living conditions. I also held formal and semi-structured interviews by following a written questionnaire, which I developed to gather data, useful for the statistical analysis of the different responses. I garnered information using peer literature reviews as well as PRA (Participatory Rural Appraisal) methods. I also conducted quantitative (statistical data analysis) research methodologies, testing theories and hypotheses to demonstrate their accuracy or fallacy, and reflect on the patterns of agroforestry adoption.

For some importance and complex matters such as wealth, degree to which one lives in an economy of subsistence or an economy of commodification, and agropastoralism, no one questions a variable offers an accurate representation. To get a more complete understanding of these matters, I aggregated answers to many relevant questions, weighted according to theoretical importance, into an index.

The construction of each index was done first by analyzing responses relevant to a theme (e.g. wealth), reflecting on the importance of each variable to the theme (e.g. cattle in this society are far more important as marker of wealth than chickens or farm implements), assigning a weight to each element, and then standardizing results to produce a 1-100 scale. These indices are discussed in

more details at the start of each corresponding chapter. I used the PRA approach to engage indigenous people in facilitating the questionnaires and proceedings (my research team included one farmer).

I followed the guidelines of an approved IRB (Institution Review Board), Human Subjects Research Protocol and personally informed the respondents of the nature, benefits, risks and anonymity associated with my research. I drew on my experience working with farmer' community development in Senegal and The Gambia, using participatory research approaches. During these experiences, we held meetings and group discussions, and agreed on the agenda prior to the study. We clearly stated that each participant voluntarily agreed to participate, could raise questions or concerns, and finally had the right to opt out from the research process and ask not to be cited or identified by name. I supplemented this experience with the study of research ethics, collaborative research and co-production of knowledge (Chambers, 1997).

The village of Toukar consists of 11 hamlets (see Map 3), which are approximately even in size and population. Each hamlet is a distinct district in the village and so the hamlet is my socio geographical unit of analysis. Surrounding each hamlet are approximately 100 fields of varying sizes and tree densities. I excluded from my study fields with fewer than 5 trees/ha, since such fields are of insufficient tree density to test hypotheses regarding intercropping, nitrogen fixing, soil improvement, and the practical farming impacts of having trees dispersed across planted fields. Based on prior personal observation, I expected to find on average 50 fields per hamlet that meet the minimal tree density criteria. Of these 50 fields, prior research suggests that, on average, 35

fields will be planted in staple cereal crops (millet or sorghum), and 15 will be planted in the local cash crop (peanuts).

For each hamlet, I randomly selected (using a random number generator in Microsoft Excel) two fields that meet the minimum tree density criteria (5 trees/ha) and are planted in staple cereal crops (millet/sorghum) (2x11=22 plots). I also randomly selected one field per hamlet planted in cash crops (peanut) (1x11=11). My sample had a slightly larger proportion of staple crop than cash crops because I was especially interested in the interplay between food production and agroforestry.

Once I selected the 33 fields as described above (22+11), I conducted interviews with the owners of these fields. I carried out the interviews in Serer, which is the language commonly spoken by the villagers. The interviews were not recorded to avoid raising suspicions, but organized as semi-structured, open-ended conversations (followed up by extensive note taking on my part). The bulk of the interviews (or semi-structured interviews), participant observation, questionnaires, and PRA took place during the rainy season from July through September 2012, which means that most interviews were conducted in the work-fields, or during off days. They lasted about an hour. The open-ended conversations took up to 2 hours. The participant observation lasted up to 3 hours per day.

Since men own most fields, most of my interviews were with men. (My own prior observation growing up and living in this village suggests about 80% of fields are owned by men). To get a female perspective on these issues, I used snowball-sampling techniques to identify an additional 10 women who own

fields. I conducted interviews with these women about agroforestry systems by asking the identical questions I asked the men, but with some additional queries asked only to women such as firewood needs, and crop selection. These interviews enabled me to examine the social, ecological and economic advantages and constraints of multi-purpose trees in farmlands, as well as the gender aspect of the study (sample questions in Appendix A). The interviews with the women were problematic because some of them were taciturn and uncommunicative especially in the presence of the husbands, as if they were hiding something, but when we met at their houses they became more open and cooperative. I later found out that they previously acted that way out of respect for the husbands, because according to the traditions, Serer women are not supposed to talk much, or respond to interviews while the husband is present.

Given the population of Toukar (3902 inhabitants in 11 hamlets, per the 2012 census), a randomized selection of 33 fields and 43 informants gives a good representative sample of variations in agricultural practice, socioeconomic background, and demographic characteristics of the population. I interviewed more men than women because men play a greater role in making agricultural decisions, especially with regard to capital assets on farms. (Trees are an important capital asset in this agricultural system.) I also interviewed people who are 18 years and older because this population group dominates the agricultural workforce, and because most people who make decisions about farming systems and tree planting and preservation are in this age group.

The data collected was transcribed, presented and analyzed through statistical data extraction (mean, standard deviation) and analysis software,

including spreadsheets, and interview compilation (using graphs and tables). For instance, farmers responded to the questions pertaining to the quantity of harvest per year (or crop yields) by giving the number of filled granaries *(ndap*) and diameter *(ndar*) of the *ndap*, which I later converted to corresponding kilograms (kg) using the factors below (Table 1).

*Table 1: Conversion of Crop Yields*

| Family size | # of persons | # of *ndar* | Kilogram | # of *ndap* | Quantity of cereals (kg) |
|---|---|---|---|---|---|
| >=20 | 29 | 4 | 2000 | 3 | 6000* |
| 12 - 20 | 17 | 3 | 1000 | 2 | 2000 |
| <=12 | 12 | 2 | 500 | 1 | 500 |

(*) A family of 29 persons with 3 *ndap* will have a total cereal harvest of (3 x 2000 = 6000 kg of cereals).

The transcriptions included fictive names of informants. Content analysis was widely used by researchers to identify and define the content of discourses and the social and cultural contexts (Chambers, 1997), allowing me to examine the significance of agroforestry systems from the perspective of the farmers interviewed. It precisely determined who supports, who opposes, and who is not sure about agroforestry techniques in Toukar. It dealt with the underlying explanations for why some people use agroforestry more, why some are unsure, and why some tend to oppose the techniques. I tested hypotheses through a detailed examination of many indicators regarding the distribution of wealth in the community, and evaluated the sustenance of the village's livelihood strategies (i.e., agropastoralism), which have been the traditional Serer model.

Furthermore, the field notes obtained through various interviews enabled me to gather knowledge of the farmers' awareness (or lack thereof) of the effects

of cutting down young seedling trees in the farm during plowing. Were their actions intentional or accidental? Also, interviews helped me explore when and how farmers draw the line between preserving trees and increasing arable lands.

These findings highlight the real motives behind adoption of sustainable agroforestry systems, while also shedding light on the practices and motivations of the unsure and opponents. For instance, some motives may include socioeconomic changes affecting people such as the impact of rural exodus (outmigration) on agricultural production, the importance or value of a cash (market) economy in present-day society, or the abandonment of historic farming systems. The findings also confirm the benefits of agroforestry in improving Toukar's agriculture, and may encourage farmers, especially young farmers, to accept these practices and help outline a productive balance among cash cropping, long term investments in trees and agropastoralism, and finally give us an overall grasp on the issue of women and firewood.

**Limitations of This Study**

I have learned that research requires proper planning and immense time to gather as much relevant information as possible. I think I should have focused more on qualitative methods to have a perspective of the social factors associated with the adoption of commodified economy and modernism. For instance, I should have asked young people to offer specific insights and potential solutions to the generational gap and the causes for migrations.

Perhaps further studies (through the lenses of cultural anthropology, scientific methodology) are needed to why traditionalism is fairing better than modernism in Toukar. Is this pattern verifiable in other villages or regions in the

Sahel? Future research may also focus on determining the underlying reasons why externally- oriented or modern farmers do not like trees in farms, and finding out may help figure out how to approach them for outreach. Potential future research may also emphasize the effectiveness, impact or adaptability of "sustainable intensification" through on-farm agroforestry experiments in rain-fed agricultural productions, or look into the interplay between indigenous heritage and applied agroforestry or both.

**My Story**

I am a farmer from Toukar, a village in West central Senegal that is facing multiple environmental, socioeconomic, and cultural problems due in part to the loss of the vegetative cover, which has increased the poverty level. I vividly remember Toukar's farmlands once scattered with scores of acacia trees as well as other essential trees that provided numerous household uses for families such as fruits, medicines, fodder for animals, wood for fuel and construction materials, and agricultural implements.

Growing up in Senegal, I have witnessed this onset of problems firsthand, and hope that sustainable agroforestry techniques can improve livestock conditions, increase crop production and diversity, and thus mitigate climate change for the overall enhancement of the quality of life in the region.

From the age of twelve, I went to school in the city, but I always came back to my village to help with the farming. Once, when I went back to my village of Toukar, cholera was ravaging the area—many children and old people were dying. With five friends, I organized neighborhood meetings to sensitize people about the disease and give basic hygienic recommendations: reheat your leftovers, wash your hands with soap before

eating, and rush anyone who is vomiting or has diarrhea to the dispensary. Thanks in part to our efforts to mobilize people against cholera, the number of deaths caused by that disease decreased considerably. That small success taught me that I could do something to improve the living conditions of the people in my community.

After the cholera epidemic, I decided to stay in my village and farm. With that decision, my classmates began to wonder about me. They thought I was foolish to stop school for the sake of a rural area where even many farmers flee the toil and poverty to search for better conditions in Dakar (Senegal's capital city). Unfortunately, my friends did not agree that we are the ones who have the capacity to restore our people's traditional self-sufficiency in food and simultaneously protect our environment.

During the dry season, everything in the village slows down. Most young people leave the village to look for jobs in the cities. I wanted to start something that would fight against people's idleness during the dry season, and talked to some of my friends about creating some community projects. Together we planned a village meeting under the big baobab tree where traditional ceremonies, rituals and meetings of the council of elders have always taken place. I told the "griot," who belongs to the drumming caste, to beat the drum to inform everyone about the meeting, and many people came. Within a few weeks of that meeting, a number of young people came together to set up a rural self-help organization, the Associations des Paysans de Toukar (APT), dedicated to applying new ecologically-based farming techniques to increase crop production, promote public health, and create a cultural center where the women can learn skills to improve the quality of their lives. We hoped to slow the rural exodus.

Soon, a relative of one member donated a field at a place known as *Takit*, where we dug a 45-foot well to start a small garden project. We experimented with vegetables, and

the success of our test garden encouraged us. But we needed five more wells, which would involve a lot of hard work and expense. I submitted a proposal for assistance to an American nongovernmental organization called Lutheran World Relief (LWR), and they agreed to finance it. There was total joy all over the village that day. But according to LWR, our co-op needed to follow their directions and welcome their engineers to supervise the work. We did this, and we worked together to dig the five wells, and with the help of imported tractors, created a huge basin for collecting rainfall. Unfortunately the new wells gave water too salty for gardening, and the basin failed to hold rainwater.

With that disappointment, all hope vanished. We tried to figure out what brought on the disaster. Some people thought the *Pangools* (spirits in Serer, my native language) were against such a project in the *Takit* valley because the tractors that came to work the soil and dig the big basin made a noise never heard in that area before. Others thought that we should not have accepted the engineers' ideas, or that we should have given milk and an ox as offerings to the spirits before we brought the machines to Takit.

In the years since the failure at Takit, we've carried out a number of other activities, such as starting a co-op general store and setting up an animal husbandry project. With the money left, we also created a women's revolving credit fund, which has helped mothers support their families in providing food and basic necessities. But the lack of fresh produce during the dry season is a threat to the nutrition and health of villagers. So one of my goals is to accomplish a year-round sustainable agricultural project at Takit.

Other important projects we have planned include environmental education and research programs to teach young people and adults about the importance and function of biological diversity, and the need for ecosystem conservation with an emphasis on

sustainable rangeland management to reduce the ecological degradation of livestock grazing. In addition, we continue to search for sustainable rural development projects designed to improve women's conditions, including women's health associated with sanitation (latrines, clean water); organization of workshops and training programs, which involve appropriate technology (improved-stove and solar box cooking, mills, water-catchment, wells, etc.) and reforestation programs dedicated to reducing women's household chores. In sum, people's livelihood are in jeopardy, so the villagers need to come together to find ways to better adapt climate-smart agricultural techniques to produce more and better food, reduce greenhouse gas emissions spewed into the atmosphere, and provide sufficient fuel wood production to curtail deforestation.

My dream has been to help overcome drought, achieve food security and alleviate rampant poverty in the region by applying ecologically friendly management systems of production. This dream led me to the M.A. program in International Studies, and to this thesis. The thesis has provided me with a clear vision and the necessary tools (environmental, socioeconomic, and cultural) to better understand the task ahead, and ways to mobilize people who are unsure about or who are opposed to the practice of agroforestry systems. The thesis has not only contributed to my knowledge of traditional agricultural systems of production, but also has taught me more about the relationship between the socioeconomic factors and the structure and social organization indispensable for a sustainable future for Toukar, Senegal, and the Sahel.

**Thesis Plan**

The rest of the thesis is organized as follows: chapters II and III provide an overview of the Western Sahel and Senegal, and introduce the village of Toukar where the study took place. They describe the physical and bioclimatic

characteristics of this semiarid environment, and list the socioeconomic and agricultural challenges affecting these societies. I argue that the origins of the deeply rooted social and agricultural disruptions stem from the legacy of centuries of French occupation. The last part of chapter II discusses in depth the strategies, practices, constraints, and the vestiges of Serer farmers' famous model of agropastoralism and agroforestry in Toukar. In chapter III, I define the concepts of agroforestry and lay out the major studies already done on the subject throughout the Sahel. I also highlight the impressive agroforestry projects undertaken by the World Agroforestry Center (WAC) throughout Africa, especially in East Africa.

Chapter IV examines the patterns of adoption of agroforestry systems in Toukar. It scrutinizes the main characteristics of the three categories of farmers, and explores the rationale behind each of the following groups: people who tend to support agroforestry, those who are unsure about it, and those who tend to oppose agroforestry. The chapter also compares and contrasts the activities of farmers in each of these three groups, and shows their level of interactions with the environment and the ways in which each group capitalizes on available natural resources for subsistence.

Chapters V through VIII look behind patterns of adoption, asking, "Who adopts agroforestry, and why?" The more we know about the underlying motivations and characteristics of adopters, opponents, and those who are uncertain, the more we can understand how to promote agroforestry techniques that clearly can improve agricultural conditions and livelihood, and can alleviate rural exodus and improve national development. The findings from chapters V

through VIII are surprising, and suggest conundrums for the further promotion of agroforestry. We take up those conundrums, and the possible ways to overcome them, in the conclusion of the thesis.

But first, chapter five considers whether there is a relationship between wealth and farmers' current socioeconomic conditions and patterns of adoption of agroforestry systems. It shows a clear positive correlation between wealth and support for agroforestry. But it also raises a chicken-or-egg dilemma: which came first—wealth or agroforestry techniques?

In chapter six, I explore women's agricultural roles and gendered power relations within the communities to highlight women's perspectives on controversial issues of deforestation and firewood supply. Rural women have been blamed by mainstream development, and this chapter reports women's attitudes and perceptions on the matter. It shows a relative correlation between gender and agroforestry techniques.

Chapter VII examines the relationship between the vestiges of the Serer model of agropastoralism and the adoption of agroforestry systems. It first establishes the degree to which farmers use agropastoral techniques, and correlates degree of agropastoralism with support for, opposition to, or uncertainty about agroforestry. It confirms the general expectation that practitioners of agropastoralism will also support agroforestry. In the context of Toukar, this reinforces findings in other chapters, linking agroforestry to greater traditionalism.

Chapter VIII takes into account the socioeconomic and cultural transformations long taking place in Toukar, considering the degree to which

farmers' economic practices reflect high levels of integration with the externally-oriented commodified economy, or reflect greater economic isolation and lack of connection to the external, commodified economic world. I then correlate degree of "economic traditionalism" with support for, opposition to, or uncertainty about agroforestry. The findings are rich, suggesting that there is a strong correlation among certain indicators of economic traditionalism and not only support for agroforestry, but also wealth. This culminates the analysis, suggesting an unexpected link among agroforestry, traditionalism, and being a successful, wealthy farmer. Inversely, in Toukar, people who are more modern are less likely to support the "new" technique known as agroforestry, and are also less wealthy.

In my conclusion, I lay out the motives behind farmers' adoption of agroforestry and the limitations for the systems in Toukar and lessons learned. As noted above, I also explore the implications of this alignment among traditionalism, wealth and agroforestry, and consider the risk associated with the fact that agroforestry here is "old people's ways," and that those who are more educated and more modern are less likely to practice it. This poses a threat to the most effective historic technique for maintaining viable agriculture and ecological functions in this part of Africa. I address this threat, and the means to overcome it, in the concluding chapter.

# CHAPTER II

## CASE BACKGROUND

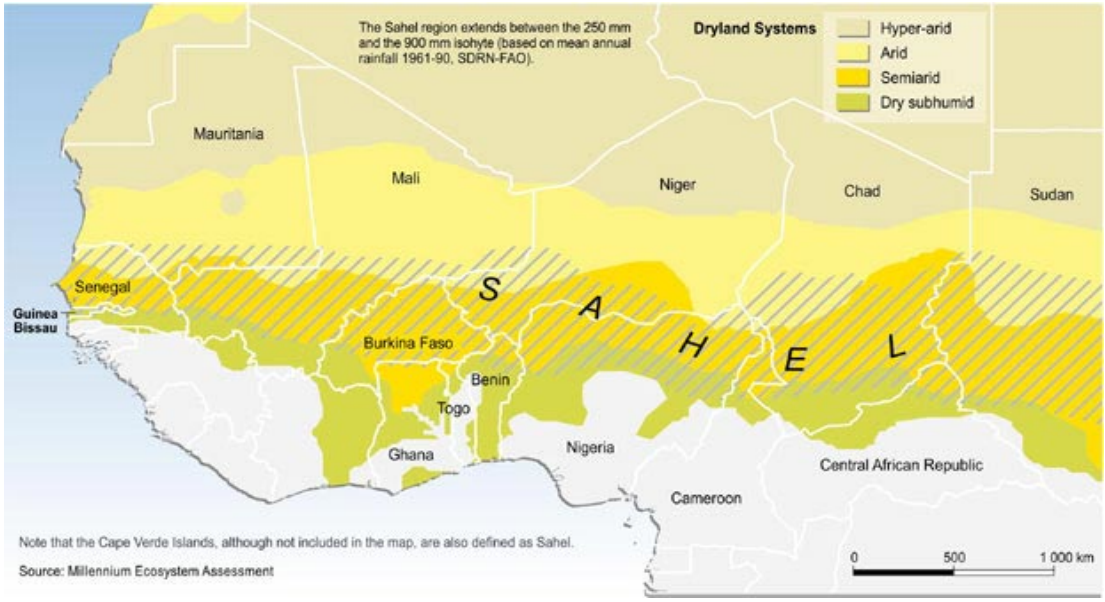
This chapter provides an overview of the agroecological and sociocultural context in which this study is set. It epitomizes the different characteristics of the Western Sahel, Senegal, and the village of Toukar, and also examines historical accounts and basic agricultural practices and food security strategies and constraints. The chapter also furnishes information on gender roles and socioeconomic factors taking place in Toukar.

### The West African Sahel

The Sahel (see Figure 1 below), an Arabic word that means "coast or border," represents the transitional zone south of the Sahara desert and north of the Sudan zone, which usually refers to the Sub-Saharan countries that forms the CILSS (Comitè Inter-Etats de Lutte contre la Sècheresse dans le Sahel): Senegal, Mauritania, Mali, Niger, Burkina Faso, Chad, The Gambia, Cape Verde and Guinea Bissau. We also find similar climatic conditions that stretch to the countries of Sudan, Ethiopia, Kenya, Somalia, and Djibouti in the East coast (Walsh, 1984). From south of the Sahara desert, rainfall increases from 100-600 mm yearly, and from south of the Sahel to the Sudanian agroecological zone extends from 600-1000mm isohyets yearly and continues into the Sudano-Guinean zone (1000-1400mm) (Le Houerou, 1989, cited by Lund & Benjaminsen, 2001). This region is important to the study because Toukar has climatic

conditions similar to the southern part of the Sahel. Basically, any successful development paradigms can be applied as well to Senegal and Toukar.

*Figure 1: The Sahel Region (Source: oceanworld.tamu.edu. 3/28/2013. Note that it should say Gambia instead of Guinea Bissau, which is just south of Senegal)*




The Sahel region near the desert is dry and hot, and one would think it lacks resources to support a large population, but research has shown that, contrary to widespread beliefs, the Sahel by itself is a great resources carrier and "has a potential for supporting human life that is too often vastly underestimated" (Franke & Chasin, 1980, p. 22). The ecological components show a gloomier picture, with extremely unpredictable rainfall patterns of little rain for a short period of time, coupled with a harsh *harmattan*, a hot and dry wind that blows across the Sahel region and often carries large amounts of dust. These conditions are viewed as the main source of soil erosion, a phenomenon that depletes farmland's topsoil, while replenishing other farms by depositing fine particles, such as clay (Franke & Chasin, 1980; Todd, 1994).

As with rainfall patterns, soils in the West Sahel vary and are generally aridisols (with little organic matter) in the North, a band of brown arid soils, and further south a mosaic pattern of ferruginous soils, mainly on sands, and alluvial material, mainly vertisols clay and clay-loam soils (Koechlin, 1997). Brown arid soils with herbaceous or shrubby steppe are unsure for agriculture, but suitable for extensive transhumant pastoralism. Tropical ferruginous soils have good soil moisture, low fertility, and are suitable for agriculture (1997). Studies have also shown that the Sahara desert of the North advanced 90-100 km southward within a 17-year period, and is currently progressing at a rate of 5 to 6 km per year (Decarp, 1974). Moreover, the soils and vegetation of sub-Sahara Africa are being degraded and impoverished at an alarming rate, due to climate change, overgrazing and deforestation. It has been estimated that the net per-hectare loss of nutrients during the last 30 years is 700 kg of nitrogen, 100 kg phosphorus (P) and 450 kg potassium (K) in about 100 million hectares of cultivated land (Sanchez et al. 1997). This loss results in low soil organic matter, which renders the soil unproductive.

With respect to plant cover, we distinguish two kinds of vegetation between the Northern and the Southern Sahel, with each zone having specific ecological characteristics: The Northern Sahel with little rainfall presents steppe-like herbaceous vegetation with less than 30% vegetative cover (Franke & Chasin, 1980). Important tree species include *Panicum turgidum*, *Aristida longifora*, *Aristida acutiflora*, along with important other species of trees that are well adapted to the harsh climatic conditions: "*Acacia raddiana*, favorite food for camels, *Zizuphus meuritania*, *Balanites aegyptiaca*, *Euphorbia balsamifera*, which

provide excellent grazing opportunities for transhumant livestock" (Franke & Chasin, 1980, p. 34). On the other hand, the Southern Sahel, with wetter season pastures, offers abundant woodlands with a variety of shrub and tree species. The most prominent include *Acacia albida*, *Acacia senegal*, and *Acacia seyal*, *Andosonia digitata* (Franke & Chasin, 1980). These particular woody perennials are present in Toukar as well, and provide unbeatable fodder for livestock herding during the dry season when pastures are completely grazed (see Appendix B).

Local conditions in the Sahel still vary largely. Although in some regions significant bush areas as well as short-duration fallows still exist, other areas suffer severe environmental degradation and extensive agricultural encroachment. Since 1965 the Sahel has suffered from a lasting drought with disastrous consequences for people, animals, and the natural environment (OECD, 1988; Franke & Chasin, 1980): "Until at least 1965, and in most areas until 1967, rainfall was good in the Sahel, as it was in the 1950s" (OECD, 1988, p. 51). I vividly remember the drought of the 1970s and 1980s, when scores of livestock were left to die out on the panorama because the price of livestock suddenly slumped to record lows, as farmers struggled to feed their animals. Historical records have also demonstrated that the droughts and subsequent famines of the 17$^{th}$ and 18$^{th}$ centuries stand as evidence of a pronounced trend towards increasing aridity in the Sahel, thus increased vulnerability to droughts (Webb, 1995). Additional evidence for Sahelians' adverse environmental changes comes from observation of the agricultural regimes along the Senegal River valley. The cultivation of maize, a staple of the valley, along with millet and sorghum and

rice, was abundant in the area, but today because maize crops require at least 600 mm of annual rainfall, the cultivation of maize has disappeared (Webb, 1995).

For centuries now Sahelian societies have practiced a double economy: agriculture and livestock herding. Dry farming millet, sorghum, and African rice (*Oryza globerrina*) (Linares, 2002) are the most important forms of agriculture, and rice paddy fields occur in the flooded zones (Senegal River valley). In the far North (Ahaggar) only goats and large herds of camels are common, while sheep and cattle can be raised in the Sahel zone. Camels are domesticated desert animals and can tolerate extreme heat (Webb, 1995). Traditional rural Sahelian societies adapted and lived in harmony with the difficult ecological circumstances of their environment. They created a balanced approach between efficient natural resources management strategies and regeneration techniques, thus keeping environmental degradation at a minimum (Berry et al., 1984; Raynaut & Delville, 1997). Among the survival strategies recorded are the pattern of transhumance, the mobility of livestock in times of changing seasonal rainfall and annual flooding of the rivers for the pastoralists, whereas rain-fed sedentary agriculturalists used a wide range of plant resources, intensive use of small sites (shifting-agriculture), and more importantly, the mutually beneficial exchange between the two groups: one providing livestock, milk, and manure, while the other supplies vegetables, millets and other important ingredients (Pelissier, 1966; Cisse et al., 2010).

However, the disruption of that ecological equilibrium began to manifest with the advent of colonization. Especially after the abolition of the slave trade (early 19$^{th}$ century), colonizers start to develop exportable commodities initially

with the gum Arabic trade until the 1850s, which led the introduction of peanut in Senegal, the Gambia and Guinea Buissau, and cotton in Chad, Mali, and Burkina Faso after the collapse of the gum production. (Note, however, that gum Arabic is still the main export crop for Sudan, further in the Eastern Sahel) (OECD, 1988; Franke & Chasin, 1980; Webb, 1995). According to Franke and Chasin (1980), the deforestation methods used for the development of export crops were extensive, and particularly destructive to the traditional farming techniques for food crops. These researchers showed that intensive cash-cropping cultivation impoverishes soil, and that after successive years of growing peanut, a fallow period of six years or more is required to replenish the soil (1980). The study notes that European colonials' imposed-production systems drastically raised the once small population of the Sahel to intolerable proportions and the environment began to break down. Europeans' disruptive actions are clearly described in the following quote: "In the process of extending this system, Europeans intervened in West Africa in several ways with many destructive effects—effects that in turn would greatly influence the development of the ecology of the region, making it increasingly vulnerable to droughts (Franke & Chasin, 1980, p. 63)." Moreover, annual precipitation in the Sahel has been decreasing considerably during most of the recent decades; it fell between 20 and 40 percent from 1931 to 1960 levels. Some scientists have even argued that the degradation of both soil and vegetative cover in the area has contributed to the decrease in rainfall (Hellden, 1991; Hulme & Kelly, 1993).

Today the Western Sahelian food production system has become unstable, with recurrent droughts leading to soaring cereals imports and rising food

dependency, which is causing food riots in capital cities such as Dakar, Bamako, and Niamey. Other strategies are urgently needed in order to improve Sahelian societies' vulnerable living conditions.

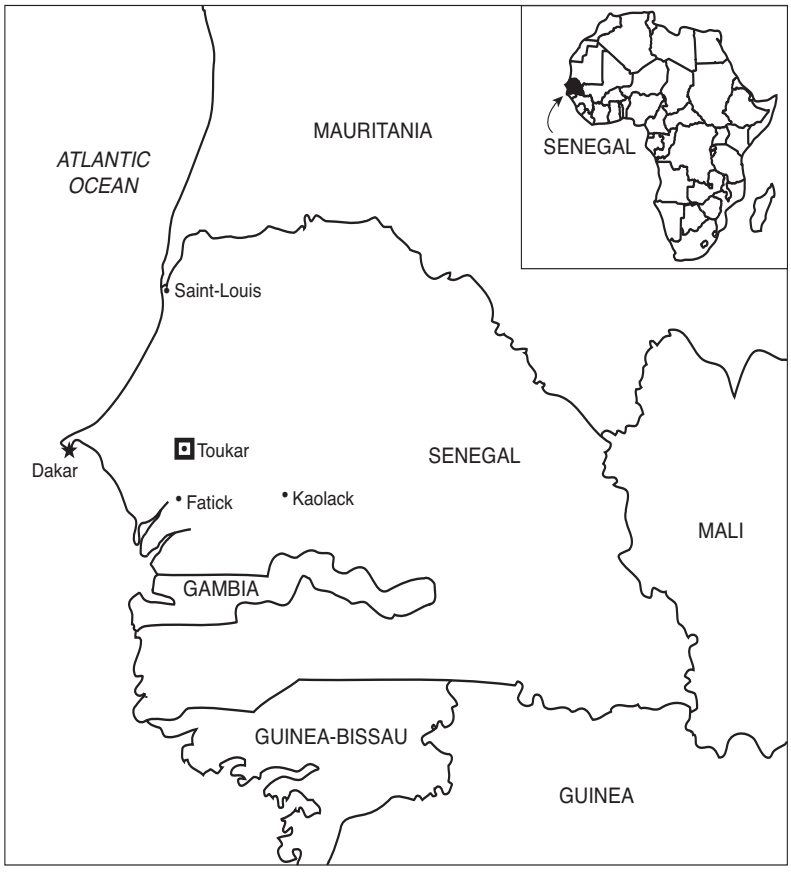
Agroforestry is one recommended management tool capable of reducing the harmful effects of soil erosion caused by wind and rain in the Sahel (Gladwin, Peterson, Phiri, & Uttaro, 2002). Planting trees and shrubs allow soils time to regenerate. Agroforestry is such an important topic in the Sahel that 11 bordering countries have developed a novel initiative to prevent the Sahara desert from expanding southward. The countries have agreed to build a pan-African "great green wall" (GGW) 15 km wide and 8,000 km long, from Senegal in the West coast to Djibouti in the East coast to curb the advancement of the desert, and at the same time provide socioeconomic means to improve people's livelihood in the region (Godoy, 2011; UN, 2013).

**Senegal**

Senegal is situated on the western edge of Africa, and has a projected population of over 13.5 million (July 2013) with a surface area of 196,722 km2 (see Figure 2 below), about the size of South Dakota (CIA World Factbook, 2013). The vast majority of Senegalese are Muslims (93%), with some Christians (5%), and the rest Animist; 42% of the population lives in cities. Senegal has an ethnic diversity composed of Wolof (43.3%), Peul (23.8%), Serer (14.7%), Diola (3.7%), Mandingue (3%), Soninkè (1.1%), and others (10.4%) (CIA World Factbook, 2013). The Wolof group lives in the peanut basin, in the Senegal river delta and in big cities; the Serer are concentrated in the central and western peanut basin; the Toucouleur and Soninke in the valley (north and northeastern part of the

country); the agropastoralist Peulh, are spread out along the valley and in Casamance; the Diola and the Mandingue are dominant in the Casamance region.

*Figure 2: Map of Senegal, and Senegal in Africa (inset):*




Forests and woodlands comprise 45% of the landscape, while meadows and pastures compose 36% and arable land only 19% (Faye & James, 1989; Ndiaye, 2007). The country has four rivers: The Senegal and its affluent, the Falèmè (1700km); the Sine Saloum; the Gambia (750km) which is Senegalese in

its upper part; and the Casamance (300km). All of these rivers are navigable (Thiam & Gueye, 2000). Yet half of its territory is located in the Western Sahel region (Figure 1).

The rainfall pattern is unequally distributed throughout the country: The Senegal River valley (Le Fleuve) receives a precipitation range of 200 mm in the delta to 400 mm in the high valley (ISRA, 2013). The farmers traditionally grew sorghum, rice, corn, and beans on the riverbed when the water level dropped, and switched to rain-fed crops such as millet and beans during the rainy season in the nonflooded area. However, the building of Diama and Manantali dams respectively in the delta and high-river have totally devastated the floodwater agriculture. People's traditional survival strategies have been converted to a commercial system that focuses on the cultivation of rice, sugar cane, tomatoes, and other cash crops in the region (Baker, 1985).

The "Ferlo" sylvopastoral zone (Zone sylvo-pastorale) located to the south of the Senegal River has a low and erratic precipitation pattern that fluctuates from 200 mm to 400 mm, enough to support livestock, which is now deprived from grasslands that provided essential livestock grazing during the dry-season.

The littoral (Littoral Nord) from Saint-Louis to Dakar, the capital city, is considered the center of market gardening. The marine climate and shallow freshwater make it a perfect place for vegetables (green beans, tomatoes). However, some farmers cultivate peanut and millet during the rainy season (Ndiaye 2007; Oxford Business Group 2011).

The peanut basin (Bassin Arachidier), the country's main agricultural region, is located in the midwest of Senegal, where the study took place. It has an

annual rainfall of 400mm to 900mm from north to south (ISRA, 2013). Crops such as peanut, millet, bean, corn, cotton, and sorghum are grown here in sandy and nutrient-poor soil conditions. The region plays a major role in the country's peanut export.

Lastly, the Southeastern region (Senegal Oriental) and the Casamance have the greatest amount of rainfall of all regions in the country. The annual precipitation varies from 700 mm to more than 1000 mm. Although this part of Senegal is rainforest, the clearance of land for peanut agriculture has been going on for generations. The cultivation of cotton (> 50,000ha/year) in Tambacounda, peanut and rice crops in Casamance, as well as millet, corn, and sorghum also has been increasing considerably (Gueye, 1992; Ndiaye, 2007; Faye & James, 1989).

As mentioned earlier in the Sahel section, the French colonial, under the authority of Governor Faidherbe, introduced peanut cultivation in Senegal in the 19th century to underpin French expansion in West Africa, and to help develop France's economies (Fall, 2011; Galvan, 2004). After several failed attempts to establish sugar cane in Richard Toll's (1820-1823) despite suitable ecological conditions, and its proximity to St. Louis, the first French post in West Africa, the French resorted to peanut cultivation in the center of the country, which turned out very successful (Fall, 2011).

While the slave trade was waning, Islam was gaining foothold in the Western Sahel region, due mainly to its egalitarian values condemning the practices of slavery. From the 11th century, with entry of the first Islamists in the North of Senegal, to the 19th century, the dissemination of Islam progressed slowly in Senegal (Fall, 2011). In the 20th

century, colonial administrators took great advantage of this development. Though skeptical at first, they collaborated with the Mourides, members of a growing Islamic sect with a distinctive attitude towards work and agriculture. Most Mourides were from the Wolof tribe. The sect's leader, Ahmadou Bamba Mbacke, founded Koranic schools called "*daara*" to teach Islam based on a concept professing that: "*liggey ci jaamu yalla la bokk*" (literally translated as "hard agricultural labor is a means to worship God"). Equipped with such mutually beneficial collaboration, the French applied coercive strategies such as the corvèe (forced labor on road and railroad construction) to force peasants to pay heavy head taxes, and further expanded large-scale peanut production in Senegal (Fall, 2011; Galvan, 1996). The Mourides were considered "enemies of the trees" because they cut down many trees and shrubs to install their *daara* and to propagate the peanut cultivation (O'Brien, 1971).

France's peanut policies have had devastating effects on the environment and a detrimental impact on the social structure of indigenous people, and France has benefited at the cost of Senegal's environment. Nonetheless, Senegal has pressed on to promulgate peanut cultivation, which has received public support through government-funded agricultural training and extensions services, and a few subsidies. However, in the 1990s this modest support for the farmers disappeared because of the new agricultural policies of liberalization, which the IMF and World Bank imposed on Senegal. Structural Adjustment Programs, also known as SAPs, are unfortunately still going on, which basically specified that the country needed to end subsidies, privatize the market, and lower output prices. The result was devastating to many resource-poor farmers who went deeper into poverty and debt (Harsch, 2003). In the same decades, the Mourides' religious leaders "received a green light" from the state to clear seven

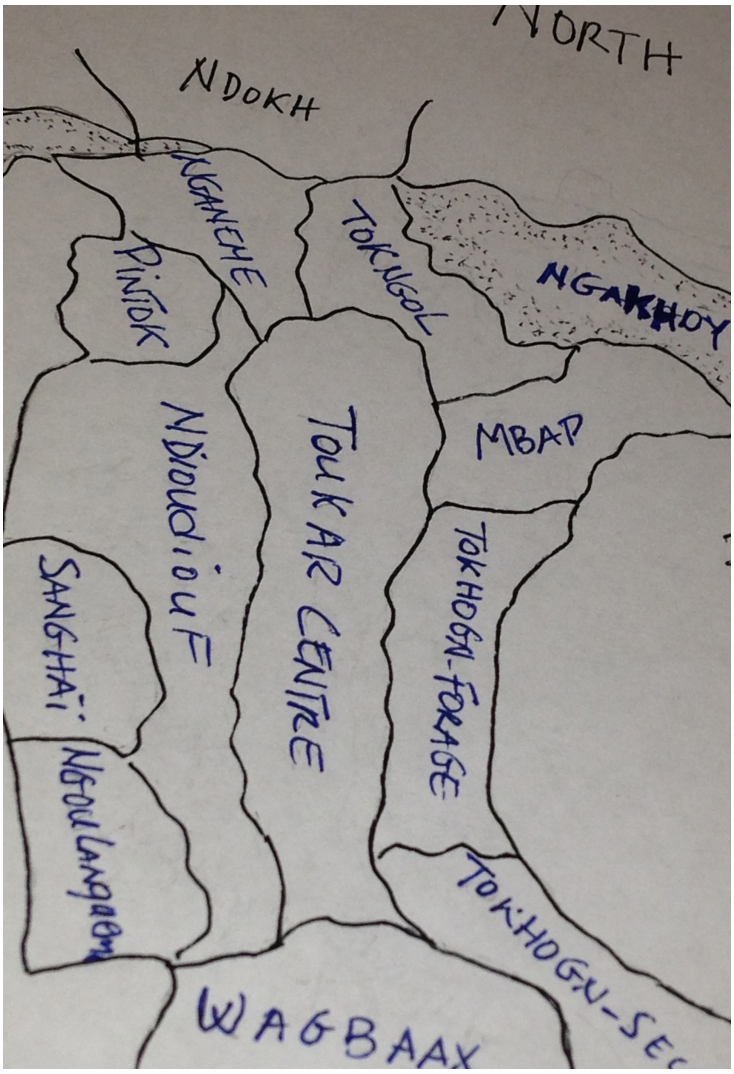
hundred square kilometers of forestlands in the Peanut basin region (Khelcom) to produce groundnuts for export. This expedition took less than a month to complete (Ba, 1991).

In striking contrast to the Wolof ethnic group, the Serer people not only refused to convert to Islam, but also adamantly managed to conserve their mix of herding and farming techniques. At first, the Serer resisted the temptation of the peanut cash cropping system (Klein, 1968; Galvan, 2004). But given the Serer's reputed farming skills, the French colonial administrators resorted to coercive methods to integrate peanut into the Serer's farming systems in order to better establish the peanut crop and increase wealth to the mother country. After farmers' useless resistance to the new economic order, the new crop became part of the traditional system of three-year rotation of *pod* (small millet) *macc* (large millet) and *toss* (improved fallows with wild harvests), dismantling a remarkably elaborate and efficient farming system. Peanut eventually replaced the large millet, which vanished from people's diet (Galvan, 2004; Lericollais, 1989; Pelissier, 1966). These longtime practices well-adapted to semiarid environments had provided a resilient livelihood for smallholder farmers for centuries. However now, due to recent abundant rainfall in the region, a farmer from the hamlet of Sanghai, in Toukar has reintroduced in the last four years the *macc* crop, a late maturing millet crop in an attempt to make up for insufficient *pod*, small and early maturing millet production. This is a good sign provided that the weather patterns hold.

**Toukar: Geography and History**

My research was conducted in the village of Toukar (comprised of 11 hamlets, see Figure 3 below) in the Siin region of west-central Senegal. The Siin is part of the highly studied Peanut Basin region of Senegal. The population is 3,902 inhabitants (Census, 2012), which is mainly composed of people who are ethnically Serer, as well as a small number of Wolof and Toucouleur people. The climate of Sudano-Sahelian is tropical semiarid with high temperatures and two seasons: wet and dry. The wet season is from June to October with erratic annual rainfall from 400 to 700mm (ISRA, 2013). The village's main crops are millet, sorghum, peanut, and cowpeas. The area is usually referred to as agropastoral millet/sorghum, which signifies that sedentary rain-fed peasants have also integrated livestock into the farming systems as a highly complex and strategic land management system.

*Figure 3: Map of Toukar and its 11 hamlets:*




The majority of soils in Toukar are *dior* (sandy nutrient-poor), but we find more clayey (*dek*) soils in the depressions. Also, where the sandy soil is light, we have a sandy-clay profile, which is a transition between *dek* and *dior* soils (*dek-dior*). The *dior* soils are characterized by a bitter sandy top soil, which varies in color from grey-beige to light pale-brown, depending on the amount of organic matter, with pH near neutral (6-7) (Pelissier, 1966; Lericollais, 1999).

The *dek* soils are characterized by a high content of fine particles of clay with high water-holding capacity and cation-exchange capacity (CEC), a

measure of fertility and nutrient retention, whereas the *dek-dior* soils are more heterogeneous with topsoil, easier to work, and having a greater chemical fertility content (humus) in deeper layers (Pelissier, 1966; Lericollais, 1989). As for Toukar's vegetative cover, see Appendix B for details.

*History of the Village*

Djigan Diayi Diouf and his brother Djik, who migrated from Lambaye in the Wolof kingdoms to the Siin, created the village of Toukar. When they arrived in the area, they set a fire to the forest to delimit their property and become *Yal naay* (master of fire or land ownership title). One day, while working in their field, the presumed second founder of the village, Fassarmane Thiao, came by and told Diigan: "What a great harvest you'll have this year," Diegan responded: "Touk" (shut your mouth), and added "karaam" (in close meaning, "say you're kidding") before you annoyed my *pangools* ("*luukugn fa tiolaye*" - spirituals beings). Later on, Fassarman got permission from the Guelwaar maad or king to own an estate too (Galvan, 2004; Becker, 1989).

*Pangools* are ancestral spirits with a protective role, which ensure the well-being of the village and fend off agricultural calamities. They play an extremely important part in the lives of the Serer; the priest-custodians, *lamans* (first settler or ownership of fire estates) are responsible for managing the *pangools'* shrine and with mystical powers can directly "communicate" or be in séance with the *pangools*, be in contact with them, pray to them and receive a power to cure, protect the whole village from evil spirits, and receive guidance to solve communal everyday problems. These *lamans* are "the intermediary between the land, the peasants, and the *pangools*" (Galvan, 2004, p. 54). According to Galvan,

the *lamans* used to be guardians of the highly praised traditional farming system, exercising careful husbandry of their resources. They ensured that members of the community followed soil preservation techniques such as crop rotation, live fencing during the rainy season, and pasturing of livestock on the land allocated to *toss* areas (2004). The Serer in Siin has a society entirely based on traditional beliefs and agricultural systems guided by natural laws—the peacekeeping law that fosters life for all—also defining the reciprocal relationship between their immediate environment. For instance, in many Serer cultures, each family has totems, which are animals or trees, and members are forbidden to kill or even touch the totem (such as harvesting or eating a fruit from the totem). Members are also forbidden to cut down tree totems because they harbor spirits that protect the family. To do so may bring bad luck and diseases into the family and the community. These rules and practices have helped the Serer preserve and protect the environment for centuries. These same concepts give meaning to life, and the people of the community have to conform to the culture's ethics in order to maintain social solidarity within the group. Moreover, these rules and practices are tools to support the social structure in the community, and to reaffirm the culture's ideologies and guide its behaviors. The community as a whole accepts and shares such beliefs and sets of rules, which they must not forget or breach.

However, this well-structured and organized Serer society, as we have seen in the previous section, was first shaken up by French domination and later was aggravated by the local elites after the country's independence (Galvan, 2004). In fact, Toukar has been marginalized and deprived of the major

infrastructures initiated by the French such as railroads and roads, which bypassed Toukar and environs. Most of the aid or assistance goes to the neighboring village of Ngayokheme, which is the chef lieu of the Communautè Rurale, even though Toukar is the most populous and better fulfills conditions to host the title. In fact, ever since the creation of the Communautè Rurale in 1972, the president has been from Toukar (except once) by virtue of its larger population. In addition, Toukar has a weekly market, founded in the late 1960s by the villagers, which attracts merchants from all over the country. The village was also one of the first few collection places for peanut during the French occupation because of its geographical location, which also drew Lebanese traders in Toukar. However, all these putative advantages have played against the village to take its due because the villagers had not accepted the wish of the chef du canton and post-independent leaders to relocate Toukar to Ngayokheme in order to create a bigger settlement. Why was Toukar chosen to move? The traditional narrative is that its inhabitants were disobedient and uncooperative to the Sous-prefet who wished to resettle Toukar. Additionally, villagers had once rebelled and attacked delegates and officials at a decisive meeting in the center of Toukar for repetitive unkept promises of the past. This last incident was "the drop that filled the bucket," and has since sealed the future of the village. After the incident, the Sous-prefet became furious and vowed to punish Toukar. Before his departure or transfer, he wrote a damaging and revengeful note to his successors, warning: "Be careful with Toukar, it is a village of recalcitrants." This identifier became the legacy of Toukar with respect to its local government.

The inhabitants of Toukar now finally enjoy electrification (since 2008), but still wait on an unfinished crushed laterite (gravel) main road leading to the capital, Dakar. Plus, the village of Ngayokheme has supplied potable water ever since the village drilling operation broke down in the early 2000s.

*Land Tenure*

Land tenure rights in Toukar are under the control of the rural government authority or rural council, which theoretically owns all the land. This rural council is led by the PCR (President de la communautè Rurale). There are basically three ways of changing land ownership and use in Toukar: "Affectation" or land given to new settlers, "disaffectation" or land taken back from people who have moved or are deceased, and "reaffectation" or land transferred from father or mother to son or daughter (Faye, 2013). Land ownership originally derived from the 1964 Land Tenure Policy instituted after the country's independence. This law transferred the control of land from the *lamans* (first settlers) to the Rural Council, which consists of locally elected officials who possess authority to take land from those with surplus or unused lands (disaffectation) for legal distribution to less fortunate farmers (affectation). In this context, the new owner must exploit the land (*principe de mise en valeur*) or fear losing it back (des-affectation) to the council (Galvan, 2004). The *principe of mise en valeur* states that a farmer is required to put into practice (cultivate or fallow) the land or run the risk of losing it or having it confiscated by the rural council who can then distribute it to a needy person. When the rural council allocates a field (affectation), the new owner becomes the full benefactor of all the trees in the farm.

Moreover, a short-term land exchange system or pawning ("*tayle*") exists whereby landless farmers, casted people, or farmers who need more land can "borrow" lands (in exchange for cash or livestock) from farmers with excess, for a period of four years or more. In the meantime the trees remain the property of the lender. After the four years limit, if the lender cannot reimburse the pawn, then the borrower can simply "nationalize" the land which will become his or her property forever, unless the borrower accepts that the lender will return the deposit at a later date, beyond the 4 years limit, to retake the farm. (See Galvan, 2004 for more details on this complex topic.)

Serer societies were once based on a matrilineal hereditary system in which the descent of property was traced through maternal ancestors. But a drastic social change occurred during the advent of the French domination, which confers patrilineal descent for inheritance (Dupire et al., 1974). So today, land ownership is transferred from father to son with the full benefits, including the trees, although women can own land. In rare instances people still inherit land in the matrilineage. But at the father's death, the son must file a request form within six months to the rural council to have the father's lands transferred (re-affectation); otherwise, the heir risks losing the lands to the CR (Faye, 2013).

**Basic Agricultural Practices**

We can organize Serer crop husbandry into five stages: preparation of the fields before the rains; the shelling and sorting of peanut seeds; sowing of crops before and after the first rains; crop maintenance (hoeing and weeding); and harvest and postharvest activities. Prior to millet sowing, the fields are cleared. Previous season debris of millet stalks or stumps and grasses are raked and

burned; the ashes serve as fertilizers, as confirmed by this farmer's testimony: "I burn residues before sowing my field because the burnt spots are propitious to plant growth. Also, the practice kills dormant obnoxious weed and parasites, and cleans the field of any obstacle that can hinder the proper function of the plow." But previous peanut fields are easier to clear because they are usually barren without plant residues, and peanut seeds are sown by machine after the first rains.

Millet is sown by machine as well, and as early as possible (even three weeks before the first rains). Short-season varieties are sown in late May until the end of June. In any case, millet-sowing stops by early July. The spacing is generally about 80-90 cm between the rows and 50-60 cm within the rows, and 5 to 7kg of seed are required to plant one hectare. Germination occurs 3 to 4 days after the soil is sufficiently wet. However, if the rains stop longer during this period, peasants would have to reseed. Generally the first hoeing happens about 10 days after germination. This is very important in order to slow down the growth of nasty weeds in both millet and peanut fields. Other agricultural chores, including thinning and transplanting, occur at this time, but less for millet than for sorghum plant, which is usually grown and transplanted on mounds of termites on clayey soils (*dek*) in the field. Then, another hoeing is done about a month later.

Millet crop is usually planted in association with late varieties of beans and sorghum, or in complex intercropping systems involving cassava root (*Manihot esculenta*), sorrel or bissap, gourd for food and recipient (calabash) and some edible herbs. Polyculture or mix-cropping, which usually involves a field of

millet or peanut grown in association with sorghum, cowpea, bissap, or squash (in some instances, a farmer may cultivate all crops in a single field), crop rotation (between millet or sorghum and peanut) and traditional manure are basic agricultural practices carried out by most farmers in Toukar.

Farmers purchase peanut seeds from local markets or the rural cooperative (*ko-opè*), which is under the state's authority. Women then do the shelling and sorting of the seed, selecting the best quality seeds while defective ones are used for sauce. In general, peasants do not save their own peanut seeds because of their incapacity to store the seeds properly. Peanut seeds are particularly susceptible to contamination during growth and storage, and farmers need a well-sealed storage and a sufficient amount of pesticides to protect them against the habitual mold fungus pest.

The harvests occur at different times, depending on the varieties sown. Millet (*pod*) is always the first crop to mature and is stored in granaries built high above ground as a protection against small insects (termites) and rain water, followed by sorghum and peanut. Later in the postharvest cowpea completes its maturation thanks to the abundance of dew. After threshing and winnowing, peanuts are taken to the cooperatives or to other available locations for sale, but the hay is stored at home as fodder for animals, mainly horses.

Millet crop not only constitutes the staple food for the Serer people, but it also plays an important role in many traditional dishes, and is included in religious rites (i.e., sacrifices given to the *pangools*) and traditional events like the *Raan* of Toukar. Furthermore, the dry stalks of millet and sorghum have multiple purposes: they are used for fuel as a substitute for firewood, for thatching hut

houses, for construction of fences delimiting the compounds (*mbind*), and for making mats and beds. The stems of a red seeded variety provide medicine and dye. Finally, millet stalks are also an excellent fodder, and some farmers store them to feed their cattle during the dry season.

The Serer people also associate crop husbandry with livestock herding, which they consider an invaluable source of essential soil nutrients. Large herds are kept close by to fertilize fallow fields (*toss*), even though fallow grazing has decreased due to recurrent disruptions of the Serer's highly regarded model of environmental conservation. Today fallow systems have become very short, lasting only one or two years.

Fundamentally, there are still four tossed-areas (or grazing lands) in Toukar, which follow a yearly rotational agenda set up and managed by a traditional farmers' committee, the council of elders, or tribal leaders. The following are the communal fallow zones: *kho-ot, ndee-njay, mbella-maag*, and *guilok*, named after their seasonal ponds. The communal *toss* area is available to all qualified farmers with large cattle who are, for the most part, farmers from the hamlets of Ndioudiouf, Nganeme, Tokngol, Sanghai, Ngoulangueme, and Pintok, along with farmers from two other neighboring villages, Diohine (5 km) and Ndokh (4 km). There are also a few individual farmers from the hamlet of Mbap. Each farmer usually possesses a field or two in the designated lands and must abide by the committee's rule. Whoever breaches the rule will have to retrieve his animals and is personally accountable for preventing the livestock from pillaging the fields, and is banned from joining the committee again.

Under normal conditions two kinds of toss are practiced: the *toss jiid*, which takes place during the dry season from January to April, and *toss ndiik* from September to December. During the hungry times, which set in around April or May, herders and livestock transhumance to the Ferlo or to the forests of Thiès in search of greener pastures, and return in September when Toukar abounds with rainfall and fertile pasturelands.

In December, which coincides with the end of the harvest periods, the herds are transferred to the newly harvested fields in order to graze as well as fertilize the fields; and the communal lands return to their particular owners who are each responsible for moving their grazing livestock across their private farm under an enclosure made of wires. The animals continue to fertilize the farms until grazing opportunities can no longer sustain large cattle numbers, when the herds start the cycle again. The Serer people have such a strong attachment and fondness towards their animals that they seldom kill them for consumption unless the animal is injured, incapacitated, or ailing (see chapter VII for more details).

*How to Improve Soil Fertility*

Soil fertility depletion constitutes one of the major constraints to food crop production, and peasants are continuously striving to win this fierce battle. Current environmental conditions and poor agricultural practices as well as overpopulation have exacerbated and rendered the task extremely difficult for the Serer people.

With respect to agronomical data collected for soil fertility purposes, farmers respectively list the following best methods to improve soil quality. First

is manure from available animals (37 of 43); second, chemical fertilizer purchased either at a subsidized price at the *Secco* (cooperative), or at Toukar's weekly market (29 of 43). *Toss* or fallow periods (19 of 43) comes in third. However, some respondents have also indicated using all available methods. Eleven of 43 farmers have referred to the prized leguminous tree (*Acacia albida* or *saas* in the Serer language), which contains symbiotic bacteria called rhizobia within the nodules of its root system, which have the ability to fix nitrogen from the atmosphere and make it available to nearby plants.

This remarkable native multipurpose tree has deep taproot systems that allow it to "pump up" nutrients (through hydraulic lift) from deeper soil horizons which are otherwise inaccessible to aboveground crops (Baumer, 1990; Lericollais 1989; Pelissier, 1966; Sanchez, 1997). The deciduous tree is leafless during the rainy season, which permits plenty of light to reach the underground crops. It also bears leaves during the dry season (reverse phenology), thus providing shade and fodder to livestock (Lericolais, 1989; Baumer, 1990). Major studies done on *Acacia albida* have already demonstrated that a density of 10 to 30 *saas* trees per ha can fertilize 10% to 50% of arable lands (Lericollais, 1989), and thus substantially increase crop yields and supply a nutritious and impressive amount of seed pods for livestock feed. In addition, some peasants also have open-compost piles made up of ashes and household garbage that are stored a few meters away from the *mbind*'s entrance, which will be spread later in the fields, as it is has been done in the past.

Interestingly, though, when farmers were asked to list their most preferred type of fertilizer, a sizeable number (19 of 43) referred to chemical

fertilizer because of the instant effect on crops, even though 27 farmers said they use inorganic fertilizers sporadically. Other farmers have cited toss as their preferred method of soil amendments. When given the opportunities, most interviewed peasants choose *toss* over chemical fertilizer because: "a well-tossed field guarantees fertility for 2 to 3 years, whereas inorganic fertilizer only secures one season" (referring to "dry-season toss" which describes the presence of rotational cattle grazing within a wired fencing field).

*How to Limit Soil Erosion*

I present peasants' attitudes and perceptions on the issue of soil erosion as well as known and available practices in the community.

Today anti erosion practices that used to be the norm in Toukar (such as the *lamans* model) are very limited or nonexistent. Many peasants have entirely abandoned the practice of living fences, and instead use rocks or old tires as field boundaries, and the toll on erosion is enormous.

When asked to choose on the best agronomical techniques available to stop or reduce soil erosion, most interviewees (32 of 43 farmers) had no solution, illustrating the lack of fundamental knowledge regarding soil erosion and its impact on overall crop production. Other farmers selected crop rotation (11 of 43) as a practical method to mitigate the effects of soil erosion. And perhaps some more informed peasants who in reality do not practice any of these techniques simply mentioned toss (8 of 43), windbreaks (7 of 43) and slash–and-burn (43) as effective procedures to resolve problems of soil erosion. Although the traditional slash-and-burn technique, defined as an agricultural practice that involves cutting and burning woodland or forested areas to make way for fields, is no

longer applicable because of the high population density and lack of sufficient arable lands in the area, but farmers still refer to it. However, a huge difference exists between the old methods and present-day techniques, which I will call "collect-and-burn." Farmers basically amass and burn crop residues (millet stalks) instead of slashing forested areas or shrub in this barren environment. Only one "classified forest" remains in the region (*Gakhoy*) that villagers are dearly holding to. Soil conservation measures are urgently needed to reverse those deleterious trends.

**Constraints to Food Security**

The study also highlighted the agricultural constraints farmers face in their effort to achieve food security. The significant handicap listed has been the impact of parasites (plants or pests) on crop cultivation (21 of 43), followed by impoverished soils (14 of 43), and lastly, drought (11 of 43). Farmers have also emphasized the unavailability of sufficient manure, toss or compost to cover a whole field as an impediment to increase crop yields like in the past.

Among the most cited pest plants is the witch-weed striga, commonly known as *duxum* in the Serer language. It is not limited to Senegal, but expands throughout the African continent, including India. In fact, according to some research, the second most important disease of millet (*pod*) after downy mildew in African fields is *Striga hermonthica* (King, 1992). Thirty-three species of Striga are present in Africa alone, and *Striga hermonthica* represents the most widespread species. It poses one of the most serious constraints of cereal production in Africa. The weed causes severe losses in cereals crops such as millet, sorghum, and corn. Approximately two thirds of the 73 million hectares

devoted to cereal crop production in Africa are gravely affected, and over 100 million people's lives are threatened (Traore, Vincent, & Stewart, 1996).

*Striga hermonthica* is an incredibly devastating weed. The host-plant does not grow; it remains short during its whole life, and barely produces grain. Symptoms occur in early development of the host and are characterized by stunted growth and yellowing of leaves, while the weed matures and blooms in beautiful pink flowers. Other study shows that the weed's seeds can survive in arid soils for 15 years, and that the number of seeds produced per plant ranges from 40,000 to 500,000 (Obilana & Ramaiah, 1992).

As for impoverished soils, this phenomenon has been lingering since the initial launching of the extensive peanut cash cropping system by the French (Lericollais, 1989). Peasants in the Peanut basin are wrestling to find solutions to this vital concern, and the state has been slow to respond to their demands. So far farmers are seeing no reason for hope. The area of Toukar is also characterized by a high population density, which puts increasing pressures on the relatively small amount of cultivated lands.

However, when asked about the comprehensive agricultural limitations to produce sufficient food for families, farmers indicate respectively a lack of chemical fertilizers (29 of 43), impoverished soils coupled with lack of farming materials (16 of 43), and lastly lack of pesticides and seeds (12 of 43). In this section, I also present reactions or opinions of participants with respect to the work of extension services in the area. I specifically asked whether farmers have ever received training or any forms of assistance from the government to improve farming techniques in an attempt to alleviate rural poverty. I was

stunned to learn that the answer was overwhelmingly negative (100%), which projects a sense of neglect on the part of the state towards this village. I began to wonder whether this attitude was widespread or specific to Toukar. For instance, farmers have relentlessly complained to the authorities over the ravages done by *duxum* in millet fields, with no effect.

From my own observation and from open-ended conversations, *duxum* usually thrives in poor soils, and in places where fallow practices are nonexistent. This important remark may confirm the fact that the relinquishing of traditional farming methods, especially the systems of toss, due in part to the increasing demand for food for the growing population, and the clearing of new land for cash-cropping agriculture are determinant factors in the spread of Striga in the region (Lericollais, 1999). Thus, alternative agriculture using crop rotation, frequent compost and manure applications (or rotational grazing), polycultures and trap cropping has tremendous impact on controlling the weed. In fact, experiments done in Mali have shown that crop rotation of 1 year of millet followed by 3 years of fallow or another crop reduces the emerged density of *S. hermonthica* to 61% (Traore & Ramaiah, 1996).

All of these negative factors curb food security in the region.

**Basic Economy of Households**

All of Toukar's inhabitants whom I interviewed (100%) indicated farming as the main source of income, even though many have taken in "trading" as a secondary activity to supplement meager household livelihood. Because of the disruption of equilibrium in the Serer traditional system by economic, ecological, and demographic factors as well as the disengagement of the state in peanut

cultivation (reduction or abandonment of agricultural subsidies), "Petit commerce" or trading is definitely gaining momentum. Now an increasing number of both men and women have embarked on buying and selling a variety of merchandise at the Toukar's weekly market to meet the food need, especially during drought seasons. While men (9 of 43) mainly sell fattened bovine and ovine or small ruminants throughout the six surrounding villages' weekly markets or at the "Darrel place" in Bambey (the nearest city at 18km), women (3 respondents of 10 total) are confined to selling foodstuff such as wild herbs and fruits of bissap, *sob*, or *baak* trees. Some women even go further, purchasing scarce ingredients such as vegetables and dried fishes in Dakar to resell in the village. Testimony of one woman confirms what many have murmured: "without my 'petit-commerce,' my family would starve in a lean year, especially when rainfalls are scant, since I have no external help" (referring to remittances).

Women and men have shown different patterns of expenditure from their commercial activities and agricultural proceeds. Women, for the most part, spend revenues or incomes in the household by either enriching the culinary delights (adding substance to the food) or by investing more broadly to ensure the overall well being of the household as confirmed by one woman's statement: "You would not believe me if I told you that I only have two set of cloths (*komplète*) because I value providing for my family first rather than using up the money on myself." Men, however, tend to squander their resources in drinking *sum-sum* (local alcohol), beers, or imported wine rather than contribute to the *depense quotidien*, or daily allowances given to the wives to prepare the family food. Men are known to divert funds from this important obligation. Certainly

men (heads of households) secure more agricultural resources and outputs since they own most of the fields and control land distribution, while women own less land, and most often receive smaller or degraded agricultural parcels. Although the economy of the household is unequally distributed, women continue to provide the bulk of the family's basic needs. We find a greater overture to the externally oriented commodified economy, while some farmers are still confined to economic traditionalism.

**Gender Division of Labor**

There is a marked gender division of labor in Toukar. Rural women take part in the cultivation and harvesting of the main agricultural crops. Although they are seldom involved in field preparation and sowing which involves animals, they do the hand weeding of millet and sorghum, the major food crops, as well as weeding of groundnut. Women are responsible for post harvesting and processing of these crops to prepare them for commercialization and food processing (including threshing and milling of cereals). They also participate in harvesting millet and sorghum, which entails felling the plants with a traditional hand-tool (*hilaire*), and bending over to cut the ears of millet or sorghum from the stems.

Men, in addition to toiling in the same agricultural activities, perform heavy physical labor such as tree pollarding for animal fodder or felling millet crops for harvest. However, they spend fewer hours in farm activities than their women counterparts as noted by this interviewee who described her daily routine: "In addition to working in the field from sunrise to sunset, I cook and deliver midday meals to the farm. In late afternoon I get ready to prepare the

couscous for dinner, and if by any chance I don't have firewood, I'll make sure to pass by the woodlands to fetch it."

Women are absent in the physical reaping of groundnut, which requires uprooting the whole plant with a plow, but they play a critical role in collecting and stacking the plants to dry in the fields before men transport the yields home. Women carry out the bulk of agricultural work and remain the principal actors in winnowing harvests of both millet and groundnut. Plus, they build compost by gathering ashes and animal waste in their backyards or in adjacent fields. The compost is later transported to distant farms before the rainy season, to enrich eroded soils with valuable nutrients.

In addition to these demanding tasks, women are solely in charge of domestic activities, such as caring for the children and preparing the family meals. Food preparation, one of the most demanding of rural women's chores, requires great amounts of firewood and consumes a great deal of women's precious time. With decimated residential forests, women must walk long distances to gather firewood, and may return home empty handed. When this happens, well-to-do women purchase firewood, as noted by this woman: "In the past firewood was not sold at all, but now we buy it at high prices at the woodcutters" (who are mainly men from the Peulh and Laobe ethnic groups). Today a three month supply of fuel wood costs approximately 1000 F CFA (or about US$2), with lots of bargaining; three small pieces cost 100 F CFA. With respect to gender division, men and women use different varieties of trees for different reasons:  In some instances, men prefer the bark to make ropes (*baak*),

while women use other parts (leaves of *baak*) for nutritional, health, and fuel needs.

Another particularity of the gender division is that even the act of eating is gendered: While meals are consumed around communal bowls, the men and older boys eat together apart from women and children. In some families, women and children wait until the men have finished eating to serve themselves. This practice is upheld in the socially stratified Serer community. Furthermore, the study revealed that the average land parcel for men (1.32 ha) is far greater than that of women (0.72 ha).

**Family Structure**

Most traditional families in Toukar consist of an extended family involving grandparents, aunts, or cousins sharing the *mbind* or family compound. Everyone works to provide for the whole family, under the sole leadership of the *yal mbind* (master of the compound). The *yal mbind* apportions land to family members and is responsible for handling the family's interior affairs such as marriage, rituals, and family *pangool*, to name a few. Occasionally family members, especially men, may wish to found their own compound nearby to gain direct access to arable land, or they may move to a new settlement to be closer to distant fields (*qol a kop*). When a girl within the family gets married she usually leaves her traditional compound to join her husband.

For the most part, the families live in harmony with one another. Due to the strong ties that bind family units and villagers together, family members are compelled to collaborate, to work together in order to achieve the basic needs of subsistence through solidarity within the unit. Given the harsh economic and

environmental conditions in which these people reside, they have no choice but to work together, pooling labor and resources to survive. They recognize the necessity of genuine collaboration, with mutual respect among the members of the kinship. Individualistic views, which tend to complicate this collaborative way of life, are vehemently discouraged.

**Education Profile**

As depicted in the study, more than half of the interviewees are illiterate (26 of 43), and among the ones who attended schools (18 of 43), only 7 persons completed the first five years of the French-style education (which corresponds to the U.S. 5th grade), while 6 persons studied in Arabic school (koranic teachings), 3 completed three years of the Serer language alphabetization courses, where students are taught to read, write, and perform math in their native language. Unfortunately, this program collapsed due to lack of funding. Two others completed the first three years of French style education.

Not until recently, in the 21st century, has Toukar begun to invest in educating its inhabitants. The village now possesses two elementary schools and a middle school. However, for more than half a century, the villagers depended on a small primary school with two buildings, which served as two distinct classrooms. Later on, the population decided to build three more classrooms, and the government supplied the teachers.

Like their forbears who mistrusted the French administration school, some community members (13 of 43) are still resistant to sending their children to school. One peasant, who tries to justify his refusal to let two of his sons enter elementary school, addresses the subject this way: "I cannot afford to send my

children to schools because they herd the cattle (*kaynack*), and if they become literate like my other son, they will not want to come back to the village and do the *baadolo* (simple peasant) work." Basically, peasants believe that they have more worthy and urgent priorities than to waste time, energy, and labor sending their children to the "white" schools (a term still associated with education in the village).

# CHAPTER III

## LITERATURE REVIEW: CONCEPTS OF AGROFORESTRY SYSTEMS

The theoretical foundation of agroforestry systems derives from the scientific study of ecology (Wojtkowski, 1998), which explores the interrelationships between living organisms and their abiotic environment. The practice of agroforestry has further been developed by way of agroecology (Wojtkowski, 1998), which is basically the convergence of two scientific disciplines, ecology and agronomy, into what Altieri (1995) calls the science of sustainable agriculture, which focuses on meeting the needs of the present without compromising the future. Sustainable agriculture requires harmony and balance among the ecological, economical, and social dimensions of agriculture (Altieri, Anderson, & Merrick, 1987; Amekawa, 2011). In fact, Altieri defines agroecology more specifically as "the discipline that provides the basic ecological principles for how to study, design, and manage agroecosystems that are both productive and natural resource conserving, and are also culturally sensitive, socially just, and economically viable" (Altieri, 1995, p. ix).

Agroecologists, including Gliessman, call for agricultural productions to mimic natural ecosystems where various species exist and interact in complex associations called communities ("an assemblage of various species living together in a particular place and interacting with each other") (Gliessman, 1998, p. 17). As in nature where no species lives in isolation but rather intermingles and depends on other species, agricultural production also entails similar

mutually beneficial rapport to govern the system. Such a system, based on checks and balances is achieved through the numerous interactions among predators, pests, plants, insects, and companion crops, (Altieri, 1995; Gliessman, 1990). Not only does agroecology seek ways to enhance agricultural systems by mimicking natural processes, it also attempts to create harmonious biological interactions and synergies among myriad elements of the agroecosystems. It provides favorable soil conditions through nutrient-recycling processes for optimum plant growth.

The practice or movement of agroecology not only incorporates principles of ecology while ensuring that agriculture is also culturally sensitive, focusing on reconstituting local farming systems. An indigenous knowledge-based agriculture relies on low-input technologies practiced for centuries, by using natural concepts or models to optimize long-term productivity rather than short-term gains (Gliessman, Garcia, & Amador, 1981).

Altieri, one of the leading scientists in agroecology, claims that farm productivity is much higher in traditional agriculture through intercropping systems, and agroforestry yields more than monocultural systems (Altieri, 1995). Altieri advocates for the reintegration of indigenous technical knowledge, or ethnoscience, into present-day farming practices to prevent the disruption of social relations, which often leads to rural poverty and famine. Furthermore, his theory ponders the socioeconomic aspect of sustainability that focuses mainly on the relationship between society and the environment, and between the various groups engaged in agriculture (1995).

Some agroecologists, such as the proponents of organic agriculture, adamantly oppose technology or inputs in farming systems. While others evaluate circumstances technology can actually be used along with natural, social, and human resources without jeopardizing a critical environmental balance (Amekawa, 2011). Here, Galvan's "syncretism" approach proposes solutions to rural development issues by combining local traditions and knowledge with modern views and technology (Galvan, 2004). From this perspective, one domain favorable to this syncretism is in integrated soil fertility management, which utilizes modern fertilizers in newly established farm tree systems to augment crop yields in the first years of management. In fact, nitrogen-fixing trees do not supply all the essential nutrients, so farmers need to apply agricultural inputs (fertilizers) to compensate for the missing nutrients such as phosphorus (P) and potassium (K). "The synergies between organic and inorganic inputs and between conservation and replenishment methods for soil fertility improvement appear widespread and certainly deserved attention" (Barrett, Place, Aboud, & Brown, 2002, p. 7). Syncretism models may also play an important role in the search for pest control measures by applying the principles of IPM (integrated pest management) tactics of pest control. IPM first relies on traditional concepts such as natural predators, biological controls, and cultural methods, but may also resort to pesticides as the last remedy, if available (Altieri, 1995).

Agroecology with its core ecological principles paved the way for the emergence of agroforestry as a scientific discipline in the 1980s (ICRAF, 1982, cited by Altieri, 1995) to produce a combination of elements that create

diversified, profitable, and safer land-use systems. Some scientists argue that agroforestry is more than agroecology because it provides solutions to land degradation, hunger, malnutrition, and poverty, which are not addressed in agroecology (Leaky, 2012). Agroforestry is a new scientific term for an old practice of land management (known as shifting agriculture) in which trees, crops, and animals interact in the same space and time (Dover & Talbot, 1987). Although many valid propositions have been used in the past to define agroforestry, ICRAF's definition captures the essence of this practice: "Agroforestry denotes a sustainable land and crop management system that strives to increase yields on a continuing basis, by combining the production of woody forestry crops (including fruit and other tree crops) with arable or fields and/or animals simultaneously or sequentially on the same unit of land, and applying management practices that are compatible with the cultural practices of the local population" (ICRAF, 1982, cited by Altieri, 1995 p. 247). Moreover, agroforestry has been shown to provide more resources (a lower land equivalency ratio) and agricultural outputs than conventional monocultural systems for the same amount of land and given similar social, ecological, and economic conditions (Nair, 1993).

Now given the prevalence of environmental degradation, food insecurity, and poverty in the developing countries, agroforersty is seen as the leading practice to help millions of families address hunger, malnutrition, and ecological dilemma (Breman & Kessler, 1997; Sanchez, 1999; Winterbottom & Hazlehood, 1987). Judging from the above definition, agroforestry as well as improved natural resources management practices, has great potential to alleviate poverty,

enhance food security, and solve environmental problems in developing countries (Barrett, Place, Aboud, & Brown, 2002). Agroforestry's immense benefits to rural communities, has greatly influenced my decision to research this topic. In addition to considerable work already done on the subject matter, "agroforestry incorporates important characteristics" (Altieri, 1995, p. 247) that are critical to solving the above pressing problems: They are structural, productivity, sustainability, and adaptability (socioeconomic and cultural). I will now focus on each of these characteristics.

Concerning structure, traditional farmers, like the Serer people described in chapter two, have long integrated trees, crops, and animals into their farming systems. Modern agriculturalists, however, avoid them altogether, and classical foresters consider forests as unique reserves to grow trees mostly for timber production, even though trees grow faster in croplands than in forestlands (Nair, 1983, cited by Altieri, 1995).

In terms of productivity, agroforestry can maintain or increase productivity of crops and animals. The production of several food and tree crops grown together on farmlands helps to sustain economic returns to small-scale farmers (Berry et al., 1984; Dove &Talbot, 1987; Gladwin et al., 2002). In these systems, productivity from the land as well as resilience during times of drought or crop failure is increased tremendously (Altieri, 2002; Sanchez, 1999).

As for sustainability, agroforestry systems are designed to conserve the production potentials of the resource base of trees and agronomic crops and animals, and to perform equitable management that sustains the overall systems without endangering future production (Altieri, 1995; Gladwin, Peterson, Phiri,

& Uttaro, 2002). These approaches are feasible through maintenance of soil and water conservation measures that increase soil fertility and reduce water evaporation (Breman & Kessler, 1997). They also entail adaptability of windbreak techniques (living fences) and evergreen agricultural practices that promote crop rotation, green cover, crop residues in fields, and biodiversity (Dover & Talbot, 1987).

Lastly, in socioeconomic and cultural adaptability, the success of agroforestry systems depends on the acceptance of farmers who have been practicing similar methods for centuries. Agroforestry techniques offer remedy to problems affecting rural communities such as alley cropping (hedgerow intercropping of crops) or mix-intercropping with scattered *Acacia albida*, or fertilizer trees; and windbreaks or living fences (boundary planting, roadside planting, woody strips) as soil conservation measures to restore soil fertility and to provide fodder and fuel wood production (Dover & Talbot, 1987; Sanchez et al., 1997). Silvopastoral systems (trees planting in rangeland, coppicing and pollarding, cut and curry) also can increase animal production. All these natural resource management practices show that agroforestry is well adapted to the circumstances of small-scale farmers by providing a reliable food source and economic stability, thus improving rural livelihood (Barrett, Place, Aboud, & Brown, 2002). Therefore, a successful agroforestry system must be biologically possible, economically feasible, environmentally sustainable, and socially acceptable (Sharrow, 2008).

Furthermore, considering that Senegal continues to struggle to feed its growing population (high rice imports), and to correct its increasing land

degradation, and given that agricultural production is declining due to impoverished and often eroded soils, agroforestry stands to supply potential benefits to soil fertility and increase agricultural production while providing insights to conserving the rapidly shrinking natural reserves. Not only do agroforestry approaches renders farmland fertile and increase food supply; they also serve as habitat corridors for numerous species of plants and animals (Russell et al. 2010). Present-day agricultural practices have resulted in soil-erosion and habitat loss, which have reduced biological diversity considerably and have diminished agricultural production (Altieri, 1995; Rodale, 1989; Vielhauer & Vlek, 1999).

Now that African soils are already denuded of vital nutrients—mainly nitrogen and phosphorus (Sanchez, 95)--scores of scientists and development practitioners suggest that Africa needs a significant boost in inorganic fertilizers in order to achieve soil fertility and increase agricultural productivity. By contrast, other agricultural experts emphasize that recourse to agroecology or agroforestry systems is the best path to lift African agriculture and to improve rural living standards (De Schutter, 2010). I argue that both methods can be mutually beneficial to the continent. Our concern is to strike the right balance.

As mentioned earlier in previous chapters, yields are falling in many parts of Africa because of over exploitation of croplands and "the estimated high rate of soil erosion due to insufficient conservations measures and consequent loss of fertility" (Place et al., 2002, p. 155). Baumer also argues that the poverty of the soils is directly related to the poverty of the people (1990). Moreover, Pimental and Kendal (1994) show that the rate of soil loss in Africa has dramatically increased twentyfold in the last 30

years. In fact, one of the most pervasive forms of arable land degradation is soil erosion, which decreases soil productivity and annual crop yields (Pimental & Kendal, 94; Place, 2012).

On this note, agroforestry holds great promise to lead Senegal's rural development towards a system more compatible with conservation and sustainable land-use practices to achieving food security and environmental protection. Agroforestry, also defined as the "deliberate association of trees and shrubs with crops, livestock and other factors of agricultural production," (Winterbottom & Hazelhood, p. 102), plays a critical role in the global fight against food insecurity and soil fertility depletion (1987). In order for the systems to be efficacious, though, farmers and local communities need to fully embrace the concept and its applications (Winterbottom & Hazelhood, 1987). When local people appropriately integrate trees and woody shrubs into their farming systems, the returns are enormous. Agroforestry can increase the availability of firewood, which alone is one of the most demanding rural chores. The excess wood production can sustain small-scale rural based enterprises, increase income for farmers, and enhance agricultural productivity (Gadgil, Berkes, & Folk, 1993). Agroforestry had been practiced for centuries in traditional farming systems. But recent land degradation has urged scientists to develop new technologies by simply integrating fast-growing woody perennials into the local farming systems to make them more sustainable and productive, with at least two or more outputs harvestable from the system (Bayala et al., 2011). The choice of trees plays an important part in the success of agroforestry, like the use of leguminous trees that fix nitrogen from the air to provide higher sustained yields (Russell et

al., 2010). In the sandy infertile soils of Western Sahel, the presence of *Acacia albida*, a tree found throughout the region, in fields of millet and sorghum actually "increased crop production up to 2.5 times (from 430 to 1000 kg/ha) over yields obtained in open fields" (Winterbottom & Hazelhood, 1987, p. 104). But today, farmlands are becoming devoid of the tree for reasons we will discuss in chapter IV. Additionally, farmers deliberately cut the young seedlings to allow easy access to plowing. This departure from traditional agricultural practices is also exacerbated by "assumptions of intensive competition between trees and crops for water, and a need to eliminate roosts for granivorous birds (such as black-faced diochs) that feed on millet crops (*Quelea quelea*)" (Berry et al., 1984, p. 14). In the same perspective, some experts have shown that modern agricultural implements damage soils and create drought (Glantz, 1994). Renè Dumont, a French agronomist, had long warned Africa of the unhealthy and negative impact of mechanized agriculture, emphasizing that "machines scrape off the top soil" and thus expose it to erosion and nutrient depletion (Dumont, 1962, p. 60-61).

Agroforestry not only helps control deforestation, but also replenishes denuded soil. Soil fertility is greatly improved when livestock and fertilizer trees are integrated in farmlands (Ndlovu & Mugabe, 2002). Specific research done in Senegal has also shown that "50 trees of *Acacai albida* per hectare provide 300 kg of organic nitrogen or 50 kg of potassium chloride (equivalent to 24 kg of K) or 80 kg of bicalcium phosphate (31 kg of soluble P2O5 and 25 kg of Ca); or 125 kg of dolomite (15 kg Mg and 25 kg Ca), or 100 kg of agricultural lime (43 kg Ca), and consistent results or better were also reported throughout the Sahel region"

(Baumer, 1990, p. 89). For instance, 20 years of research on effects of *Prosopis cineria*, a farm tree commonly associated with cultivation of millet in arid India, have resulted in positive influence of soil fertility. The same results were recorded with the *Grevilla robusta* in Kenya (Winterbottom & Hazelhood, 1987). Other research proposed a combination of cultivation of fertilizer trees (from tree biomass) or shrubs in farmlands but with an emphasis on appropriate technologies such as improved stoves to reduce the pressure on dwindling forests (Le Tacon & Harley, 1990).

Alley cropping systems, one of many agroforestry applications, can also serve as improved tree fallow systems, uses preferred tree species as opposed to natural regeneration. Alley cropping systems become potential replacement to shortened or nonexistent fallows in semiarid Africa (Altieri, 1995; Harrison, 1987; Fries, 1991). Scientists argue that leguminous trees not only fertilize the soil, but also provide green manure to the food crops grown in alleys. Here, branches and twigs lopped off the trees, through techniques known as coppicing or pollarding, are applied as mulch in the field to suppress weed, reduce soil dryness and excessive heat, and thus improve soil moisture retention (Altieri, 1995; Bayala et al., 2011). Hence, multipurpose trees return organic matter to the soil and thus increase yield and economic productivity. It is estimated that each *Acacia albida* tree improves 100-300 square meters, and thus 10 to 15 percent of the land is fertilized (Charreau & Vidal, 1965; Swift, 1984). Coppicing, a worldwide technique that consists of cutting back a tree or shrub to ground level periodically to encourage growth and provide firewood and timber, could yield tremendous benefits to farmers. The question is whether native trees, like *saas*,

can undergo coppicing and regrow from the stump or roots. Such a technique, if feasible, could have the potential to generate incomes to farmers of all categories and preserve trees on farms.

The agro-silvopastural subsystem, another beneficial agroforestry application in which trees, livestock, and crops are combined, maintains and increases nutrients levels and thus enhances soil structure (Ndlovu & Mugabe, 2002; see chapter VII). When animals, crops, and trees are properly managed, the result can create one of the most sustainable forms of agriculture (2002). In fact, semiarid African farmers often invite or pay migrating pastoralists to pen their livestock overnight to fertilize crop-fields (Baumer, 1990). However, this practice is often compromised due to conflict of interest that arises between agriculturalists and pastoralists.

Shelterbelts, which utilize native trees, such as *A. nilotica*, or *A. Senegal*, or *E. balmisera*, improve soil organic matter, and along with contour planting are valuable soil conservation measures in poor or easily depleted soils of areas of medium to high population density (Breman & Kessler, 1997). Shelterbelts also supply tremendous benefits in reducing the impact of wind, and thus conserve soils (Sanchez et al., 1997). Other agroforestry techniques, like riparian buffers, have considerably decreased nutrients losses from soil and water erosion, and leaching. Planting trees in these areas will reduce the damage to water sources and erosion caused by livestock (Bishaw & Abdelkadir, 2003). For instance, fast growing trees such as *L. leucocephala* in Benin and Kenya have reduced nitrate leaching considerably (Sanchez, 1995). However, this specific tree is known to perform better in humid or semi humid areas (WAC, 2009). There are tremendous

soil benefits to integrating trees in farmlands: their litter layer and leaf canopy help protect against soil erosion. These environmental benefits lead to soil conservation and biodiversity conservation, two indispensable concepts to restoring soil depletion and increasing crop yields (Breman & Kessler, 1997; Place, 2012; Sanchez, 1999).

Significant benefit is also gained from soil macro- and microorganisms, such as earthworms, fungi and nitrogen-fixing bacteria associated with agroforestry systems. These organisms increase organic nitrogen in the soil and play vital roles in soil fertility and overall balance of underground ecosystems (Altieri, 1995; Conway, 1997).

Another agroforestry practice of significant importance to soil fertility replenishment and food security is the incorporation of legume cover crops in association with annual food crops. These cover crops serve as living mulches growing under the woody shrubs (Tarawali et al., 2002). In agroecology class experiments that I conducted, white clover grown with millet in a stressed environment (limited watering) tolerated dry soil, and showed increase in height. This practice is feasible during the rainy season to provide proper moisture for growth since irrigation is lacking in most rural communities. Although further research is needed to prove the reliability of such an experimental method, it could represent a plausible step towards improving soil fertility in semiarid Africa. In addition, cover crops can eventually replace millets stalks that are being collected for firewood or used as construction materials. Conservation tillage, in which soil surface is disturbed as little as possible, constitutes another approach

to reducing runoff, sediments, and nutrients losses, diminishing soil erosion by as much as 50% (Bayala et al., 2011; Pretty, 1995)

Other experiments done with *L. leucocephala*, have contributed to 3.5 cubic meters/ha/yr of fuel wood, which is significant given the massive amount of time women spend to search for firewood (Winterbottom & Hazelhood, 1987). Farmers in Kenya have met the 100% mark on fuel-wood gathering, especially when conditions are favorable, from a combination of farm trees, hedgerows, field boundaries, and small wood lots (Winterbottom & Hazelhood, 1987). Extended new research has also been done in Burkina Faso, Mali, and Senegal with respect to incorporating leguminous tree products into farmlands. The following results were recorded: "leaf biomass of *Guiera senegalensis* has produced 5 tons/ha/year, whereas *C. lezardi* has given only 2.5 t/ha/yr in Burkina Faso" (Bayala et al., 20011, p. 16). Similar experiments with *Prosopis Africana* and *Gliricidia sepium* in Mali have produced an increased yield of 1.86t/ha/yr compared to only 1.23t/ha/yr in the control plot. But a more interesting experiment that yielded greater results was recorded with *Acacia albida* in Senegal. The study here showed that *Acacia albida* increases millet yield tremendously. Soil around the tree produces up to "113% higher yields than those outside the acacia crowns, but with a depressive effect on peanut at 3 meters distance, then a increased yields form 3 up to 8 m before declining again" (Bayala et al., 2011, p. 29). But the experiment showed an increase in peanut hay at harvest. Similar research done on matured *Acacia albida* in Zambia showed sustained yields of maize by producing 4.1 tons/ha, compared to only 1.3 tons/ha without the trees (Langford, 2009).

Most recently, new science-based techniques called evergreen agriculture emphasize conservation tillage methods based on minimum or zero tillage, crop rotation, and diversification with the introduction of leguminous trees and shrubs in already existent farming systems. Evergreen agriculture also focuses on keeping the plant's organic material in the fields to cover and protect the soil (WAC, 2009). The scientists conducting this research are reframing the old traditional farming practices that have sustained Africa's farmers for generations. Their research, mostly based in East Africa, is showing that evergreen agriculture offers multiple livelihood benefits to farmers and serves as a remedy to food insecurity while providing environmental resilience.

When farmers apply or bring back these traditional sustainable farming techniques, not only do they improve crop productivity and biodiversity, but they also attain food self-sufficiency and raise cash in the process, all while maintaining cultural traditions. For instance, African's environment produces fast-growing leguminous trees and other species that are valuable sources of cash. Gum Arabic, extracted from *Acacia Senegal*, could be sustainably exploited to provide peasants with cash. There is currently a lucrative high-demand international market for gum Arabic, and poor farmers can benefit tremendously from it (Bayala et al., 2011; WAC, 2009).

The World Agroforestry Center has also discussed the benefit of agroforestry in mitigating the effects of climate change in Africa. Climate change, an increased atmospheric concentration of greenhouse gases (GHG), which results from human-induced deforestation and fossil fuel burning, has brought about unprecedented rainfall patterns, and has caused droughts and floods in

many part of the world, especially in Africa. The Sahel region is likely to be heavily impacted (WAC, 2009). This part of Africa already is experiencing problems as a result of rising temperatures and advancement of the Sahara desert in Northern Sub-Sahara Africa (SSA). For instance, some Cameroonian maize farmers are reporting considerable drop of yields from 125 to 95 tons due to unusual irregular rains (Ntungwe, 2011). In addition, fishermen, farmers, and herders near Lake Chad are facing extremely difficult conditions as a result of the continuous dwindling of the lake. Many of them are forced to relocate or must adopt techniques to increase productivity and maintain the stability and resilience of their new production systems (Ntungwe, 2011). This is a familiar scenario throughout SSA, and as a result of climate change, farmers around these settlements are losing their basic livelihood because of the vagaries of the rainy seasons.

However, scientists at the WAC estimate that agroforestry can result in 50 billion tons of carbon dioxide sequestration within fifty years (Garrity & Verchot, 2008). Note that agrogroforestry stores carbon (C) both in soil and woody vegetation (known as carbon offsets). Climate-smart agriculture will mitigate the adverse impacts of global climate change in the lives of poor farmers. The international community has been talking about reducing global emissions, and one way is to allow countries to participate in carbon trading. SSA can be a larger beneficiary in this, since it is estimated that "the continent potential mitigation of GHG emissions stands at $ 4.8 billion at carbon prices of $ 0-20/tCO2e" (WAC, 2009, pp. 17). The same estimates also suggest that "Africa could potentially contribute to GHG emissions reduction of 265 MtCO2e (million tons of carbon

dioxide or equivalent) per year at carbon prices of up to US$20 through agricultural measures and 1,925 MtCO2e/yr at carbon prices of up to US$100/tCO2e by 2030 through changes in the forestry sector" (Bryan et al., 2008, p. 18). This carbon trading could be huge for SSA if agricultural mitigation measures such as soil and water conservation, and agroforestry practices are designed and implemented properly throughout the continent.

As explained in chapter I, the international community with its financial support regards the Great Green Wall (GGW) as an opportunity for economic development, environmental protection, and political stability; above all, it views agroforestry as a mean to curb desertification. According to the article, there are tremendous benefits associated with such a gigantic international project. Some of the advantages are poverty alleviation of inhabitants along the green wall by protecting water sources such as Lake Chad, which is drying up fast, and by restoring biodiversity, thus fostering the return of previously resettled people who depend upon the lake for their livelihood (Godoy, 2011). The choice of native trees for reforestation can provide indigenous people with incentives to fully participate in the implementation and success of the project. These multipurpose trees and shrubs are beneficial to local people, and can provide income-generating activities. They will allow nearby communities to live together in harmony whereby the interests of farmers, herders and fishermen are taken into consideration. It is crucial that all participating countries abide by the rules to ensure success of this important regional project.

International organizations now seem to understand the benefits of agroforestry and have begun to promote sustainable agroecological systems to

reduce poverty and achieve food and nutrition security. For instance, FAO has developed the "Acacia Project," a small-scale women's pilot project in Northern Senegal, which has restored women's confidence and dignity in the area. This initiative is dedicated to combating desertification and restoring women's marginal and degraded dry lands to fertile lands (FAO, 2011).

In addition, agroforestry offers excellent ways to use agrobiodiversity, the science that encompasses diverse genetic resources such as edible plants and crops, soil microorganisms vital to soil health, livestock, and agroecosystems (Gladwin, Peterson, Phiri, &Uttaro, 2002; Winterbottom & Hazelhood, 1987). Winterbottom and Hazelhood argue that the introduction of green technologies has reduced biodiversity in Africa, and that many traditional cereals are threatened or have faded away as a result of modern high-yielding crop varieties. The example of a traditional Senegalese crop called *Fonio* (*Panicum laetum*) is pertinent. This cereal, which is highly nutritious and well suited to a semiarid environment, is now endangered and risks extinction if preventive measures are not taken. Traditional farming practices must be maintained or reinstated in order to preserve both crop genetic resources and indigenous cultures. Many scientists look at traditional agroecosystems as a center of diversity, since they comprise huge varieties of cultivars as well as wild and valuable weedy companion crops (Harlan, 1992). These wild organisms are very genetically diverse, ensuring adaptability and resistance to a changing environment. Traditional agroforestry systems throughout the tropics contain over 100 species of plants per field for food supply, building materials, soil erosion, and water conservation (Altieri, 1995; Gladwin, Peterson, Phiri, & Uttaro, 2002). Conservation of genetic resources

is intimately related to preservation of indigenous people and cultures. Metaphorically, just as native plants thrive and prosper in their natural ecosystems, so indigenous cultures are bound to their traditional agroecosystems (Altieri, 1995); rarely can one persist without the other. These ecological settings contain vast repositories of numerous plants species that are also used for medicinal purposes. Clearly, tree resources are traditionally and culturally important.

The Zai technique, one of the best-known traditional practices to reclaim degraded lands and rehabilitate agroforestry systems in the Sudano-Sahelian semiarid zone, has continued to win praise in the field of conservation agriculture (Reij, Scoones, & Toulmin, 1996). The documentary film "The man who stopped the desert" (Dodd et al., 2010) clearly describes how a smallholder peasant (Yacouba) in Burkina Faso was able to improve the traditional farming technique of Zai, and reverse the advance of the desert in this part of the Sahel. The Zai technique consists of planting seeds or transplanting trees in dug holes in the fields to collect rainwater and increase infiltration. Yacouba made the pits bigger and added manure and plant detritus, which provided decomposed nutrients to the plants. According to Reij, Scoones and Toulmin (1996), this traditional technique, which is now widely applied in Burkina Faso, has reduced soil erosion, increased soil moisture, structure and chemical content, and thus increased crop yields. Zai pits have also proven more effective in low rainfall areas compared to abundant tropical rainfall (Reij, Scoones & Toulmin, 1996). In the film, Reij also argues that this simple method has reversed desertification in a short period of

time in contrast to what international organizations, NGOs, and agricultural experts around the world have achieved over many decades.

Dennis Garrity (2011), the former director of the World Agricultural Center, has highlighted the rehabilitating effects of agroforestry systems in denuded African soils and the effects of bountiful farm production in poverty alleviation. He reiterates the need for Sahelian farmers to reincorporate agroforestry practices into their present-day resource management systems to improve rural livelihood and environmental resilience (Garrity, 2011).

Clearly agroforestry as a land use system can achieve social, economic, and environmental sustainability by combining food production, income generation, and promotion of ecological services including carbon sequestration and biodiversity protection.

**Potential Constraints of Agroforestry Systems**

Noticeable constraints and limiting conditions are associated with the implementation of agroforestry (Altieri, 1995). Planting and propagation of trees has faced significant problems related to lack of water and maintenance, and free roaming of animals during the dry season. Farmers' disinclination to enable natural regeneration of native trees in their fields has also hampered agroforestry initiatives in Toukar (discussed in chapter IV). Other constraints include the reluctance of native peoples to return to traditional agroforestry practices because of national agricultural policies that advocate expansion of cash-cropping agriculture (see chapter II). Farmers also lack materials and equipment to protect young seedlings, and have to contend with the increasing vagaries of the weather,

especially drought and short rainfall. Availability of seeds, training in nursery management and maintenance of reforested trees during the dry season are critical factors in achieving vegetative cover in these barren Sahelian plantations (see chapters II and IV).

Another serious constraint is the competition between trees and food crops. The urgency to meet basic food needs may exclude resource-poor farmers from growing trees in their small parcel of land (see chapters IV and V). In this regard, recent experimental work done in East Africa (WAC, 2009) has shown satisfying results in alley cropping of *Acacia albida* with crop foods, demonstrating that growing trees does not mean taking land out of production.

Lastly, tenants rights may be a limiting factor. In some instances, the field in which trees are naturally grown may not be owned by those who cultivate the field since the land is acquired through the "*tayle*" system or leased. Here, the original owner (or lender) retains the right to exploit the trees. However, trees in historic or traditional farmlands are passed on from generation to generation, and descendants of the original planter or protector are entitled to the trees. When the Rural Council allocates a field, the new owner becomes the full benefactor of all the trees in that particular farm.

Overall, the literature review conveys a robust and very consistent message with respect to the capacities of agroforestry systems in solving food insecurity in the Sahel.

# CHAPTER IV

# THE STORY OF AGROFORESTRY IN TOUKAR

## Patterns of Adoption of Agroforestry

In this chapter, I report patterns of adoption of agroforestry techniques among farmers in Toukar, which enable them to conserve soils and tree resources in an ecologically sustainable manner while negotiating the challenge of livelihood, especially securing food for household consumption. I asked farmers a series of questions to determine the pattern of adoption of agroforestry practices. Three patterns emerged.

i) The Pro-agroforestry group (17 respondents out of 43 total) are farmers supportive of and engaged in some forms of agroforestry practices closely associated with the Serer's traditional farming techniques.

ii) The Unsure or in-between group (15 of 43 respondents) are farmers who show indifference or hesitancy about tree planting and are unenthusiastic about agroforestry methods.

iii) The Anti-agroforestry group (11 of 43 respondents) are farmers who not only are reluctant to adopt the system, but may also undertake adverse farming activities inconsistent with agroforestry techniques, such as cutting seedlings.

Table 2 below shows the different patterns of adoption and also points to the various practices used by each category.

*Table 2: Agroforestry Patterns: (X) refers to farmers who do the action, and (-) farmers who do not*

| Agroforestry patterns | Pro-Agroforestry | Unsure | Anti-agroforestry |
|---|---|---|---|
| Plant & Protect trees | X | - | - |
| Intercropping | X | X | X |
| Crop rotation | X | X | X |
| Live fencing (ndamul, tuduy) | X | - | - |
| Protect (found) trees | X | X | - |
| >Avg. tree total | X | - | - |
| >Avg. saas | X | - | - |
| Toss | X | - | - |
| Tradl. Manure | X | X | X |
| Intentional seedlings cut | - | - | X |

**The Pro-Agroforestry Category**

As illustrated in Table 2, the pro-agroforestry group (17 of 43) is characterized by factors such as planting and protecting trees in fields, and the presence of more than the average numbers of trees in farmlands. Furthermore, in addition to practicing intercropping and crop rotation, as does every farmer in Toukar, and regardless of attitudes toward patterns of agroforestry adoption, these individuals keep more than the average number of *saas* trees and maintain living fences (*nding*) made of *tuduy* or *ndamul* (*Euphorbiacea balsamifera*) as farm borders. They also practice toss or fallow periods with traditional manure to enrich farm soils.

The pro-agroforestry group indicates that they nurture high-value trees into their farmlands for multiple benefits like their ancestors had done for

centuries. Acknowledging that they seldom plant trees, these farmers claim to assist young seedlings to develop and mature into robust trees. The seedlings inevitably require a passage into the digestive system of a ruminant, most preferably cattle, in order to germinate at the onset of the rainy season. Pro-agroforestry farmers also report protecting the seedlings by carefully pruning and tailoring the seedlings until their main stems (terminal shoots) are higher than humans, and out of reach from wandering animals that roam the fields during the dry season. This intricate process entails surrounding the young tree with *ndamul*, unpalatable fast-growing shrubs, and adding thorny branches of *saas* or *ngiic* around the site. As described by this pro-agroforestry farmer: "I generally transplant cuttings of *ndamul* around seedlings to be protected, and surround them with dead spiky branches to guard against animals, and once the trees are matured, I also continue to save them from illegal logging." Among the many species of trees these farmers conserved in their farms is the *Acacia albida*, a tree also called *saas* in the Serer language. The presence of large stands of *saas* is indicative of Serer habitations (Pelissier, 1966), illustrating the profound attachment of the tree with the Serer people.

By the same token, pro-agroforestry farmers also maintain and manage living fences (*nding*) that border their fields for multiple purposes. *Nding* are made of *ndamul* or *tuduy*. The latter is a perennial herbaceous plant or grass that dies down at the end of the growing season to the soil level, and regrows during the rainy season. But Pro-agroforesters warn that the evanescent *tuduy* grass that has been traditionally gathered for roof huts is rapidly diminishing. From their accounts, the paucity of *tuduy* in the agroecosystems has begun to adversely

impact farmlands because some farmers have commenced to substitute the grass for millet stalks, endangering soil replenishment. Crop residues left in the fields help control erosion and, when decomposed, return organic matter back in the land. This means that there is an imbalance between nutrients lost and nutrients returned to the soil in crop residues. When I probe into other types of shrubs or grasses for potential live fences as replacement to *tuduy*, farmers recalled jatropha, or *litroog* in Serer language, that was used in the past, but has also completely disappeared from the landscape, probably due to repetitive droughts in the early 1970s.

Pro-agroforestry farmers proclaim they have gained numerous benefits from maintaining living fences. The principal function mentioned is that living fences separate toss-areas from farmlands. Furthermore, these farmers depict well-designated paths (*pech*) taken by herders to guide animals to the water holes and toss areas without trespassing on cultivated plots during the rainy season. Living fences not only delineate fields, but also eliminate disputes between neighbors, as is the case when there is no distinctive landmark (Galvan, 2004). More importantly, living fences are of immense ecological benefits to humans and wildlife. They serve as windbreaks to ease soil erosion due to recurrent and devastating dry windstorms or *harmattan*.

Supporters of traditional agroforestry not only understand that *nding* as borders stop or reduce the transport of rich topsoil from exiting the field, but also serve as habitats for both beneficial and harmful animals. However, few farmers think they attract damaging birds that feed on millet and sorghum crops, but in reality many of these ravaging creatures are migratory birds that perform their

regular seasonal journeys in the region, irrespective of living fences. My research suggests that the benefits outweigh the risks; 88% of Pro-agroforestry farmers are not convinced by the others' fears or misgivings, but think the birds' damage is rather ephemeral.

Agroforestry farmers have also pointed out the extraordinary array of edible wild herbs such as *khout* and *ndur* that usually grow under the protection of these living fences, and which provide an important source of nutrition in green leafy vegetables for the villagers who continually harvest them for cooking the main dinner dish of *saadji fa ba'see*. One woman's statement is evidence of that: "At times, especially in the early rainy season, I do not need to go far into the bush to fetch wild herbs. I can harvest an incredible amount of *khout* and *ndur* right here from my *nding*." Another advantage, which adapters of agroforestry point out, is that these hedgerows are favorable hunting grounds for children who search for hares or other small animals for a supply of animal protein. Despite numerous benefits associated with living fences, pro-agroforestry farmers acknowledge that they are labor-intensive since they require constant and seasonal repairs. On the one hand, women pick up loose branches from the fences for firewood, or sometimes animals find or create holes in the fences—not to mention the damaging work of termites. On the other hand, fences may last a few years or longer when well-built and constantly managed. Overall living fences, as opposed to barren farm borders, provide numerous environmental, economic and political opportunities to pro-agroforestry farmers.

*Toss* or "fallows" in Toukar, another critical factor in agroforestry systems, are uncultivated farmlands reserved exclusively for livestock during the three

months of the rainy season. Toss is such an important component of agroforestry systems that the 17 people who identify as Pro-agroforestry regard the practice as having an immense positive effect on soil fertility replenishment and on tree regeneration. But a subtle difference exists between toss and fallows: *toss* in Serer also means the practice of rotational cattle grazing in continually cultivated fields that do not rest fallow anymore.

Toss or nutrient-rich farmlands, predominantly adopted by pro-agroforestry farmers, are effective natural resource management strategies to ensure soil fertility improvement, and thus enhance crop yields. Toss also enables agroforestry farmers to have a place to graze their animals and obtain milk for family consumption and for sale while the herd is nearby. Pro-agroforestry farmers have also mentioned the possibility of saving a few seedlings in toss areas because the land stays uncultivated and free from the plow for at least a full year. All of these traditional practices and factors have influenced the adoption of agroforestry systems.

Furthermore, Pro-agroforestry farmers (15 of 17) who planted trees also protected them with *ndamul*, and all 17 practitioners of agroforestry protected found trees in their fields. The pro-agroforestry category exhibits the highest tree density with an average of 14 trees in farms, compared to 8 for the unsure group, and 7 for the anti-agroforestry farmers. Tree density constitutes a considerable asset to rural people and fulfills the triple action of increased crop yields, availability of fodder for livestock, and an occasional supply of firewood. In a similar fashion, all of the Pro-agroforestry members (17 of 17) hold more than the average (10) total trees in fields. They also hold the largest average number of

*saas* trees in farms with 10, compared to 6 for both the unsure and the anti-agroforestry group, and thus have more than the average total *saas* trees (8) in their farms.

However, when farmers in the entire population were asked to cite the main obstacles to supplementing *saas* density in their fields, they alluded to the absence of technological knowledge but also the marked lack of interest of the state's government to provide nurseries (20 of 43). Meanwhile in the pro-agrogroforestry group, 15 respondents out of 17 repeatedly blamed state authorities for failing to supply basic necessities to regenerate dwindling parkland trees. One farmer stated: "I thought about planting *saas* trees, but I do not know how, and the government never provided any assistance in this regard." These indigenous farmers announced that they are now confronted with unprecedented climatic changes against which they have few weapons. A second farmer put it this way: "It is absolutely critical for us to replace our dead and fallen *saas* trees in our farms, but unfortunately we do not have governmental support or any access to seedlings around here." The villagers told me that they never received any training or assistance from extension services because of a long history of conflict and mistrust with the local officials. According to historical narrative, the village of Toukar has been marginalized for years, and has garnered very little aid from the state. Most of the aid or assistance goes to the neighboring village of Ngayokheme, which is the chef lieu de la Communautè Rurale. So this group of peasants continues to accuse the state for all their misfortunes and tribulations, and demands that the government intervene in providing the basic necessities to regreen their farmlands.

By and large, pro-agroforestry participants (17 of 43) have recognized the functional benefits of trees as soil nourishment as well as the socioeconomic advantages attached to them. Therefore, they are deterred from cutting them down because they think trees produce or attract rains and thus increase the likelihood of good harvests, and provide protection against violent winds. A farmer in the group states that "trees, especially *saas* trees, are very useful to us, and the more trees one has, the more abundant crop yields the person harvests." This statement reflects the local proverb that says "*saas nbetic a maya o ndap*"(five *Acacia albida* trees fill a granary). These benefits are even more noticeable when we consider the fruits of *baak* and *sob*, which are not only valuable market-based products that generate substantial incomes, but also provide nourishment. The Serer community relishes the *togn*, a lunch dish made out of *baak* fruits mix with curds or sour milk and poured over a thick millet-based porridge. A similar meal (*ngurban*) as well as a widely brewed drink is also concocted using *sob* fruits.

Trees in farms can also meet multiple household objectives, including food security and fuel wood, and cash as well as savings to meet future needs. As a rule, tree resources are of fundamental importance to Sahelian farming systems (Breman & Kessler, 1997). Pro-agroforestry farmers have received tremendous ecological benefits as they reap the rewards associated with preservation and regeneration of farm trees, as has been done for centuries by their ancestors. However, there exists a relentless resistance or opposition to planting or protecting trees in farms, which is relatively manifest in the next group of farmers.

**The Unsure Category**

The Unsure group of individuals (15 of 43) consists of farmers who regard trees as wasted arable lands. Hence, they do not plant or protect trees. Only 2 farmers in this group have protected "found" trees, but interestingly, they do not cut them down, either. This group of farmers holds the second highest tree density, with an average of 8 in farms, which is less than the average number of total trees in farms (10). They also hold the same average number of *saas* trees in farms (6) as the anti-agroforestry group; thus both have less than the average total *saas* trees (8) in farms.

In the Unsure category, only 2 of 15 farmers practice *toss*, while 3 of 15 keep patchy living fences that fail to accomplish their dual function of protection and delimitation. Defective or inexistent fences are common in some areas. The two cultivators who are women argue that they would rather grow nutritious shrubs like the widely used annual bissap plant (hibiscus) between fields for household use as well as for cash than to allocate the patch of land to living fences (*ndamul*), even though some pro-agroforestry farmers have incorporated both systems into their farms. With respect to live fencing, another Unsure woman made an interesting comment regarding living fences and mechanization. She pointed out that "the use of machine (plow) is actually incompatible to maintaining living fences because the draft animals and the person leading them need room to maneuver and turn when they reach the end of the crop rows, but a living fence usually blocks them from turning correctly without damaging the plants."

However, we found two farmers in the Unsure group with the average tree density (10) in their fields. This abundance of trees is the result of inheritance, as confirmed by this woman's testimony: "I received this field including the trees as a gift from my husband, as is the custom for husbands to provide land for their wives." Another farmer asserts: "I do not intentionally cut seedlings while plowing, but have noticed that they frequently do not resist the tilling and die easily." In fact, it is extremely difficult to weed a field or harvest the crops while trying to protect the young seedlings at the same time. The laborious process of hoeing newly sprouted plants has always been challenging to cultivators. It entails holding the plow firmly with both hands and weaving through rows of millet crops while simultaneously dodging the fragile plants. Normally a field receives two to three weeding sessions. Subsequently, another critical millet thinning session, this time done by hand with a "*hilaire*" or long-hoe, follows the first plowing to give young crops an advantage over the fierce competition of weed. Indifferent farmers cite the difficulty of crop husbandry as one of the underlying causes for the low survival rate of seedlings in farms. In fact, a handful of Unsure women farmers (5 of 15) have admitted cutting seedlings accidentally. They made clear to me that some of the accidental cut stems from children performing the plowing. In a more recent past mechanized plowing and weeding were primarily performed by adult males, often with a child leading the animal. But today, half of the women interviewed (5 of 10) indicated that children do the plowing for them. One woman clearly stated, "It is a man's job, therefore men are to blame for the lack or sluggish paced of tree regeneration process." In the maintenance of field crops, most sowing and

weeding operations are mechanized. Horses and donkeys provide draught power, which renders the task quite challenging.

This specific group of Unsure farmers (11 of 15) also declared that despite some effort to avoid plowing seedlings, it is difficult to protect them. Because seedlings are so fragile, and require immediate attention to survive the torching seasonal sun, indifferent farmers are disinclined to help them recover from the rigors of plowing. Since plowing is time-consuming and labor-intensive, short-handed farmers disregard the care of seedlings, and concentrate instead on the paramount issue of subsistence cereal crop production. Such arguments do reinforce their attitude and indifference toward trees on farms. They are not motivated to assume the elaborate task of nurturing young seedlings to maturation. In fact, the data shows that such attitude is more common in the next Anti-agroforestry group of farmers.

**The Anti-Agroforestry Group of Farmers**

In addition to considering scattered trees as constraints to adequately cultivating the field because of the nonlinear tree patterns, Anti-agroforestry peasants intentionally cut seedlings while plowing their fields, which hinders tree-regeneration and affects the future density in the area. They also consider the presence of trees in farmlands as a waste of arable space. They openly manifest their opposition to planting or protecting certain species of large trees, such as *sob* and *baak*. This group of farmers holds the lowest tree density with an average number of 7 in farms, which is less than the average number of total trees in farms (10). They also hold the smallest average number of *saas* trees in farms (6), and thus have far less than the average total *saas* trees (8) in farms.

As I mentioned in the previous section, Anti-agroforestry farmers also find it complex and burdensome to simultaneously preserve young seedling trees in fields and adequately plow, which suggests that only the dedicated farmers can take the extra effort of conserving trees in their farms. It is also quite remarkable that a considerable number of Anti-agroforesters (7 of 11) have stated that they have cut down other trees than *saas*, which they regard as super beneficial. Here the vast repertoire of essential trees includes large species such as *baak*, *sob*, and *ngaan* that are highly valuable but take up a sizeable portion of cultivable lands. One peasant admits: "I deliberately cut seedlings of *baak*, *sob* and *mime* trees (an introduced species from India) in plowing areas to allow for more arable lands, but try hard not to uproot *saas* or *ngojiil* (a highly-favored hardwood producing-tree for construction and firewood)." Another farmer confirms this: "I calculatedly kill all seedlings on the machine's path and unsuccessfully try to spare the ones outside." A confession from another Anti-agroforester sums it up this way: "I'd rather cut down trees when confronted with shortage of arable land because crops planted under these large trees barely grow and yield poorly, anyway."

However, 2 opponent farmers (2 of 11) responded that they are afraid to cut down trees because of the severe fines from forest agents as an impediment to tree removal. To cut a tree, dead or alive requires a permit. These farmers report that ever since the Senegalese forest services have resorted to punishments in the form of payment of cattle, small ruminants, or the equivalent to discourage deforestation and clearance of stands of shrubs and trees from farm and farm-borders, they revert to other techniques that they did not share with me.

Although it is quite difficult to enforce the law because the authorities are seldom present, some farmers fear or suspect others will denounce the felling of trees in their farms. This enforcement may dissuade peasants from planting or protecting trees if they perceive that the ensuing sanction is a breach of privacy or a drastic shift from traditional tree ownership in the Serer's concept of land tenure.

One Anti-agroforestry farmer posed the question, "How can I own the land and not own the trees growing in it? And why do I need a permit to do something that will improve my livelihood?" This is a relevant question, but very complex in itself because although it casts doubt on the validity of land ownership, it also calls for a review of the controversial 1964 Land Tenure Policy, instituted after the country achieved independence. This newly instituted law transferred the control of land from the *lamans* to the Communautè Rurale (the rural government authority), or locally elected officials with authority to take land from those with surplus for "legal" distribution to less-fortunate farmers (Galvan, 2004).

The Anti-agroforestry category also includes peasants who may overly pollard farm trees to death for economic profits such as construction materials, firewood, or fodder. Researchers have highlighted that excessive pollarding, or topping off branches of trees to stimulate new growth, can be injurious to trees (DePommier, 1998). Arborists set definite limits on pollarding to enable enough time, approximately 2 to 3 years, for the tree to heal before another pollarding can take place (DePommier, 1998). With too much pollarding, farm trees become weakened and susceptible to disease, drought, and death. Farmers likely do not

associate this repetitive practice with the frequent death of overly pollarded *saas* trees, or they may knowingly want the death of such trees to profit from them. No farmer has admitted undertaking this practice for personal benefit, even though they dwell on anti-agroforestry activities.

Some Anti-agroforestry farmers in this bracket (20%) have also indicated a marked absence of financial resources as an obstruction to conserving trees in their fields. Farmers struggle to eke out a living, especially during the dry season when agricultural activities die down and life in the village becomes lethargic. Remunerative work is almost nonexistent, which forces many young men and women to leave the village in search of work in the cities. This rural exodus, whether seasonal or permanent, further exacerbates the already strenuous living conditions. Elders are left to fend for themselves, and are incapable of making their livelihood, let alone purchasing trees in distant localities to plant in their farms.

This last obstacle may shed light on the socioeconomic dimension of the different categories, and leads me to study the correlation between the adoption of agroforestry systems and wealth, which is one of the principal tested hypotheses for the thesis.

# CHAPTER V

## THE WEALTH HYPOTHESIS

This chapter seeks to determine the rationale behind the adoption of agroforestry systems. In this chapter I pose the following questions: What accounts for the difference between the three groups of farmers? Do they represent different subgroups within the Toukar population in terms of some identifiable attributes? I explored many possible differences such as economic, but found that the most important differences among the three groups had to do with wealth. The issue of wealth seemed to play an influential part.

Therefore, I searched for a correlation between the adoption of agroforestry techniques and wealth, which led me to raise the following key questions: Does the adoption of agroforestry systems foster wealth? Or does poverty inhibit agroforestry? Or is it that the already-rich farmers are more likely to adopt agroforestry? I was also interested in determining whether the traditional practice of agroforestry techniques leads to richness, or whether richness leads to the traditional practice of agroforestry techniques.

These questions and subsequent issues have great potential to shed light on farmers' perceptions and attitudes towards agroforestry systems. In order to measure wealth in this society, we must recognize that there is no one reliable indicator, such as gross income, that fully explains the differences in material

well-being. For this reason, I built a wealth index that is based on rural capacities, namely all natural resources available to farmers with respect to enhancement of living conditions. Wealth or poverty level has usually been measured using household incomes, but such a procedure may be misleading in the case of the Serer people who count their riches in the number of livestock rather than household items. The wealth index I developed is designed to measure the overall welfare of these people, grounded in part on their resource potential to offset food insecurity and to rebound unscathed from eventual agricultural threats. The wealth index provides some indications of the social stratification of the different groups of farmers in the community based on shared socioeconomic conditions and sets of inequalities and individual achievements.

I took into account essential indicators that farmers considered as wealth or likely socioeconomic activities that produce acquisition of tangible resources in this part of Senegal. Being a Toukarois myself has also influenced my selection of the following elements in the index: the quantity of livestock a farmer owns (especially cattle, sheep, goats, and pigs), as well as the number of draft animals (horses, donkeys); annual crop yields (mainly cereals, millet and sorghum production), sufficiency of annual harvest (to last the whole year); family size (usually extended family groups sharing a single household); farm size; chemical fertilizer (mainly the purchase and use of the product by individual farmer); and lastly, for women, the selection of cash-crop (peanut) cultivation.

I constructed the wealth index by first using a conversion factor for all the components, such as cows goats (by dividing 100 from the highest number of entry, i.e., x=100/62, or 1.6129 for cow). Then I multiplied every cow number reported by x, (for instance, a person with 7 cows will have the standardized number of 7 * 1.6129 or 11.2903). I repeated this procedure for every cow entry to form a "cow"-column. Second, I made another column to the right for cows-standardized, then I multiplied each entry by the conversion factor (1.6129) to form a complete column of cows-standardized. Once I converted all the elements of the wealth index to this standardized (100 scale) format, I applied the assigned weights of each component (from 1 to 5) (Table 3). Third, I created a formula like this: cows-standardized * cows weight + sheep & goats-standardized * sheep & goats weight + next item-standardized * next item weight + etc.) This computation gave me the full weighted wealth score, and I standardized that number to a 100-scale score by dividing by the total possible standardized-weights (addition of all the standardized-weights 500 + 400 + etc.), which resulted in the final wealth index score for all individuals, on a 0-100 scale (weighted values/total weights = wealth index score). Finally, to check my results, I created a row for a hypothetical farmer who scored highest on all wealth indicators (e.g., 62 cows, etc.), and that person's final wealth index score showed exactly 100, which proved that the formula worked.

I then derived the overall average number (mean) of all the participants from the wealth index scores, which equals 26.1 (signifying that the majority of the participants are not wealthy) and a standard deviation of 16.2 (showing that the data are spread out over a large range of values). I will first explain the

composition of the wealth index, followed by a thorough description of the index itself, including its connection to the adoption of agroforestry systems, and then finish with the measures and significance of the various components studied.

*Table 3: Weights and Standardized-weights for Wealth Index.*

| Elements | Cattle | Sheep Goats | Draft animal | Pigs | Crop yield | Enouh Harvst for year | Chem. fert | Women peanut | Farm size | Fmly size |
|---|---|---|---|---|---|---|---|---|---|---|
| Weights (1-5) | 5 | 4 | 4 | 1 | 4 | 3 | 1 | 2 | 5 | 4 |
| Stand-weights (x 100) | 500 | 400 | 400 | 100 | 400 | 300 | 100 | 200 | 500 | 400 |

The subdivision of livestock has engendered distinct types of animal assets with varying weighted values (from 1 to 5) for cattle, sheep, goats, and pigs. The different components were weighted following Table 3. For example, we assigned number (5) for cattle because it carries great weight in determining wealth in Toukar. Animal husbandry, especially the rearing of cattle, has been a sign of wealth in Serer societies for a long time. People with large herds of animals are still very influential in the society, and thus participate in the management of various communal activities in the village. For instance *siidee*, the term used for farmers with vast numbers of cattle, take part in the committee responsible to designate tossed-areas for several neighboring villages.

Also in this bracket, another fundamental criterion of significance is the ownership of draft animals (weight 4), usually horses, donkeys, or to some extent oxen. These docile working animals perform most of the agricultural tasks and provide transportation for the communities. Draft animals, especially horses, speed up the tillage operations, and thus contribute enormously to farming

yields, and bring extensive area of land in cultivation. Furthermore, in the short and unpredictable rainfall seasons, it is imperative to own draft animals. Most interviewed farmers confirmed that having draft animals as well as agricultural equipment such as seed drills and hoes is indispensable for a quick and proper plowing operation because farmers without these resources will resort to borrowing or renting from neighbors, with a huge detrimental impact on crop production and food security in general.

In addition to agricultural activities, farmers who possess horses and carts also operate them to carry clients to weekly markets in exchange for money. These carts are the rural people's equivalent of modern cars that the locals employ to travel to nearby cities and markets. In this context, there are five important weekly markets in the area: Niakhar at (8 km) on Mondays, Toukar on Wednesdays, Mbafaye (12 km) on Thursdays, Bambey (18 km) on Fridays, Patar (9 km) on Saturdays, and Diohine (5 km) on Sundays. These markets constitute significant economic activities in the lives of these communities, whereby agricultural produce and other local goods and services are sold based on supply and demand between participants on barter or money, the typical medium of exchange. So, farmers who own horses and carts also earn good money by transporting people to and from these crucial markets.

Crop yields (weight 4) is another key element in the wealth index, which shows whether farmers harvest enough to cover the whole year. In this regard, many farmers complain about the incapacity of present-day farming to feed families. A farmer from the hamlet of Sanghai stated: "Farming alone no longer delivers for the basic survival needs."

Another component of wealth is farm size (weight 5), with diminishing arable lands in the region ascribed to high population density. Farm size plays an important role in determining the wealth status of a farmer. Without enough lands farmers usually resort to *tayle* or pawning (items as collateral), which is an exceptionally unstable practice by the national domain law. The law basically forces owners to withdraw their lands within 4 years for fear of losing the field "being nationalized" to the borrower or the government (Burns, 1995). Besides land and cattle, family size (weight 4) or labor is another important asset to farming in Toukar. Farmers here still depend on the availability of labor, or human capital, to achieve greater agricultural productivity.

The affordability of chemical fertilizer (weight 1) is another critical measure of wealth. Many farmers in Toukar are organic peasants by default because they cannot afford fertilizers, and very few farmers use it consistently, so I assign this variable a lightweight. I then calculated the percentage of farmers who use fertilizer. Chemical fertilizer is a highly treasured commodity, especially in times of soil fertility depletion. It has been widely regarded as an instant yields booster, thus a potential driving force to achieve household food security. The lack of inorganic fertilizers has been one of the major constraints reported. Farmers are passionately dissatisfied with the government's unwillingness to provide needed subsidies such as chemical fertilizers, improved seeds, and pesticides. Many still recall the heyday of the 1960s when agricultural and affordable credits were widely available. One participant declared: "We get enough harvest only when we apply inorganic fertilizers, but when we lack them

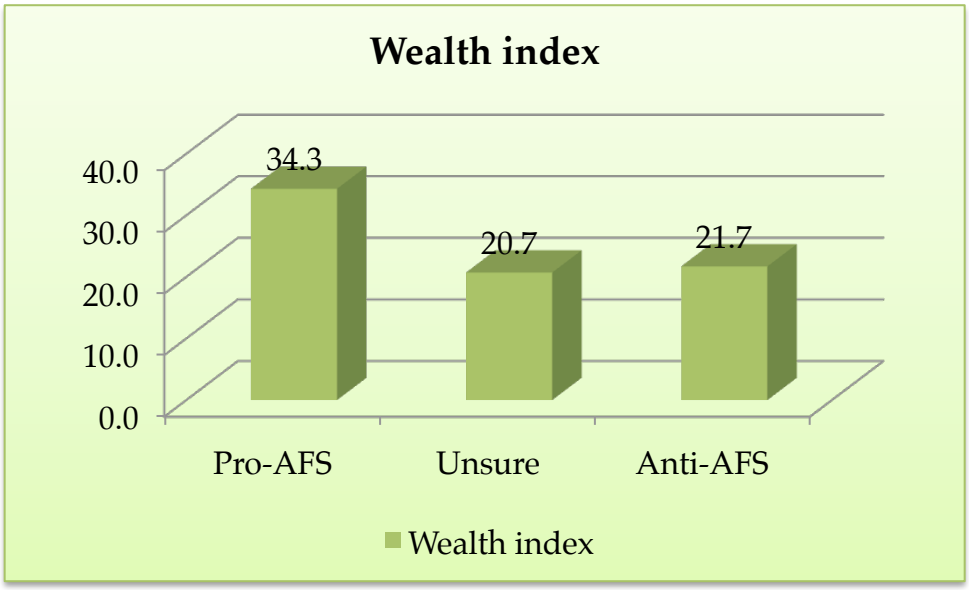
we face food insecurity." Today use of chemical fertilizer has risen to higher proportions, and only the cash-secure or rich farmers can afford it.

The women's peanut variable (weight 2) is equally worthy of attention, since I have observed that most women in the village grow peanuts to obtain cash to improve their household's condition. I have assigned this weight to improve women's position, and besides, most women grow peanut. I then calculated the percentage of women who grew peanut. Women use the cash to purchase healthy ingredients such as fish and vegetables to improve the quality of their meals or to help their husbands to supplement ordinary expenses. One woman puts it this way: "I grow peanut to produce cooking oil, *rakaal* (peanut paste), *ngogn* (animal hay), and peanut powder for cooking." Other women have expressed different arguments for growing peanut—in order to simply tackle their children's school needs or to pay for their own clothing.

The results emphatically confirm the importance of the wealth index as an indicator of farmers' willingness to adopt agroforestry systems. So far I have reported the components of the wealth index. Now I will focus on the index itself by asking whether the differences in wealth explain differences in adoption of agroforestry practices in the three groups. Unequivocally, the data demonstrates a direct relationship between the wealth index and adoption of agroforestry practices. As Figure 4 below confirms, supporters of agrogroforestry are largely wealthier than those in the other categories, and the figure represents the overall results of the average wealth index scores for each category of farmers with again the preponderance of the Pro-agrogroforestry group (34.3) followed by the Anti-

agrogroforestry (21.7) and the Unsure (20.7) groups, both in close proximity. The wealth index scores have a mean of 26.1 and a standard deviation of 16.2.

*Figure 4: Average of Wealth Index Scores*




The pattern is reasonably consistent with the reasoning behind the selection of the variables described above, and reveals which farmers are adopting agroforestry systems. Compilation of results also reveals strong correlations between wealth and the major indicators tested: cattle, sheep and goats, draft animals, use of chemical fertilizers, farm and family sizes, and crop yields. Pro-agroforestry farmers have overwhelmingly overshadowed the other categories, and firmly establish that the adoption of agroforestry systems does foster wealth, or that wealthy people adopt agroforestry systems. When small-holder farmers have access to virtually all the resources cited above, they start to rise through the echelons of the village's hierarchical system. They are considered by many as talented farmers (tantamount to having a "green thumb")

who can cultivate the land, and successfully manage the local natural resources at their disposal, as their ancestors have done for centuries.

The characteristics of agroforestry systems described in chapter IV highlighted *saas* trees in farms to provide fodder for livestock production, household fuel wood supply and increased crop yields. More importantly, farm trees generate income from the sale of wood products as well as the sale of high-value fruits such as *sob*, *baak*, and *sew*. Likewise, the practice of live fences helps to conserve farm topsoil or "A-Horizon" which has the highest concentration of organic matter and microorganisms essential to maintain farm soil fertility, and thus increase food crop yields and food security. The use of some technologies such as composting, residues management, and manure use helps to improve natural resource practices (Barrett, 1997).

In retrospect, traditional agroforestry systems had been the norm in the village of Toukar for centuries, and practicing agroforestry techniques made people relatively wealthy. Today the relatively wealthy farmers are largely choosing agroforestry systems. Historical narrative has shown that the Serer have long relied on an integrated farm-production system with proper management of the "Acacia parklands" in which emphasis is placed on a holistic system approach involving the welfare of all species in animal husbandry, on the preservation and improvement of soil fertility, and a steady seasonal food crop production of millet and sorghum (Lericollais, 1999; Pelissier, 1966). This has been the historic pattern for productive and sustainable agriculture in the region.

Equally important, most hamlets in the study are spread out within the three patterns of adoption. But Ndioudiouf, Ngoulangueme, and PinTok are

specifically more attuned to agroforestry practices. This characteristic makes a lot of sense since Ndioudiouf is Toukar's first settlement where the village founder "master of fire" lived and set the fire "*yaal naay*" that created the village (Becker, 1984; Galvan, 2004), whereas Ngoulangueme and PinTok, which used to be part of Ndioudiouf, have now expanded and formed their own distinct hamlets. Such an important factor posits that hamlet settlement patterns are also consistent with the village traditional agricultural farming systems, with Ndioudiouf still in the lead.

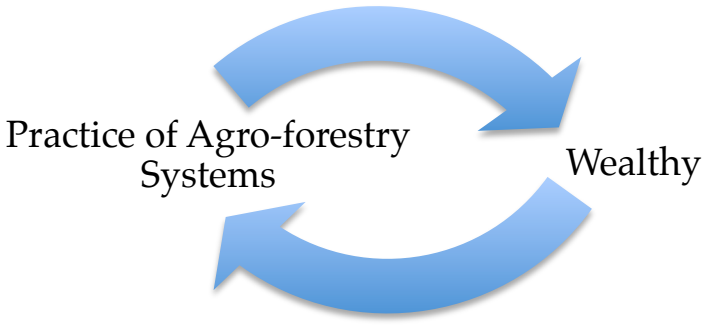
There is an inverse assertion to the first statement though, that shows poverty inhibits agroforestry systems, which is indisputable not just because it is the reverse of the first pattern of traditional agroforestry systems promoting relative wealth, but also because poor people tend to lack resources such as livestock, and therefore care less about fodder production. Moreover, they usually possess small parcels of land, and therefore tend to concentrate most of their energies on producing food for subsistence rather than on farm tree density and management. Somehow, these farmers have abandoned the traditional version of the Serer farming systems and established economy that sustained them for centuries.

However, the pattern also upholds the argument that, when farmers are already wealthy (by the village standard), they tend to adopt agroforestry systems not only because this is the historic pattern, but also many of their assets such as livestock are heavily dependent upon the healthy soil-tree-crops interactions to thrive. Large herds of cattle not only require fodder production from farm trees to survive the long, and harsh climatic months of the dry season,

but also the herd supplies large quantities of basic soil inputs such as animal droppings. In order to keep their wealth, already rich farmers need to ecologically sustain or manage the productivity of the agroecosystems in which they cohabit, which also requires having a good source of labor and an intensive knowledge of the *terroir*. Wealthy farmers usually display larger farm size as well as bigger family size, necessary to augment food crop production and secure enough available food for their larger family sizes. Further, these people make use of draft animals for farm activities as well as for transportation.

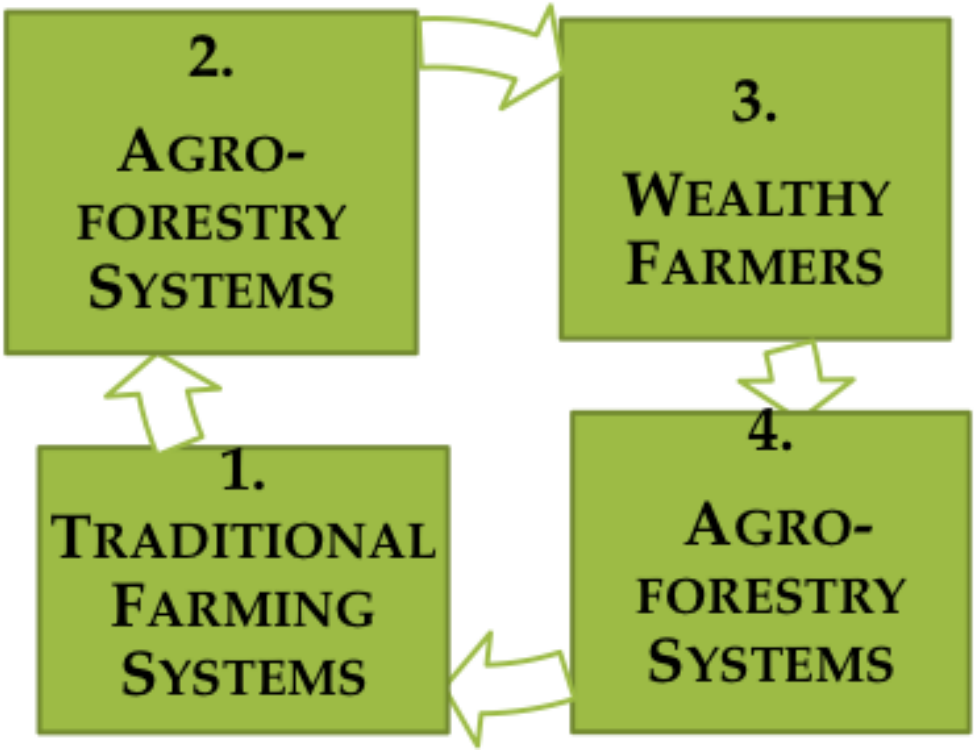
At first this pattern can look like a paradox, but an attentive scrutiny reveals, rather, a virtuous circle (Figure 5). The result of each event aims at adding to the beneficial effect of the next; the practice of agroforestry systems makes a farmer wealthy, and reciprocally an already wealthy individual is more likely to adopt agroforestry systems.

*Figure 5: Virtuous Circle 1*



We clearly see that historic farming systems required agrogroforestry, and that doing agroforestry conferred a relative wealth to adopters. We also notice that the relatively wealthy farmers are continuing to adopt agroforestry technologies, but this is not because they were first wealthy and then chose agroforestry practices. Rather, because they have maintained the most intact version of the Serer historic farming systems, they have become wealthy. Far from the "dilemma" posed at the start of the chapter, we find a relationship of reciprocity. Here, traditional farming practices initiates the recurrent cycle of events of what is now defined and confirmed as a virtuous circle (see Figure 6 below).

*Figure 6: Virtuous Circle 2*



A further study of the wealth index's variables reveals that practitioners of agrogroforestry possess the largest average number of cattle (13.0), whereas opponents of agrogroforestry have an average of 7.0, and the Unsure an average of 2.0. Table 4 below gives a comprehensive overview of the results, and shows how the component elements of the index sometimes support the way the whole index relates to adoption, but sometimes does not, as when the Unsure farmers score lower than the Anti-agroforestry farmers. This discrepancy in the numbers of cattle, sheep and goats, and pig stems from the unusually high number of cattle (61) recorded for one opponent, has considerably increased the value for the whole group.

*Table 4: The Average Numbers for Wealth Components*

| Wealth components | Pro-Agroforestry | Unsure | Anti-agroforestry | Units |
|---|---|---|---|---|
| Cattle | 13.0 | 2.0 | 7.0 | Average # |
| Sheep & goats | 33.0 | 7.8 | 15.0 | Avg. # |
| Pigs | 4.0 | 2.5 | 4.0 | Avg. # |
| Draft animals | 3.0 | 2.0 | 2.0 | Avg. # |
| Crop yields-millet | 1176.5 | 787 | 623 | Kilogram (kg) |
| Enough harvest for yr | 735.3 | 720 | 273 | Kg |
| Chemical fertilizer | 70.6 | 66.7 | 45.5 | Percentage (%) |
| Women/peanut | 100 | 80 | 33.3 | % |
| Farm size | 1.32 | 1.06 | 1.13 | Avg. # |
| Family size | 17.0 | 11.0 | 14.0 | Avg. # |

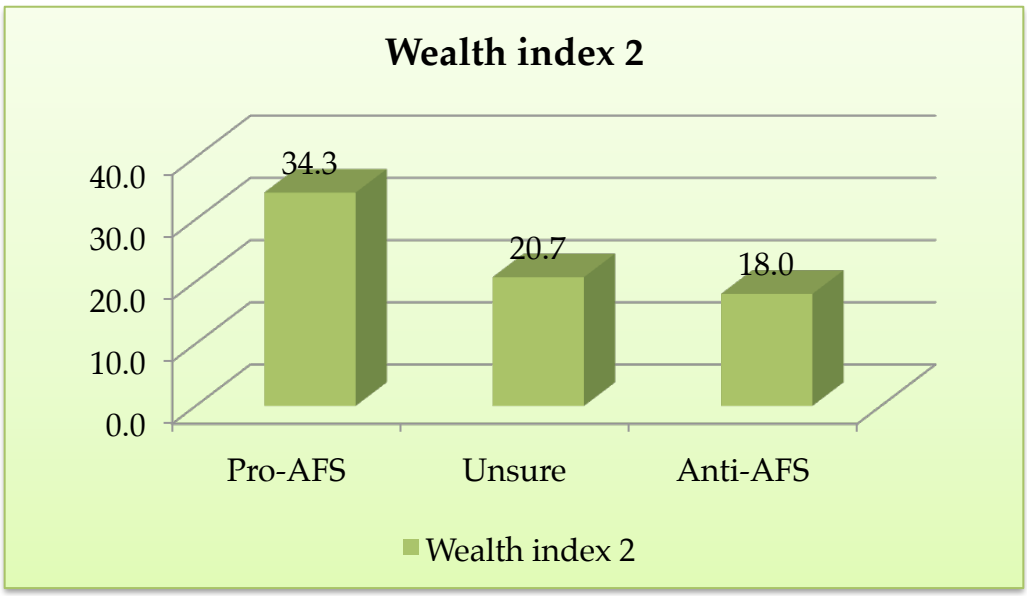
The same observation is also valid for farmers who have the greatest average number of sheep and goats, with the Pro- agroforestry farmers (33.0) versus (7.8), and (15.0), respectively, for the Unsure and the Anti-agroforestry groups. The uncommon data of this particular opponent of agroforestry has

dramatically influenced the data for the whole group. For instance, when I simply remove the data of this farmer, I obtain a completely different table and figure (see Table 5, and Figure 7 below) that follows the expected pattern of adoption, this time with the Unsure farmers outstripping the Anti-agroforestry farmers by an average of 2.0 to 1.4 for cattle. The Unsure group also shows a slightly greater average of 7.8 to 7.6 for sheep and goats, and 2 to 1.6 for draft animals, while the other data remain the same. The wealth index also shows different results with Pro-agroforestry farmers still in the lead (34.3), followed by Unsure farmers (20.7), and in last position, Anti-agroforestry farmers (18.0).

*Table 5: The Average for Wealth Components (without the farmer).*

| Wealth components | Pro-Agroforestry | Unsure | Anti-Agroforestry | Units |
|---|---|---|---|---|
| Cattle | 13.0 | 2.0 | 1.4 | Average (Avg.) |
| Sheep & goats | 33.0 | 7.8 | 7.6 | Avg. |
| Pigs | 4.0 | 2.5 | 4.0 | Avg. |
| Draft animals | 2.5 | 2.0 | 1.6 | Avg. |
| Crop yields-millet | 1176.5 | 787.0 | 623.0 | Kilogram (kg) |
| Enough Harvest for yr | 735.3 | 720.0 | 273.0 | Kg |
| Chem. Fertilzer | 70.6 | 66.7 | 45.5 | Percentage (%) |
| Women/peanut | 100.0 | 80.0 | 33.4 | % |
| Farm size | 1.30 | 1.10 | 1.10 | Avg. |
| Family size | 17.0 | 11.0 | 13.0 | Avg. |

*Figure 7: Wealth index 2 (without the opponent farmer):*




Animals are critical for soil replenishment. They provide organic manure and allow beneficiaries to participate in communal fallows activities. For instance, one interviewee confided that "5 cattle can properly fertilize one ha of land, when using the *toss jiid* method (rotational grazing)." Hence, the presence of large herds permits a farmer to manure a larger area, thereby maintaining the fertility of the millet fields. Table 5 also indicates that the Pro-agroforestry group exhibits the largest average number of draft animals with 3.0, whereas Anti-agroforestry and Unsure groups both receive the average of (2.0).

It is also important to clarify that a small number of Catholic participants (4.0) raise pigs for cash, which I believe is a valid wealth indicator that merits scrutiny. The data shows that Pro-agroforestry farmers and their opponents both lead the pack with an average of (4.0), followed by the Unsure category with an average of (2.5). This result is relative because most of the participants are Muslims who are forbidden to raise pigs, which may explain the disparities

between the groups. For instance, all women surveyed were Muslims, and that religious affiliation is obvious in the village. However, raising pig is a very lucrative business, and farmers can utilize the feces to manure crop fields, and pig owners may barter the excrements for goods or services.

Other important variables to measure the significance of the wealth index are the quantity of crop yields harvested, and whether peasants were able to grow enough cereals for the whole year. Table 5 once again illustrates the greatest average number of crop yields for the Pro-agroforestry group with 1176.5 kg, followed by the Unsure group (787 kg), and the Anti-agroforestry group with 623 kg. I observe similar outcomes for the average number of kilograms of grains sufficient for the year, with the Pro-agroforestry group still leading with 735.3 kg, followed by the Unsure group (720 kg), and further behind the anti-agroforestry category with only 273 kg. In both instances the supporters of agroforestry systems have fared much better than the rest, which reveals the variation and significance of these elements, knowing that most of the cereals produced in the village are mainly for consumption. As one farmer confirms, "We grow millet to ensure self-sufficiency in food, and when our granaries are full, we are happy and in good spirits."

A moderate number (18 of 43) from the entire population of interview participants indicate that their harvests suffice for only about eight months, and it is extremely difficult for them to survive the "hungry season." Some respondents (4 of 18) report selling their small ruminants to purchase millet and rice, or borrowing money or other assets from neighbors and relatives (2 of 18), or perhaps hock a field in pawn "*tayle*" to obtain cash to navigate through the

year (2 of 18). Sometimes, destitute farmers who lack resources to barter for food go hungry during these lean times.

In contrast, a number of farmers from the entire population (16 of 43) have affirmed their ability to harvest enough food to satisfy the yearly requirements. Fewer peasants (8 of 43) were simply not sure whether their harvests will last the year or not. This category of participants has mentioned different scenarios to justify their arguments. One has argued that it sometimes decisively depends on the number of persons in a household (her children go to school in the cities, and may opt to stay in the city during the rainy season), which not only increases the labor force that must be fed, but also augments productivity. This woman articulates that: "I used to be able to provide for the whole family when the boys were around, but now that they left, farming yields much less and is harder for me."

The data in Table 5 for chemical fertilizer, reveals that the Pro-agroforestry group has the largest number of persons (70.6%) among farmers who use inorganic fertilizers, followed by the Unsure category (66.7%) who satisfied the criteria, and the Anti-agroforestry group with the lowest number (44.5%). This pattern once again reaffirms that supporters and practitioners of agroforestry have more financial capital, and a comparative advantage over the other categories, which allows them to expand and prosper in agricultural endeavors. The pattern also confirms the direct relationship between wealth, the index, and adoption of agroforestry, since wealthy farmers who are supporters of agroforestry have the purchasing power for these expensive fertilizers in comparison to the other groups.

As mentioned earlier, family size as well as farm size is an important wealth indicator. The total average farm size surveyed is approximately 1.18 ha, but the biggest average farm sizes are found within the Pro-agroforestry group (1.32 ha), followed by Anti-agroforestry (1.13 ha) while the lowest average number is in the Unsure group (1.06 ha) (Table 5). The availability of land has become so scarce that farmers are cultivating marginal and degraded lands. The total average family size surveyed is 14 persons per family, and Pro-agroforestry farmers have once again established the largest average number of persons (17). Opponents of agroforestry exhibit an average of 14 persons, followed by the Unsure group with the smallest average number of persons per family (11). This pattern is consistent with the Serer's logic that a bigger family accompanies more land or vice versa. It confirms that Pro-agroforestry farmers have bigger families and larger holdings, and therefore retain more opportunities to excel in agricultural productivity.

The last segment of the wealth index discusses the results for women who are engaged in peanut cultivation. Among the ten women participants interviewed, seven grew peanut this year, and within the seven, the Pro-agroforestry women all grew peanut this year (100%), followed by the Unsure group (80%), and the last group, the Anti-agroforestry, with an average of (33.3%). Half of the women interviewed are in the Unsure group of farmers. It must be emphasized that women who cultivate peanut for cash in their parcel also practice intercropping with other plants to maintain and increase food productivity. One woman says: "I intercrop bissap, cowpea, and sorghum in my peanut field to multiply my chances of harvesting more, also hoping that one or

two crops will produce enough for the year if the rains diminish at the end of the season." Her statement confirms the different combination of household strategies women undertake in order to meet their family's livelihood needs. The results once again show that Pro-agroforestry women farmers are serious about growing peanut since it represents their only secure source of cash.

A thorough interpretation of the data clearly suggests that Pro-agroforestry farmers have amassed virtually all the socioeconomic and environmental benefits associated with the implementation of farmland use management practices. These farmers have also achieved their household welfare, enabling them to secure enough food output through soil conservation measures to contribute significantly to capital formation.

**Conclusion**

To sum up, this compilation of interview results discloses that Pro-agroforestry farmers tend to have larger families and bigger farm sizes, and do harvest enough crop yields for the year (Table 5). Anti-agroforestry farmers have the second biggest farm size. And most importantly, according to the wealth index discussed above (Figure 4), Anti-agroforestry farmers are the second wealthiest, behind Pro-agroforestry, but in close proximity with the Unsure group. However, when I remove the opponent who owns an unusually large number of livestock, the pattern is consistent with the other findings (Table 5 and Figure 7).

As a whole, participant farmers who are significantly wealthier than others in the community have invested more heavily in protecting trees in farms, maintaining live fencing and practicing *toss* to increase the ecological rewards.

They are definitely more aware of the potential benefits associated with natural resources restoration and strive to secure greater livelihood systems. Finally, indifferent farmers have the smallest family size, and are the poorest farmers among all categories. Therefore a marked relationship exists between people's wealth and the adoption of agroforestry systems: the more a farmer adopts agroforestry, the more that practice tells about that person's social status.

The data corroborates the finding and denotes that most farmers who embrace agroforestry are likely to be wealthy, and vice versa, in what appears as a virtuous circle. Due to the increased profitability in such indicators as availability of land for grazing (toss), large stands of trees to provide livestock fodder during dry season and the potential to enhance soil fertility from multipurpose trees, and a crucial supply of firewood, the wealth paradigm corroborates its direct relationship between index and the adoption of agroforestry. Pro-agroforestry or wealthy farmers have the opportunity to rely on market-based produce to meet some of their cash needs. Furthermore, all the natural resource factors mentioned above positively affect both the health and the reproduction of the cattle herds: Healthy animals give birth to healthy offspring, one of the most significant wealth indicators in Toukar (Table 3). As the data reveals, differences in wealth do explain a marked difference in adoption of agroforestry. The data reveals that wealth goes with traditionalism and support of agroforestry, while poverty goes with people who are uncertain or opposed to agrogroforestry. So, by examining factors that are associated with the wealth index, such as the promotion of trees in farms and improved-fallows,

policy can be shaped to respond to challenges of food production and efficient natural resources management among these important groups of producers.

# CHAPTER VI

## WOMEN AND DEFORESTATION

I started the chapter asking these core questions: Is there a relationship between gender and agroforestry adoption? What might that relationship be, based on empirical data, on what the literature says, or based on other sources? In this context, conventional wisdom maintains that because women need firewood to prepare household meals, they cut trees (Eckholm, 1975; RdS, 1993, cited by Ribot, 1999). So, one might think that women would probably not advocate for the practice and adaptability of agroforestry systems. However, I disagree, and in this chapter I will report women's accounts on this thorny issue, which are highly inconsistent with established beliefs. My qualitative research results (including participant observation, firsthand experiences, personal accounts, and open-ended interviews) not only challenge mainstream arguments about women's impact on deforestation, but also dispute the idea that women should be held accountable for the widespread clearance of woody perennials for fuel wood. As we saw in chapter II, rural women are instrumental in household welfare, assist greatly in agricultural activities, and are the ones responsible for collecting fuel wood.

When women were asked whether there is a shortage of firewood in their household or in the village, all of the female respondents (10 out of 10 total) gave an affirmative response. However, there were a few interesting twists in some of the

answers. Most women noted that they obtain firewood by cutting dead branches from desired trees, or by collecting dead or fallen branches from the ground throughout the farms, brush land, or distant remaining woodlands, which is an extremely laborious task. Women maintained that dead firewood collection, rather than having a serious and destructive impact on tree cover, can be a productive management strategy, and constitutes a natural pruning technique, quite beneficial to the tree. They absolutely discredit the mainstream argument that women are to be blamed for the rarity of woody perennials, or deforestation (Ribot, 1999). One woman professed that "although I have an acute shortage of firewood in my household, it is unthinkable to cut farm trees to meet this basic need because trees are truly useful. Without them there is no farming, and besides, one can find other alternatives to that."

In order for women to address the pressing demand for firewood, some of them (4 of 10) resort to new methods to replace firewood. They use millet stalks, and *ndef* (cattle dung) as a substitute for firewood, which diminishes the manure available as fertilizer on already denuded farmlands. This specific method may be disturbing because *ndef*, the only available manure to poor farmers, is removed from the field, and may exacerbate soil fertility depletion if another replenishment medium is not applied. As a matter of fact, most women (8 of 10) have more recently turned to *niakh* (millet chaff) to complement limited wood supplies. As one woman describes it: "Yes, there is a dearth of firewood, but we also capitalize on this new practice called "billi", which uses *niakh* with 2 to 3 pieces of wood, enough to cook breakfast and dinner." These are new tools available to women to relieve the pressure on firewood, tools which also help them to strengthen their claims about deforestation, that they are taking all necessary measures to reduce fuel wood consumption. The "billi" method is quite interesting, in

that it uses an abundant material that people had no use for, and which constituted a huge fire hazard. It is common to find big mounds of *niakh* piled up in people's front or backyards. The local procedure is also different from improved stove technologies available to women, but at a certain cost. So, overall women have produced innovative strategies to adapt to these dire fuel-wood conditions. They are now using less firewood to assume the cooking chore.

When asked to name the best native tree for firewood, they unanimously referred to the *ngojiil* tree, which has a durable fuel and provide lots of charcoal. A woman responded that: "*ngojiil* is the most preferred native tree for firewood because of the quality of its wood which burns very slowly, and does not release lots of smoke." Women's local expertise in fuel wood management strategy was phenomenal: They were able to distinguish species of trees that produce durable fuel, or have desirable slow burning process, or carry a disagreeable taste to food, and which ones repel insects. One of the women supporters of agroforestry validated the earlier statement by saying that: "A few dead branches of the *ngojiil* tree are enough to assure cooking for the day, and the burned wood is also an excellent charcoal that gives us additional fuel. This is the reason why I make sure *ngojiil* seedlings are not plowed over during the hoeing process." These women are saying that because of the fuel-efficiency, or economy properties of this species, they shun fetching fuel wood indiscriminately, but rather can rely on a small amount of dead branches of this species for quite some time. This information shows that most women are mindful against using a great deal of firewood, carefully managing available resources, and are making an effort to preserve some tree species on farms. Another woman asserted: "During the rainy

season, I prefer to stock up on *ngojiil* wood because that's when the shortage is more persistent, and a small quantity of this wood, can assure my cooking during this period; therefore we need to encourage the protection of this species."

Women had a lot to say when asked to discuss the reasons for the general scarcity of firewood in the village. Some women were quick to point fingers to woodcutters and bakers, who need tremendous amounts of wood to heat up their mud-brick ovens. As one woman noted: "There is shortage of firewood, especially *ngojiil*, in the village because of these woodcutters and charcoal-makers who 'illegally' cut trees for sale, and due to the rarity of the product, they raise the price too high, and poor people like me cannot afford it. Someone needs to do something about this." Another woman adheres to the same narrative: "We have a shortage in the village because of higher household needs to cook 3 meals per day, and dead wood has become extremely rare. Also the "diothie" is only organized once per year." The "diothie" is an organized seasonal permit by the Senegalese forest services that allows women to cut firewood in the bush at the onset of the rainy-season.

However, it was thought-provoking to listen to some of the women inculpate the forest services for coordinating these "cutting events" which in their view encourage deforestation while pretending to regulate the remaining woody shrubs. They contend that the government needs to engage in real reforestation programs, and get women involved in the process. One participant asserts that: "I think today peasants in general, and women in particular, are no longer considered by the authorities. They have done absolutely nothing for us

to improve our conditions." The women themselves insist that they are wrongfully accused of deforesting the area, while states have originally lacked adequate conservation and natural resource management policies for sustainable use of forest products, and have maintained unfair policies towards women (including gender inequalities in assets ownership). There is truth to their assertions, since women have long been exposed to gendered agricultural policies that marginalize them in numerous arenas: ownership and inheritance of land, forest exploitation, extension and training services. For instance, as a result of changed traditional matriarchal laws of the Serer people, inheritance of land now follows patriarchal state laws and regulations which deprive Serer women of land and other properties. Agricultural lands and cattle used to follow matrilineal inheritance, but after achieving independence, the state reformed its laws to copy the French colonial rule of law based on patriarchy (Dupire, 1975; Galvan, 1996; Lericollais, 1989; Pelissier, 1966). Moreover, the forest services exacerbated the injustice suffered by women when they forbid them to fetch firewood at certain time of the year, or to search for wild foods in *Gakhoy*, a "classified-forest," which is in reality the only remaining forested land in the area. Some women who live adjacent to the site think that they can do a better job of managing and conserving the woodland because their survival and that of their peers depends on this forest. So, in addition to wanting to restore firewood stocks in the village, some women have noted their closeness to nature as another reason to entrust the preservation of *Gakhoy* to them. They believe, as do many scholars (Shiva, 1988, cited by Ellis, 2000), that they can nurture the forest better than men because it is similar to their daily care for their family.

Another woman considers the lack of bois de village, and an increased price of wood established by woodcutters as the main sources of the village fuel-wood scarcity. The concept of a "bois de village" or woodlots has been raised many times, but questions remained as to whether these will be communal or individual woodlots. Hence, some women interviewees, two from the Unsure group, and two from the Pro-agroforestry (4 of 10), have mentioned the urgency to plant trees in farmlands as an avenue to alleviate the disappearance of these physical resources. Others (7 of 10) think of planting farm trees as a great idea, but are quick to point out that the last word belongs to the male decision-makers. Few women own plots, and most are assigned by male heads of household, in which they often grow cash crops for their own benefit, mainly to provide for additional household needs, medicines, and school supplies for the children. Another group (6 of 10) declares the lack of access to seeds or seedlings, or to cash or credit to acquire the trees, as the limiting factors in the fuel wood supply. Some women have offered several answers to this problem. For instance, a woman from the Unsure group concurred with the answer related to planting of trees in farms, but was also part of the group (6 of 10) who asserted the lack of seedlings as a critical handicap.

In comparison to the Unsure women's group (5 of 10) and opponents of agroforestry (3 of 10), Pro-agroforestry women (2 of 10) have considerably increased the availability of firewood, and are reaping the rewards of appropriately integrating trees and woody shrubs into their farming systems, as their forebears have successfully done for centuries. We learned from chapter II (Table 2) that Pro-agroforestry farmers have the greatest number of trees in

farms, which subsequently increase the fuel wood production in their fields. So, the two women supporters of agroforestry must have more firewood supply than the members of the other groups.

Studies done in East Africa have also shown that certain agroforestry innovations such as "improved fallows have the potential of being gender-neutral, scale-neutral soil fertility technologies adoptable by women as well as men, by the poor and food-secure as well as the food secure" (Gladwin et al., 2002, p. 117). Thus in addition to firewood, women can derive many profits from various beneficial trees such as *baak*, *sew*, *saas* and *sob* (see Appendix B). For instance, the production of *netetou* (fermented fruits of the *sew* tree), or *soumbala* in Bambara language, is a valued commodity, because it is used in many African dishes.

**Conclusion**

In sum, all women participants (10 out of 10) indicated that they do not cut live trees for fuel wood, and are adamantly opposed to felling trees for more arable lands. Even though the fuel wood crisis constitutes a huge challenge for women who need to properly manage available stands, and simultaneously tackle both economic and physical scarcities of this critical resource, women have shown, and continued to show, incredible coping mechanisms to mitigate this deficiency. They reiterate their proactive effort and willingness to deal with the issue in a sustainable manner, and insist that they are not to be blamed for the ongoing deforestation, because they are opposed to cutting down live trees by any means.

In fact, most women interviewed point to the uncontrolled woodcutters as the main culprits because of the highly lucrative business of fuel wood productivity. Additionally, women have reproached the authorities for lacking adequate, comprehensive, and fair policies in terms of natural resources conservation.

Even though half of the women participants are Unsure or indifferent (5 of 10) about agroforestry technologies, the majority of interview women (7 of 10) viewed trees in farms as a genuine option, with respect to fuel wood production. They repeatedly voiced their opinions against certain agricultural policies gendered in men's favor, as in their incapacity to plant or protect trees in fields they care for, without approval of the husbands. This data shows that there is a definite relationship between gender and agroforestry adoption, and that most women are willing to plant or protect trees in farms to curb the fuel wood shortage, but unfair gendered policies and reproduction tasks are weighing heavily on the balance.

Despite the complexity of the issue of firewood and deforestation, and despite the lack of compelling statistical data on my part, I believe my qualitative results underscore women's continual denial of deforestation by presenting their main arguments, which emphasize the removal of already-dead branches as opposed to live trees or limbs.

Generally speaking, Toukar's women believe that the time has come for nongovernmental organizations, policy makers and development practitioners to modify their policies and their assumptions toward women, if they are serious about improving the conditions of life in the impoverished world. They also

need to close the wide disparities between rural women and men, focus more on rural women-centered development strategies, and enable them to operate fully, since their cause concerns the whole family, which is to strive for raising people's standards of living, and achieve food security. Furthermore, national governments have a responsibility to include women in sustainable agroforestry projects that protect the environment, alleviate fuel wood scarcity, offer resilience in the face of adversity, and above all, empower women to grow more nutritious food, and earn more money, so that they can continue to provide greater care for themselves and their communities.

# CHAPTER VII

## AGROPASTORALISM

In my continual search for the underlying motives for adopting agroforestry systems, I consider it important to examine more closely the agropastoral systems carried out in the village. According to mainstream literature, agropastoralism is an essential component of agroforestry systems. So, I intend to determine whether the agropastoral system practiced in Toukar is part and parcel of the agroforestry systems, or whether there is a difference between the two systems. The agropastoral system is defined as the combination of crops and livestock in space and time, characteristic to this part of Africa, since the strategy of land-use is based largely on sedentary rain-fed agriculture. Because the agropastoral system is an integral component of agroforestry systems, supporters of agropastoralism should also be supporters of agroforestry.

To examine the relationship between agropastoral and agroforestry systems, I built an agropastoral index based on two key components of natural resources management strategies which farmers use to improve their livelihood: the number of livestock (cattle, sheep, goats, horses, donkeys, pigs, and chickens), and the patterns of animal feed which consist of the following: pastureland (access to *toss* areas); *rakaal* (peanut byproduct); *ripass* (cotton byproduct); *ngogn* (peanut hay)/fodder; sorghum/millet feed grains. *Rakaal* is a

peanut byproduct obtained from pressing the grains to produce oil. The oil is locally extracted using mechanical means, whereas *ripass* is a cotton byproduct sold in stores, fabricated to fatten up cattle and sheep intended for sale. Raising animals for various purposes (meat, milk, cash, manure, etc.) constitutes the principal activity of agropastoral systems. In addition to food cultivation, agropastoral farmers make their living raising livestock, and provide water and pastures for their herds, which can be extremely challenging in this semiarid environment.

The agropastoral index aims to determine the level of adherence on a scale of 1 to 100, and farmers with a score equal to or higher than 50 follow agropastoral practices more than individuals who score less than 50. I constructed the agropastoral index using the same approach, and formulas already applied to build the wealth index in chapter V. By assigning different weights (Table 6) to each component, I was able to calculate the weighted values, and produced a final score. I then derived the overall mean of all participants from the agropastoral index scores, which equals 54.1 with a standard deviation of 18.0 (showing that the data are spread out over a large range of values, and are not close to the mean). A mean of 54.1 illustrates that the average number of farmers tend to be agropastoralist.

*Table 6: Weights and Standardized-weights for APS Index.*

| Elements | Cattle | Sheep/ Goat | Draft Animals | Pigs | Pasture | Rakaal | Ngogn/hay | Millet Grains |
|---|---|---|---|---|---|---|---|---|
| Weights (1-5) | 5 | 4 | 4 | 2 | 5 | 3 | 4 | 2 |
| Stand-weights (x 100) | 500 | 400 | 400 | 200 | 500 | 300 | 400 | 200 |

The agropastoral components are all important factors, which allow sedentary small-scale farmers to conserve animals close by. These factors tell us about the hurdles farmers must overcome to keep a healthy and productive herd. Farming in Toukar concurrently involves growing crops and raising livestock, which the Serer people have so well integrated for generations. As mentioned in the wealth chapter, Serer farmers are typically fervent millet cultivators, and attach a similar passion to animal husbandry, namely, cattle rearing. The number of livestock is an important determinant to agropastoral systems, since a large herd entails carefully managed practices to guarantee its long-term productivity. In fact, there are several essential socioeconomic and cultural factors associated with the practice of herding.

First of all, it plays an immense role in savings and capital accumulation. The vast majority of farmers (40 of 43) consider animal husbandry as a form of savings (safeguard against emergencies). One farmer says that "animals are our bank accounts; whenever we are faced with an emergency, we sell a small ruminant to solve that problem."

Second, livestock herding is so intertwined in the Serer day-to-day activities that it plays another role of prestige, or an element of social

differentiation, especially with regard to cattle and horses. People with many cows and horses are usually ascribed the title of *sidee*, which is a higher social rank that enables them to take part in decision-making groups that determine land use and allocation.

Third, livestock plays a significant role in many familial events such as bride prices, funerals, sacrifices, and rituals. In a Serer wedding, the groom is required to pay a hefty price, or offer cattle to the bride's parents, before she can join her new family. Animals are always slaughtered during funerals or rituals. Moreover, given the high percentage of Muslims in Senegal (90%), who are required under Islam to slaughter a sheep for the yearly celebration of Tabaski, it is a common and lucrative business to fatten up sheep for a period of 2 to 3 months to sell at this highly celebrated event.

In addition to these essential agropastoral components, livestock feed plays another crucial function, in the life of an agropastoralist. Especially in times of harsh climatic conditions (recurrent drought) and unpredictable rainfalls, peasants face the extremely difficult task of supplying grazing opportunities as well as water to the animals in dry seasons. Such work requires relatively elaborate resource management initiatives to mitigate perplexing environmental circumstances. The availability of *toss* or fallows (directly associated with the reliability of arable land) is not only a paramount factor in the survival of the herd, but plays an important role in the pattern of adoption of agropastoral systems. Basically, the more land a farmer has, the more that farmer can practice *toss*, and thus ensures access to pastureland. Hence, farmers with means can tap into different amounts of biodiversity such as farm trees for fodder production

(cut-and-carry), pastureland, mix-cropping with peanut for both cash and hay (*ngogn*), and a multitude of local products, like *rakaal* (peanut byproduct) and *soxon* (millet byproduct), that contribute to the adaptability and sustainability of the system. For instance, in order to stock up sufficient amounts of *rakaal* and *ngogn* (peanut hay) for the year, a farmer needs to allocate a considerable amount of land (approximately 2 to 3 hectares) to peanuts, as confirmed by this farmer's statement: "I have been wanting to buy a horse for a while, to replace my old donkey, but I do not have enough land in which to grow the crop to feed the horse, and cannot afford to buy *ngogn* all the time."

Once again, farmers with large herds (especially cattle and sheep) need access to suitable pastureland (or *toss* areas) to provide for the animals. Goats are less demanding, and more adapted to the harsh environment, and do not necessitate a large amount of feed to survive. They are frequently left to fend for themselves, without any additional feed supplements. The horse, on the other hand, requires lots of attention and a considerable amount of feed (especially, *ngogn* and millet/sorghum grains) to befit the laborious tasks of tillage, sowing, weeding, and harvesting the fields. The horse is also used to pull carts to transport goods and people to weekly markets, while the donkey is more flexible in terms of feed, and maintenance. They are cared for only during the rainy season, to perform donkey tasks in addition to agricultural chores, such as fetching water, transporting fuelwood, and the like. Only during this time can donkeys be given some additional hay, but the bulk of the peanut hay is reserved for horses, and to some extent for cattle and sheep when the time comes to fatten them for sale.

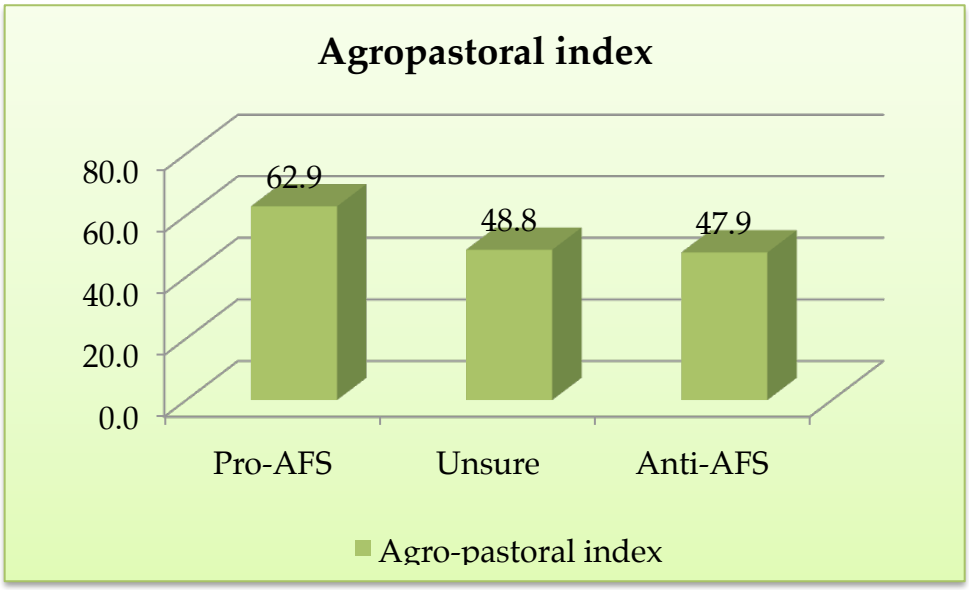
Many Serer people enable animals to graze on agricultural lands after the harvest times, a practice which not only fertilizes the land but also helps restore the ecosystem with intact grass root systems holding the soils in place. Furthermore, the practice of *toss* associated with the rearing of large herds of cattle assists in the restoration of grassland ecosystems (holistic management and planned grazing) since the grazing of cattle does not entirely uproot the grasses (Savory, 2013).

Another important agropastoral indicator is the availability of fodder in farm trees. Farmers rely on the acacia parklands (*Acacia albida*), and a few other trees (i.e., *ngaan*) to maintain large herds of animals for most of the year. When farmlands are completely grazed, farmers turn to the *saas* trees (through lopping and pollarding) for fodder production. The tree has a reverse phenology, which means it bears dense foliage and nutritious pods during the dry season, supplying an excellent feed for animals (Baumer, 1990).

The pattern is fairly consistent with the reasoning behind the selection of the indicators described above, and tells us something about the kind of people who can adopt agropastoral systems. So far I have reported the components of the agropastoral index, and because of the similarity of the means used to measure agroforestry adoption such as livestock number and farm trees, we note a direct relationship between agropastoral and adoption of agroforestry systems. I will now present the index scores to further demonstrate the correlation between the two, and point out the people who adopt agropastoralism, and why they do so, and why not. Figure 8 below shows a glimpse of the average for each category of the agropastoral index scores, with the highest for the supporters of

agroforestry (62.9, and a std. 19.8), followed by the Unsure group (48.8, and a std. 13.2), and the opponents of agroforestry (47.9, and a std. 18.5). This data supports the argument that the higher the average number on the agropastoral index, the more likely the group is an agropastoralist. It establishes that the supporters of agroforestry are the most agropastoral farmers, followed by people who are uncertain about it, and last farmers who are opposed to agroforestry systems (Figure 8).

*Figure 8: Average of Agropastoral Index Scores*




The table below shows that the Pro-agroforestry category includes the highest percentage of people (60%) who score more than 50 in the agropastoralism scale, followed by the Unsure groups with 30% of people, and the anti-agroforestry group with the lowest percentage of people at 10% (2 of 20) (Table 7). This information tells us that there are more supporters of agroforestry who still adopt the vestiges of the Serer's model of agropastoralism, strictly based on the important components described earlier.

*Table 7: Number of People: Scores, Mean and Standard deviation*

| | Pro-Agroforestry | Unsure | Anti-Agroforestry |
|---|---|---|---|
| # Persons with > 50 scores | 12 | 6 | 2 |
| Average (mean) | 62.9 | 48.8 | 47.9 |
| Standard deviation | 19.8 | 13.2 | 18.5 |

These high scores for the supporters of agroforestry emphasize the numerous resource capacities (pastureland, fodder, peanut hay, and other livestock feed) accessible to farmers who are wholeheartedly engaged in traditional agroforestry techniques to improve their immediate environment, and benefit greatly from such efforts. It is further evidence that practitioners of agroforestry farmers are enthusiastic agropastoralists, which makes sense since the agropastoral system is an integral component of agroforestry systems.

One Pro-agropastoralist/agroforester corroborates this by saying: " I practice *toss*, but also I absolutely do not collect millet stalks after the harvest, in order to provide additional feed for my livestock." Farmers like this one seem to understand and appreciate the agroecosystem in which they interact, and tend to harness its full potential in order to increase crop production through diversification, improving diets and income, thus promoting food security in a sustainable manner. For instance, these particular farmers pollard *saas* trees in such a way that they remain healthy and productive over time because they know that the survival of their livestock depends upon farm trees. These complex efforts explain how these peasants are able to conserve the natural resource base, and simultaneously manage large sedentary herds of cattle and a permanent rain-fed agriculture. Their system ensures a symbiotic relationship

among traditionalist farmers or supporters of agroforestry, livestock, and farm trees. Farmers secure meat, milk and soil fertility from the livestock, and essential tree-products (firewood, construction materials), while the trees provide fodder, and receive manure from the animals as well as protection from farmers.

Given the inextricable relationship between animals and farm trees, the dwindling of tree density and the disappearance of *toss* directly affects livestock production, which explains in part the frequency of transhumance (the seasonal movement of the herd towards distant greener pastures). In the traditional Serer' view, farming would not have been possible without these complementary parts. The relationship between agropastoralism and agroforestry systems is undeniable, especially when we examine the patterns of adoption of supporters for, opponents to, or those who are unsure about agroforestry practices such as planting and protecting trees, a greater average number of *saas* trees, *toss*, and so on. It is clear that the more one plants and protects trees in farmlands, or has more access to *toss* for both grazing livestock and additional organic matter, the more easily one can start to put into practice agropastoral systems and strengthen the concept that Pro-agropastoral farmers are truly Pro-agroforesters.

In contrast, both the Unsure and opponents of agroforestry are left out from these ecological practices because they lack adequate resources such as farm trees, cattle, or land, and thus are less equipped to fully adopt agropastoral systems. Their lack of access is due to the fact that they have abandoned the historic patterns for good farming that their ancestors successfully used for centuries. These groups of farmers, especially the Anti-agroforesters, have an

increased vulnerability to environmental risks, and are less likely to recover from major agricultural disturbances such as drought. Abandonment of these traditional practices greatly affects their livelihood, and complicates the challenge to secure food for their household, and may exacerbate ecosystem degradation if they continue to refuse propitious change. The quality, diversity, and function of agropastoral techniques underpin farmers' overall wellbeing.

The results below corroborate the importance of the agropastoral index as an indicator of agroforestry adoption. They overwhelmingly confirm that Pro-agroforestry farmers are the most supportive of agropastoral techniques. These farmers register the largest number of cattle, sheep and goats, horses and donkeys, as well as a great deal of agropastoral components, except for *ngogn*/hay, and millet/sorghum grains. These results are actually not far apart from the other results (Table 8).

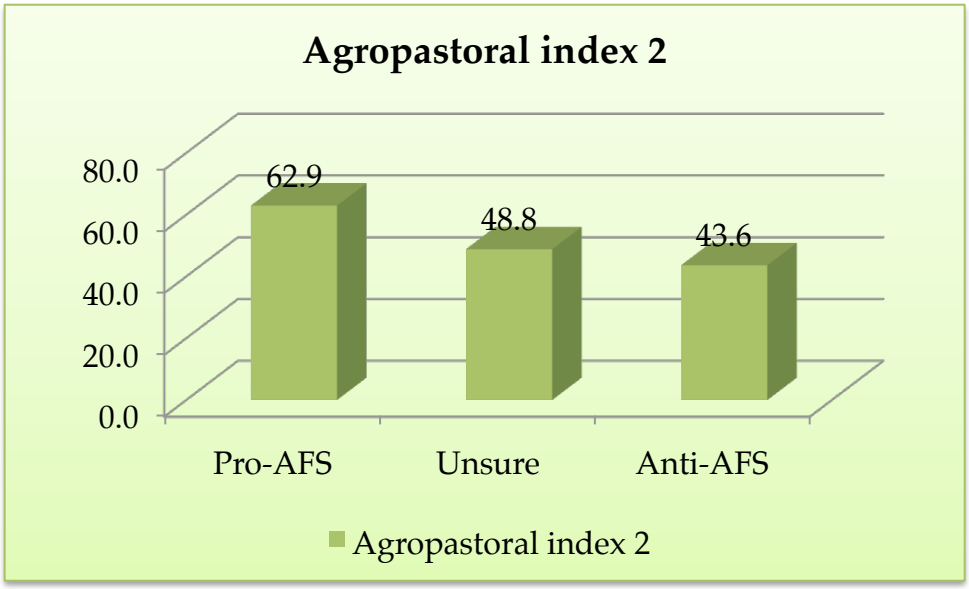
*Table 8: The Average Numbers for APS components*

| APS components | Pro-Agroforestry | Unsure | Anti-Agroforestry | Units |
|---|---|---|---|---|
| Cattle | 13.0 | 2.0 | 7.0 | Average (avg.) |
| Sheep & goats | 33.0 | 7.8 | 15.0 | Avg. |
| Pigs | 4.0 | 2.5 | 4.0 | Avg. |
| Draft animals | 3.0 | 2.0 | 2.0 | Avg. |
| Chicken | 17.0 | 7.0 | 9.0 | Avg. |
| Pastureland | 70.6 | 33.3 | 18.2 | (%) |
| Rakaal/ripass | 41.2 | 13.3 | 9.1 | (%) |
| Ngogn/hay | 82.3 | 100 | 81.8 | (%) |
| Millet/sorghum grains | 88.2 | 73.3 | 100 | (%) |

The data clearly shows that supporters of agroforestry have the highest scores for pastureland, one of the most important components of the agropastoral index along with cattle (70.6), followed by the Unsure farmers (33.3), and finally the opponents of agroforestry (18.2). The wide gap in the data for *rakaal/ripass* illustrates the importance of this component. Although *rakaal* is a peanut byproduct, *ripass* is not, and can be purchased only at the local store, or in cities. The facts suggest that the traditionalists and wealthiest who are supporters of agroforestry can afford *rakaal* (41.2%), followed by the Unsure group with (13.3%), and the Anti-agroforestry group of individuals with the lowest percentage (9.1%).

But the data also shows the opponents of agroforestry with more animals than the Unsure farmers, mainly because of the one unique opponent of agroforestry who has an unusually high number of livestock (61 cattle, 89 sheep and goats) which increased their values compared to the Unsure group. In fact, as in the wealth hypothesis, when I remove this particular farmer's facts, I have completely different data for both the agropastoral index and the average numbers for the components. This scenario confirms the pattern of adoption we have seen all along (see Figure 9 and Table 9 below).

*Figure 9: Agropastoral Index 2 without the anti-agroforestry farmer*




So, when this exceptional farmer's data are removed from the population, the table still shows the supporters of agroforestry outpacing the other categories, in the most important components, followed by the Unsure, and at the bottom, opponents of agroforestry (Table 9).

*Table 9: The Average Numbers for APS Components without the farmer*

| APS components | Pro-Agroforestry | Unsure | Anti-Agroforestry | Units |
|---|---|---|---|---|
| Cattle | 13.0 | 2.0 | 1.4 | Average (avg.) |
| Sheep & goats | 33 | 7.8 | 7.6 | Avg. |
| Pigs | 4.0 | 2.5 | 4.0 | Avg. |
| Draft animals | 3.0 | 2.0 | 1.6 | Avg. |
| Chicken | 17.0 | 7.0 | 5.8 | Avg. |
| Pastureland | 70.59 | 33.33 | 18.18 | (%) |
| Rakaal/ripass | 41.18 | 13.33 | 9.1 | (%) |
| Ngogn/hay | 82.35 | 100 | 81.81 | (%) |
| Millet/sorghum grains | 88.23 | 73.33 | 100 | (%) |

**Conclusion**

In conclusion, the data supports my original hypothesis, and denotes that farmers who adopt agropastoral practices also embrace agroforestry systems as well. The data clearly demonstrates that practitioners of agropastoralism also support agroforestry. It also shows the expected correlation between the two, and once again confirms the findings of the literature that defines agropastoral as a subsystem, or an integral component of agroforestry systems. However, the mainstream literature vilifies livestock as a precursor of desertification, and advocates for the removal of livestock from the ecosystems (grasslands) for rehabilitation purposes, while the Serer people regard livestock herding, or planned grazing, as an integral part of a holistic management system. Traditional agropastoral systems offer increased availability of land for grazing (*toss*) and fallows, and increased tree density to provide fodder for livestock during the dry season. Such systems have the potential to enhance soil fertility from multipurpose trees and animal droppings. Today this benefit is more than significant, since the decline in soil fertility has coincided with the transhumance of the herd outside of the *terroir* and the disappearance of fallows, as well as the tremendous decrease of *saas* tree density. This situation negatively impacts crop yields and food security. In the past, prior to commodification, the elaborate and efficient system of land use and soil conservation through *toss*, pastureland, live-fences, and intercropping (traditional agroforestry systems) ensured soil fertility, and enabled the Serer to arrive at one of the highest population densities in the Sahel (Galvan, 2004; Lericollais, 1999; Pelissier, 1966). We must revisit, or recover this indigenous knowledge and heritage to promote agroforestry

techniques that clearly can improve agricultural conditions and livelihood, alleviate the rural exodus, and above all, improve the quality of life in the village.

# CHAPTER VIII

## ECONOMIES OF SUBSISTENCE VS. ECONOMIES OF COMMODIFICATION

In this chapter I will explore respondents' devotion to traditional survival strategies (or economy of subsistence), as opposed to economies of commodification based on quasi-modern management practices (selling commodities for cash). I will also examine whether a correlation exists between the pattern of adoption for agroforestry techniques and both economies, which led me to ask the following key question: Are farmers who adopt agroforestry systems traditional or commodified?

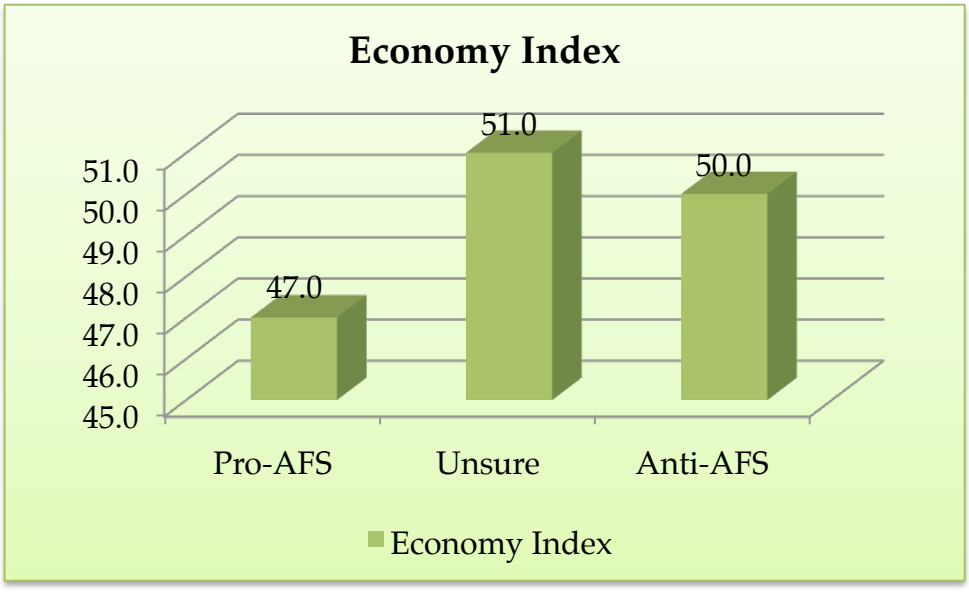
In order to fully examine the level of each subgroup's economic practices, I built an economy index to observe whether farmers still remain closely attached to their traditional way of life, and to determine which group consumes its farm products rather than sell them. Moreover, the index may shed light on whether Toukar's peasants are shifting towards modern systems of production by switching to inorganic fertilizers, or by interacting, or exchanging more frequently with city dwellers, thus bringing modern technologies into their lives.

I then developed the index based on the same criteria applied to the other indexes, except here I assigned numbers between 1 to 100 depending on the importance of the component and subcomponents in the community, which are the following: age, education level, diet change, fertilizer use, sale of harvest, food consumption, and economic activity. For instance, for the variable of economic activity: Farming is assigned the number (50) since all participants are

farmers, livestock sale (25), and trading or "petit commerce" (75). As for education, if a person has been to school, I ask for the level or years of attendance and assign it a number (from 1 through 13). By using Excel formulas like this one (e.g., 6 * (100/13)+25 = 71), in which 6 is the years of school, 13 the total school years available to the participants, and 25 is a number given to all participants, I was able to construct the education level scores. I followed the same procedure to complete the rest of the index's indicators.

Subsequently, I derived the overall average number (mean) of all the participants from the Economy index scores, which equal to 48.9 with a standard deviation of 5.8 (showing that the data tend to be, clustered closely around the mean). The mean demonstrates that the overall participants still slightly cling to subsistence economies despite the rapid modern pressures affecting them (Figure 10).

*Figure 10: Average of Economy Index Scores for Subgroups*



Before delving further into the index itself, I closely explored each component to highlight its role in the pattern of adoption. First, I was interested in finding out whether age, or level of education, was decisive in farmers' penchant towards modernism. The age indicator informs about social generations, or cohorts of people who were born in the same range and share similar cultural experiences. These different categories of people, based on age and level of education, may provide clues to the transitional period from a "traditional" to a "pre modern" society or vice versa, or simply identify individuals who resist the evolutionary transition to an urban, or more developed society. As for the education variable, the body of knowledge or curriculum offered at the schools in Toukar (primary and secondary education) conflict vastly with the realities of the community, and more strikingly, the teachings are done in French, the language of the colonizer. This type of education gives us a sense of the skills and habits transferred from one generation of students to the next. At an early age, children are exposed to the teachings of the outside civilization that may later have a changing effect on the way they think, feel, or act.

Second, I was intrigued by the proliferation of local stores selling large quantities of bags of rice, given that the cultivation of rice has long vanished from the farming systems. I then started to suspect a probable diet change in Serer households. Plus, unusual foreign products, including rice, fish, and vegetables were invading the local market.

Lastly, I looked into the growing micro businesses or "petit-commerce," and the kinds of people involved in such enterprises, in the village. I believe that

these indicators are pivotal in building the Economy index, and give us a clear understanding of the types of food economies the three different groups of farmers are confronted with. These indicators also pinpoint the sorts of foodstuff coming into Toukar.

Figure 10 above illustrates the three groups' attitudes about agroforestry, and represents an overview of the averages of the Economy index scores for the Pro-agroforestry, the Unsure, and the Anti-agroforestry farmers. The basic principle is that, on a scale of 1 to 100 (1 being the most subsistence or rural-oriented farmers, while 100 represents the most commodified modern or new urban farmers), a farmer who scores higher than the mean (48.9) is closer to a modern lifestyle than the lower scored individuals.

The figure shows that supporters of agroforestry (47.0) are slightly more likely to utilize traditional economies to improve their livelihood, followed by the opponents of agroforestry (50.0); closely behind are the Unsure farmers (51.0). The difference between these last two groups is relatively insignificant. It moderately explains that both the indifferent and opponents of agroforestry seek more modern ways or economic practices to meet their livelihood needs.

However, by examining more closely the different components (see Table 10 below), we distinguish a clear correlation between the level of education and farmers who maintain traditional farming practices. The latter, who are supporters of agroforestry, are the least educated, followed by the Unsure group and the opponents of agroforestry. The index sometimes supports the pattern of adoption, but sometimes does not, especially with the age component, and to a

lesser degree with food consumption and economic activities. In fact, the latter does not show much of a discrepancy because the values are almost identical.

*Table 10: Averages for Components of Economy Index*

| SubGroup of Farmers | Age | Edu. | Diet change | Sell harvest | Chem. Fert | Food consumed | Econ. Activity |
|---|---|---|---|---|---|---|---|
| Pro-AFS (17/43) | 54 | 32.8 | 57.35 | 58.23 | 42.35 | 53.6 | 50 |
| Unsure (15/43) | 44 | 41 | 71.66 | 61.67 | 40 | 52.91 | 52.5 |
| Anti-AFS (11/43) | 47 | 44.9 | 70.45 | 68.18 | 27.27 | 52.83 | 51.1 |

In addition, farmers, who are unsure about or opposed to agroforestry techniques, have the highest education level, and practice economies of commodity. These farmers sell most of their harvest rather than consume it, with averages of (68.18) and (61.67) respectively, for uncertain about, and opponents of agroforestry, and (58.23) for practitioners of agroforestry. They are also more likely to consume differently as opposed to the older and less educated supporters of agroforestry, due in part to their close interactions, dealing with, or integration with the externally oriented commodified economy.

Although the data reveal a significant difference among these people with respect to dietary practices, the different categories of farmers (the Pro-, the Unsure, or the Anti-agroforesters) have experienced an unprecedented diet change. However, supporters of agroforestry have shown the least diet change with an average of (57.35), followed by the opponents of agroforestry (70.45), and the Unsure group (71.66), which are virtually tied for second place. The consumption of rice (*maalo* in Serer language) has skyrocketed in recent decades. Not only interview participants in the entire population (40 of 43) have

overwhelmingly indicated a moderate change, introducing rice into their three daily meals, but also a sizeable group, mostly supporters of agroforestry (14 of 43), have declared that they have, for the most part, preserved their traditional diet made of millet products (*sadje*/couscous for breakfast and dinner), or *togn*, a millet-based food for the midday meal. The Serer of Toukar, have always consumed millet, or its derivatives, in all three meals: breakfast with *sadje fa a niaw* (couscous with cowpeas), lunch with *togn fa njuwaax* (thick millet-porridge served with sour milk), and dinner, which varies with *sadje fa ba'see* and *fosis* (couscous with peanut sauce, wild herbs, cowpeas and fresh cow milk). Often, leftover dinner is saved for breakfast, or a new sauce is cooked in the morning, over the *sadje*.

Nonetheless in recent years, *maalo* for lunch has increasingly begun to replace *togn* in Toukar, due in part to the erratic weather patterns, soils fertility depletion, and densely populated area, all impacting cereals production. These aggregate of factors has largely undermined farmers' ability to provide adequate food crops for the whole year (chapter V), which propels them to buy or barter rice as an alternative. They now take on additional occupations, like trading or "petit commerce" (5 of 43), tailor (1 of 43), mason (1 of 43), and city-migrant (1 of 43), as a means to enhance their livelihood. A closer look at this agrarian community shows scanty crop yields, leaving some peasants better off than others. This insufficiency has now constrained farmers to seek other solutions to survive. The amount of food consumed today no longer depends only on the millet and sorghum crops grown, but also on the amount of cereals bought (rice),

or bartered as well as on migrants' revenues (remittances), and different other available strategies that generate money.

This new rice adoption may as well stem from an overture to modernism in certain households. Famers can fulfill this need by either selling animals to purchase rice, or remittances from seasonal migration—a dynamic and complex issue—occurring mainly during the dry season, as a result of people's idleness, but also the ineffectiveness of peanut cultivation to provide the cash needed. Rural people, especially the young, migrate to the cities for search of better opportunities to supply for their poverty-stricken families. However, some migrants return to the village to farm in the rainy season, while others without a parcel of land tend to stay indefinitely in the cities, and come back only occasionally to visit during religious or familial ceremonies.

The Serer people have long resisted the introduction of rice into their household, even though the cereal had reached wider proportions throughout the country, solely because they relied on one of the most effective historic farming techniques to produce and maintain food self-sufficiency. It is important to mention the current growing dependency of Senegal on imported food crops. For instance, 70% of cereal imports is allocated to rice (Stads & Sene, 2011). Senegalese peasantry had long been encouraged by the French colonials to eat imported rice, primarily from Indochina in their successful campaign to establish and intensify peanut cultivation in Senegal (Franke & Chasin, 1980). Thus, imported foods such as rice and wheat have replaced traditionally grown staple grains (*fonio*, *macc*), and Senegal has remained the second-largest African net importer of rice after Nigeria, and the 10$^{th}$ in the world (Addamah, 2012).

When farmers were asked to explain the reasons for some of the diet changes, one woman replied: "The change does not actually depend on us, it is periodically caused by the lack of foodstuffs during the rainy season, which is due in part to the impracticality of defective roads that hinder accessibility of certain goods in Toukar such as fish and vegetables." Another participant confirmed what I discussed earlier, by declaring that: "Farming no longer feeds us for the entire year." In fact, many farmers (25 of 43) concur that food is plentiful in the start of the dry season (after harvests), but scarce during the rainy season when granaries are habitually empty. These trends elucidate how rice has slowly become such a dominant staple in Serer 's household economies.

As mentioned in preceding chapters, another element of capital importance is farmers' attitudes towards the use of chemical fertilizers as a means to revive exhausted soils and increase crop yields. Given that inorganic fertilizer is such an expensive commodity, barely affordable by most farmers, Table 10 corroborates what was already highlighted in the Wealth index (see chapter V, Figure 4), that the wealthiest farmers, the traditionalists, or supporters of agroforestry, tend to use chemical fertilizer the most, with an average of (42.5), followed by the Unsure group (40), and the opponents of agroforestry with the lowest average of (27.27). In addition to using organic nutrients (manure and natural residues) in their fields, practitioners of agroforestry also highly regard chemical fertilizer as a valuable approach to a quick bump of crop yields. Earlier in the discussion, we saw that supporters of agroforestry were more closely associated with the traditional subsistence economy, but now we discover that they actually use more chemical fertilizer than people who are uncertain about,

or opposed to, agroforestry techniques. Because they are wealthier, they can afford it. This pattern is diametrically inconsistent with the development paradigm which holds that: "Modern equals rich, and Traditional equals poor," whereas here traditional is equivalent to rich, and modern is poor. These farmers are mixing "modern" available techniques (i.e., chemical fertilizer) along with "traditional" practices (i.e., polyculture) to reap the benefits from both models of development.

However, an underlying explanation for the low score of the opponents of agroforestry (27.27) stems from their level of poverty in particular, and their unenthusiastic behavior for historic farming systems in general, coupled with an increasing inclination or openness toward modernity. This attitude can also derive from their high education level, which puts them in a lead to adopt western lifestyles and economies (interactions with city-dwellers, or the outside world, consumption of rice, etc.) and forgo traditional belief systems and modes of rural productions. Astonishingly, farmers who in the recent past kept their livestock herd intact rather than butcher it for food are beginning to consume more meat. As a matter of fact, the data reveals that 30 participants out of 43 (with 8/17 for Pro, 12/15 for Unsure, and 10/11 for opponents of agroforestry) have admitted eating meat more often now. It is historical as well to highlight that rice consumption in the Serer community (40 of 43) for the first time has superseded peanut consumption (20 of 43). These behavioral changes were inconceivable just 20 years ago, and further emphasize the rapid socioeconomic transformations and pace of linear progression towards "modernity," creeping

into the once stronghold of sustainable integrated-farming models that have fed the Serer people for generations, without jeopardizing their natural ecosystems.

**Conclusion**

The data clearly shows a strong correlation among certain indicators of "economic traditionalism," and not only support for agroforestry systems but also wealth. For instance, the elders and less educated farmers, who are also the supporters of agroforestry, are more prone to hold on to traditional subsistence, and lack a connection to the external commodified economic world, whereas the young and more educated farmers are more opened to modernism, and more exposed to the externally oriented commodified economy. These small landholders are not just farming but are more engaged into economic diversification to make ends meet. Strikingly, we found that the opponents of agroforestry, who are the most educated the most likely to sell their harvest, and to have a diet change, and above all, are the most modern, are surprisingly the ones who least can afford chemical fertilizer, and therefore are the least wealthy. In contrast, those with the most traditional profiles in terms of lifestyles and economy (supporters of agroforestry) and the least educated are the ones who most can afford chemical fertilizer, and therefore are the wealthiest farmers.

Now we are faced with a complex question concerning what it means to be "modern." Does it mean a total abandonment of traditional ways of life, or a combination or "syncretism" of local knowledge and technological advance (Galvan, 2004) to enhance diminishing agricultural returns, as the chemical fertilizer narrative has shown? I would hope for the latter, and since it is already happening, one must focus on taking the best of both systems (intensification of

traditional agriculture, and economic diversification out of agriculture) to alleviate rampant poverty in Toukar. This outcome also raises a significant argument about whether traditional styles and values that have been passed on for generations are now being challenged by modern influence, and imperiled by the ongoing large-scale rural exodus of young people to the cities. However, I believe that as long as indigenous cultures and legal rights are not infringed upon, both paradigms can cohabit successfully. The overarching assumption is that farming systems (or endogenous development or self-sustaining systems), based on management intensification (with limited use of inorganic fertilizers and integrated pest management) to produce what you need from existing farmlands (with minimum inputs from external sources), and traditional polycultures or agroforestry systems, can increase crop yields and simultaneously protect the environment. This coexistence or synergy will inevitably help convince young people to stay in the village, as well as struggling peasants to maintain the viability of their livelihood systems in the face of recurrent crises, and continue to generate income and produce food for themselves and for the market.

# CHAPTER IX

## CONCLUSION AND RECOMMENDATIONS

There is a wide consensus in the literature on agrarian change and development of agroforestry in Africa. This method of farming has great potential to restore soil fertility, provide fodder for livestock production, secure organic fertilizer in the form of manure, alleviate the fuel wood shortage, mitigate deforestation and climate change, and above all, improve agricultural yields and incomes, ensuring a more secure livelihood for Africa's poorest.

Yet there is a problem. If this technique is so useful and can make such a difference with regard to the pressing challenges of development, resource management and livelihood stabilization, why doesn't everyone adopt it? Why don't 100% of farmers in a place like Toukar practice agroforestry?

To help answer these questions, and to understand the obstacles to agroforestry adoption, and begin to suggest ways to make the practice widespread, I looked closely at two sets of questions: First, do farmers practice agroforestry in Toukar, and if so, what elements of agroforestry do they practice? Second, what are the social, economic, and cultural characteristics of people who adopt agroforestry, of people who do not adopt, and people who are not sure about it? By knowing who these people are, can we understand motivations and rationales for adoption? And by answering these questions can we return to the core issue of the promotion of agroforestry as a useful means to improve African

agriculture, fight deforestation and soil degradation, empower farmers, stem the rural exodus, and enhance livelihood? Will knowing more about who opposes agroforestry suggest ways to overcome opposition and ambivalence and expand the use of agroforestry techniques in a place like Toukar?

*Adoption Patterns*

On the first set of questions, my findings reveal three clear patterns regarding adoption of agroforestry techniques in the Senegalese village of Toukar. In the largest subgroup of the population surveyed, 17 out of 43 respondents are more supportive of agroforestry techniques. An almost equally large number, 15 respondents out of 43, are hesitant about planting trees in farmlands and unsure about the practices of agroforestry in general. Lastly, the opponents of agroforestry (11 out of 43) are not only reluctant to adopt the system, but do not hesitate to undermine its practices.

The supporters of agroforestry practice these specific agroforestry techniques: they plant and protect found trees by allowing the natural regeneration of seedlings in their farms. They have more than the average numbers of trees. In addition to practicing intercropping and crop rotation, as does every farmer in Toukar, regardless of attitudes toward patterns of agroforestry adoption, these supporters of agroforestry have more than the average numbers of *Acacia albida* trees, and maintain living fences as farm borders. They also practice *toss* or fallow periods for livestock herding and soil enrichment.

The Unsure group of farmers regard trees in farms as wasted arable lands, hence they generally do not plant or protect. (Only 2 farmers in this group have

protected found trees.) As does every farmer in Toukar, they intercrop millet and sorghum crops with cowpea, or peanut crop with sorghum and cowpea, and practice crop rotation. However, these farmers count fewer trees in their farms than the average numbers, and they also have fewer *Acacia albida* trees than the average numbers (see chapter IV). These farmers generally do not practice *toss* (only 2 farmers do), nor do they maintain living fences. Even though these farmers who are unsure about agroforestry say that they accidentally cut seedlings while plowing, they do not actually spend the time and protection required to allow for natural tree regeneration.

Although the opponents of agroforestry practice intercropping and crop rotation like other farmers in Toukar, they intentionally cut tree seedlings while plowing because they consider trees in farms not only as a constraint to an adequate cultivation of the field, but also a wasted arable space. Therefore, they openly manifest their opposition to planting or protecting trees in farms, especially the larger species of trees, such as *sob*, *baak*, and *ngaan*.

The findings on patterns of adoption reveal that the overwhelming majority of respondents (90%) attribute the pronounced dwindling of trees in Toukar's existent parklands to natural phenomena, including drought, strong winds, old age, and illegal logging, rather than to deforestation or fuel wood collection. But only pro-agroforestry farmers are enthusiastic about planting and natural tree regeneration. By contrast, other farmers (indifferent and opponents) are not passionate about adopting agroforestry practices for a host of reasons. Some reasons include the unavailability of *saas* nurseries as well as the lack of extension services in the village, and farmers' lack of financial resources.

The study has also found other limitations to the implementation of agroforestry in Toukar, such as the lack of land and labor, the accidental or intentional cutting of trees or seedlings for more arable spaces, the nonlinear farm trees patterns in farmlands, and the difficulty of plowing or weeding around trees with mechanized tools. Other contributory factors for uncertain and opponent farmers are their high level of education and their greater tendency towards modernity and externally- oriented commodified economy.

*Who Adopts*

Second, having established patterns of adoption, I then considered the social, economic, and other characteristics that correlate with support for, uncertainty about, or opposition to agroforestry. I found a positive correlation between wealth and support of agroforestry (34.3 for supporters of agroforestry, 20.7 for the unsure group, and 18.0 for opponents). It could be that most farmers who embrace agroforestry are likely to be wealthy, or that agroforestry might make people wealthy. The relationship might take the form of a chicken-and-egg dilemma. Closer examination in light of the historical record shows that traditional farming systems were very consistent with agroforestry and required many techniques that are now considered key elements of agroforestry. These agroforestry techniques, practiced over generations, provided wealth. Today, relatively wealthy farmers are continuing to adopt agroforestry technologies, but this is not because they were first wealthy and then chose agroforestry practices. Rather, they have maintained the traditional farming practices, which are the first in the recurrent cycle of events of what is now defined and confirmed as a

virtuous circle. In essence, the practice of traditional agroforestry systems makes a farmer wealthy, and conversely, an already wealthy individual is more likely to adopt agroforestry systems.

Regarding women's practice of agroforestry, my findings were mixed, but in the end proved conventional wisdom wrong. A straightforward count of patterns of support, ambivalence, or opposition to agroforestry revealed that most women were ambivalent or opposed. But survey findings can be misleading. When we actually spoke at length to women, we found a more complex story. The women interviewed in this study insisted they are not responsible for deforestation. They are opposed to cutting down live trees. They argued they harvest only dead wood, and are adamantly opposed to felling trees to clear arable lands. While they acknowledged the fuel wood crisis, they properly manage available stands, and have alternative mechanisms to mitigate the crisis. Thus, when we talked to those who oppose or are ambivalent about agroforestry, we found that their motivations are more complex than they might appear at first glance. In fact, qualitative findings upend the quantitative survey-based account: Female opponents say that they are against agroforestry because they own small plots (assigned to them by the male heads of household) in which they grow mostly cash crops for their own benefit, to provide for additional household needs such as medicines and school supplies for the children, and cannot afford to maintain living fences or allow the natural regeneration of trees that take up valuable space. Women who identified as unsure indicated in more open-ended interviews that they are unsure because even though planting trees in farm is a good idea, the last word belongs to the

male decision-makers. Even if they managed to convince the husband, they still lacked access to seeds or seedlings, cash or credit to acquire the trees.

The findings also show a strong correlation between agropastoralism and support of agroforestry, confirming that agropastoralism is an integral part of agroforestry systems. An agroforestry system is defined as a deliberate combination of sustainable land-use practices or interactions between trees, shrubs, crops, and livestock to increase yields in tree crops, food crops and animal production on a continuing basis, simultaneously or sequentially, in the same land. Agropastoralism is the combination of crops and animals in the same space and time for crop and livestock production. In addition to food cultivation, agropastoral farmers make their living raising livestock for prestige, meat, and organic manure, and provide water and pastures for their herds. Agropastoralists require trees in farms for animal feed during the dry season, and living fences to separate the herd from cultivated lands.

As for the economy of subsistence versus the economy of commodification, the findings reveal that supporters of agroforestry are more likely to utilize traditional economies (or economic isolation), while those who are indifferent or opposed to agroforestry practice more modern economic ways (based on more outside connections) to meet livelihood needs. We found that the latter groups are the most educated, are the people who sell most of their harvest, the most likely to change their diet, and above all, who are surprisingly the least able to afford chemical fertilizer. In contrast, supporters of agroforestry are the least educated, the least likely to change their traditional diet, and the

ones who most who can afford chemical fertilizer. This suggests an unexpected link among agroforestry, traditionalism, and being a successful, wealthy farmer.

These results overwhelmingly suggest that people who are more attached to the Serer traditional farming systems are the most supportive of agroforestry. Although it is considered a "new" technique throughout the world, it appears old and historic in Toukar. The results illustrate that people who are seemingly more modern are less likely to adopt agroforestry than people who fit a more "traditional" profile. Further, farmers who are wealthy in this society tend to be the most traditional in terms of lifestyle and economy. These farmers hold more natural resources or assets (e.g., tree farms, land, livestock, labor) because they have preserved the historic pattern for good farming. For these farmers, this outcome is not surprising but natural, because this is how farming has been done for generations and passed down to them by their ancestors. Traditional farming involves maintaining and carefully managing available natural resources such as live fences, fallows, and agropastoralism, and maintaining diversified cropping systems. More importantly, the results highlight that in this pattern, wealth goes with traditionalism and support for agroforestry, while poverty goes with being more modern and being more opposed to agroforestry.

On close historical and cultural analysis, the study revealed that farmers who support agroforestry became wealthy in part because of the cultural, socioeconomic, and environmental benefits associated with the practice, which helps them to overcome vulnerabilities of climate change and crop failures through soil fertility improvement and income generation. But they also remain

wealthy because they still rely on historic farming systems, which include traditional agroforestry practices.

In contrast, farmers who are unsure about or opposed to agroforestry, and who also exhibit modern characteristics, are poorer partly because they lack adequate natural resources such as productive land. In fact, their soils may be so impoverished or degraded that they are incapable of producing good harvests. Or, they lack or are unaware of the historic farming knowledge essential for a viable agricultural production, which makes them more vulnerable to drought. Or perhaps these more externally- oriented farmers are skeptical about agroforestry because they are underprivileged by the land tenure law, and therefore own small parcel of lands in which they view trees in farms as a constraint to self-sufficiency, and would rather avoid initiating a competition between trees and food crops. Because these farmers prioritize meeting basic food needs and lack access to enough land, they exclude growing trees, practicing *toss*, or maintaining living fences from their small parcel of lands to allow for more arable lands rather than take the risk to incorporate agroforestry techniques.

*Implications for Agroforestry Promotion*

The findings from this study suggest that agroforestry and related natural resource management strategies can enable low-resource, poor smallholder farmers in the Sahel to significantly reduce their constraints on food production and enhance self-sufficiency and improve overall living standards. Agroforestry techniques not only can generate employment and income opportunities for rural households through the sale of wood and non wood products from

dispersed farm trees, but also can minimize potential agricultural risks and the daily struggle for subsistence by providing a more diversified and stable farming system (Berry et al., 1984; Winterbottom & hazelhood, 1987). In contrast to governmental programs that focus exclusively on raising rural income through maximization of peanut cash crop production (the main export crop of Senegal) without paying much attention to the area's vulnerability to drought, agroforestry techniques emphasize crop diversification and sustainable resource management practices such as mix-cropping and improved-fallows to enhance livelihood.

As shown in this thesis, agroforestry in Toukar is associated with traditional farming practices, lifestyles, and economy. It also is associated with being older and less educated ("old people's ways"). However, as tradition fades and people become more modern, more educated, and more connected to the outside world, they become unsure about or more opposed to agroforestry. This poses a serious threat to one of the most elaborate and effective techniques for maintaining viable farming productions.

As discussed at length in the background chapter, traditions in Toukar are belief systems, customs, or practices rooted in the past, transmitted from generation to generation, and now associated with a sense of Serer cultural identity. The local concept is *cosaan*, the way our ancestors did things, ways that define us as a people. In Toukar, and in Serer communities in general, there is much *cosaan* that has to do with caring for the soil, farming, raising animals, knowing and protecting the best trees, and being in good relations with the natural world. Serer people think of themselves as knowledgeable farmers, what

Wooten has referred to in another setting as "champion farmers" (Wooten, 2011). Non- Serer people in Senegal, including Wolof neighbors and French colonial rulers, have long reinforced this image, calling the Serer the "model African peasant" (Pelissier, 1966).

Traditions may change over time, even if people following them may not be aware of the changes. For instance, traditional farming practices in Toukar have been altered in part because of the high population density in the region, which is putting tremendous pressure on access to farmlands. This population pressure has completely eliminated the practice of shifting agriculture and has reduced fallow reserves. However, some farmers have preserved certain resource management practices associated with ecosystem and soil conservation. The new generation may not perceive those traditional and effective farming practices as beneficial and adaptable anymore, or are simply neglectful of them because they are more interested in modern ways. However, my findings show that people who are seemingly more modern (more educated and more in contact with the outside economy and outside world) are less likely to adopt agroforestry than people who fit a more "traditional" profile. Yet farmers who are wealthy in this society tend to be the most traditional in terms of lifestyle and economy.

The findings presented here might seem to suggest an irreconcilable tension between clinging to the past and the pursuit of new approaches. In my view, a coexistence or synergy between traditional and modern methods may constitute a valid option to finding solutions to present-day agriculture, and may appeal to young people. For instance, agricultural intensification (using

endogenous and exogenous inputs) in which modern techniques (fertilizers, pesticides, seeds, IPM) and traditional methods (polycultures, crop rotation, compost, trees in farms) are synchronized or practiced in sequence. First, the synergy may start with modern methods in soil fertility management by using chemical fertilizers in newly established farm trees systems to augment crop yields in the first years of management. Since nitrogen-fixing trees alone do not supply all the essential nutrients, and require at least 3 to 4 years for desired productions, the system needs a combination of both techniques to be fully productive. The synergies between organic and inorganic inputs for soil fertility improvement surely deserve attention, and offer solutions to impoverished soils in the village.

Likewise, alley cropping (or interspersing) useful trees, with animals integrated within the system, can increase crop yields and achieve food self-sufficiency even in small farm plots. In this case, exogenous inputs (inorganic fertilizers, pesticides) are used only in the beginning until the system can generate and satisfy it own nutrient requirements through ecological recycling. At this point the new closed-system will stop using external inputs, and rely exclusively on essential nutrient sources such as compost, manure, nutrient-cycling, improved fallows, leaf litter) to reach a fully "sustainable intensification" stage.

These synergies are useful in promoting agroforestry because inorganic or synthetic fertilizers, as most farmers already acknowledge, are a quick fix to increase crop yields. Given the pronounced soil fertility depletion in the area, access to sufficient and sustained chemical fertilizer (for 3 to 4 years) may

complement the loss of production from land allocated to trees, while providing self-sufficiency in food. Likewise, farmers do acknowledge the benefit and usefulness of traditional systems such as *toss*, as confirmed by this peasant's quote: "A well-tossed field guarantees fertility for 2 to 3 years, whereas inorganic fertilizer only secures one season."

My findings show 17 out of 43 interviewees adopt agroforestry, 15 out of 43 are unsure, and 11 out of 43 are against agroforestry systems. Now, by knowing about the underlying motivations of adopters, opponents, and those who are indifferent, we can provide ways to promote more agroforestry techniques that clearly can improve agricultural conditions and livelihood. Since farmers who are unsure about or opposed to agroforestry are mainly concerned about increasing crop productivity and achieving food security, intensification in farmlands with synergy between organic and inorganic fertilizer methods can increase yields, and therefore may bring these farmers (who also seek modern ways to meet livelihood needs) to consider agroforestry techniques. Moreover, the technique of alley cropping with leguminous *Acacia albida* in farmlands in combination with animals can be of great interest to both indifferent and opponents to agroforestry, since this technique can reduce pressure on available land. In other words, arable land is not taken out of production. Given that these farmers lack sufficient land, the technique may suit them well. Since *Acacia albida* are leafless during the growing season, there is no competition between them and the crops grown in alleys. Plus, with their small sizes, they do not take up space but instead fertilize the crops underneath. Finally, crop diversification in Toukar's farmlands with reintroduction of valued native crops or well-adapted

plants that can withstand the vagaries of the weather) may help attract farmers' interest to agroforestry. Furthermore, if these farmers have access to lucrative markets that generate incomes from diversified productions, to reduce the pressure on the single cash crop (peanut) cultivation, they may adopt agroforestry and increase their farm outputs. These farmers are mainly worried about inaccessibility to land, capital, and soil fertility. The management strategies described above address their concerns and provide tangible solutions to these problems, and could make them change their attitudes and adopt agroforestry.

*Implications from an Insider's Perspective*

As a person brought up in this community, it is appropriate for me to offer some reflections on what my community ought to do in response to these findings. It is incumbent upon people in the community to find ways to demonstrate to the young generations that traditional agroforestry works, is successful, and is indispensable for the survival of the village. We need to restore some of the old and efficacious methods of farming that supported our ancestors for centuries, making them a part of present-day farming practices. Thus, I argue that the unsure groups of farmers may be swayed into adopting agroforestry systems because their farming practices are not far off from those of the pro-agroforestry farmers.

To that end, farmers as well as extension services can work together and promote agroforestry techniques, to improve farming systems and achieve food security in Senegal. For instance, extension services can utilize the "push and pull" factors to provide agricultural inputs (seeds, fertilizers, pesticides) and encourage trees in farms by developing lucrative tree market-products for

adopters of agroforestry (Jerneck & Olsson, 2013, p. 8). Given that my findings show that supporters of agroforestry, and people who are unsure about agroforestry as well as opponents to agroforestry, all regard the use of chemical fertilizers as an important element to increase crop yields, farm subsidies and tree market opportunities may appeal to farmers who are indifferent or opposed to agroforestry, and may thus boost enthusiasm for agroforestry practices in the region.

At the village level, as in Toukar, supporters of agroforestry can create agroforestry experiments on highly visible fields owned by effective supporters and advisers (possibly from the council of the Elders) who are well respected in the village. These fields may serve as a demonstration proof of the potentials of traditional agroforestry systems (since young people still show deference to the elders). These on-farm projects may shift unsure and anti-agroforestry farmers into considering the adoption of sustainable resources management practices in their fields because of the enormous benefits these practices provide, such as resilience to drought, incomes, confidence, and food security.

By the same token, my findings show that some farmers who are unenthusiastic about or opposed to agroforestry have indicated the absence of nearby nurseries as an impediment to planting trees in farms. So villagers can engage in socially responsible development projects, such as establishing agroforestry nurseries and reforestation projects to remedy this absence of tree nurseries. These projects may be specifically designed to increase the density of high-value multipurpose trees to supply fuel wood and fodder as well as generate incomes. Such projects can be expanded in various hamlets in which

participants design a tally system that recognizes variation among farmers in terms of numbers and effectiveness of leguminous trees in the field, and provide incentives for participants, such as gifts or prizes to farmers with the most diverse croplands. These projects, along with energy-efficient cooking stoves, can reduce pressure on remaining woodlands in the region. They can bring positive changes in the lives of the many disadvantaged people in Toukar, and keep young people in the village.

My findings also illustrate that farmers who are unsure or opposed to agroforestry lack adequate natural resources such as productive land, or are unaware or skeptical about the historic farming knowledge that is essential for a viable agricultural production, which makes them less food secure. Therefore, agricultural lands in Toukar need to be used optimally to ensure food security, since farm and forested land are not increasing as fast as human population. This land optimization requires that we design and implement genuine sustainable agricultural intensification and rehabilitation projects to restore damaged ecosystems in marginalized areas with native trees to allow proper use of available land for these unmotivated or skeptical farmers. It seems that people have forgotten the miracle performed by trees, which can serve to moderate the climate and break the cycle of poverty by providing wealth, as already demonstrated.

However, the road to national agricultural development does not have to follow disruptive foreign-imposed models of extensive monoculture peanut production, which endangers already fragile agroecosystems. Senegal may need real agricultural policies (i.e., fair and transparent forest laws and regulations,

comprehensive land reforms) built around participatory, multidisciplinary, and effective historical models of farming. Present trends show peasants' disaffection with the ineffective extension services or lack thereof as well as lack of improved seeds and credit. Small-scale and resource-poor farmers should be allowed to receive assistance from the government irrespective of historical past, sentiments, or political affiliations. A change of mindsets will be needed in both farmers and governmental entities, as well as a balanced approach that focuses primarily on improving existing agricultural productivity and the optimization of the multiple benefits of trees in farms and conservation measures through fair and sustainable agroforestry practices to provoke genuine equilibrium within the three pillars of sustainability (environmental, social, and economic).

Finally, the emphasis should also be both in implementing policies to improve and maintain traditional agroforestry systems and cultures, through the integration or enhanced forms of agriculture with the synergy between modern and traditional farming techniques to attain a sustainable agriculture. Biological and cultural diversity are both conserved and increased in these applied agroforestry systems. In such models, indigenous people shape their own destiny through self-help cooperatives, maintenance and reintegration of traditional survival strategies that focus on preventing disruption of the social relations. Only then will agroforestry systems have a future in Toukar, Senegal, and the Sahel.

# APPENDIX A

## QUESTIONNAIRE

A. Family Structure:
1. How old are you?
2. Have you been to school? If yes, how far, if no why not?
3. How many people are in your immediate family?
a. Male--------b. Female------ c. Boys--------- d. Girls--------
4. What's your family main source of income?
a. Do you have another occupation besides farming?
5. What kinds of expenses do you have?
6. Do you own animals?
a. What type? E.g. cows, sheep, goats, chickens, etc… and how many?
b. Why do you own this type of animal? E.g. is it for meat consumption, or a form of savings?
c. What do you feed them?

B. Land Size and Tenure:
1. Do you have a farm?
2. How big is your farm?
3. How did you acquire the farm?
4. Is your farm fenced?
5. If so, how, if no why not?

C. Crop Production:
1. What do you grow on your farm, and Why?
2. Do you grow other crops, with your main crop on the same field, and why?
3. Do you grow the same crops now as you did 10 years ago?

D. Food Security:
1. Do you consume, or sell the majority of your crops?
2. Does the harvest, (or the money you receive from your crops), suffice for the entire year?
3. What do you do to compensate if the harvest is not enough?
4. What kind of foods do you eat? (Please cite: millet, rice, meat, sorghum, wild herbs, mangoes, etc…)
a. Does your diet change in the last 10 years?
b. Or does it just change from season to season, please explain?
c. How much food crop (or number of granaries) have you harvested this year?
d. Does this year-harvest better than (more productive) the year before?
e. If so or no, what are the reasons for that?

E. Multipurpose Trees:
1. Are their trees in your farm?
a. What are the species? Can you please name them in Serer or Wolof?
b. How many trees are there in your field?
c. What are the trees used for?
2. Did you plant them or were they already here?
a. If they're already here, why were they maintained on the land?
b. Have you protected them until they mature?
c. If yes you protected them, how many and how (materials used)?
d. If you planted them, how many have you planted, and how, please explain?
e. Why didn't you cut down the found trees, to gain more arable lands?
3. How many *Acacia albida* trees (or leguminous trees) do you have in the farm, and why?
a. What are their purposes?
b. How do you delimit your field from your neighbors? If any, do they have any other uses?
c. Do you think you have more *Acacia albida* trees now than before? If yes why, or if no why not, and what happens to the other trees?
d. If no you don't have more *Acacia albida* now, why don't you plant more, or let more regenerate naturally?
e. Do you think there are more *Acacia albida* trees in Toukar now than before, if no, what's the reason to the decline?

F. Soil conservation measures:
1. What do you do to stop soil erosion if any?
a. And to improve soil quality?
b. If there's a living fence: what's it role?
c. Do you think *Acacia albida* fertilize your soil?
2. Do you use chemical fertilizer, if yes why, if no why not?
e. If yes, how and where did you get it?
f. Do you use other methods to fertilize your soils, if yes what are they and why?
g. What's your most preferred method of fertilizer and why?

G. Constraints:
1. What are some of the main problems you experience in your farm?
a. Water constraints
b. Pests: domestic or wild animals
c. Soil erosion/quality
d. Why do you not have more trees in your farm? Or is having more trees already a constraint?
e. What are your general constraints, if any?

H. Extension services (assistance):
1. Have you ever attended any trainings or workshops offered by the government or an NGO on farming?
2. Have you tried anything new or different on your land that your neighbor has not tried?

3. Have you received input packages (improved seeds, pesticides, fertilizers) from the extension services?

I. Farming techniques:
1. Do you practice fallow, if yes or no, why?
2. How do you prepare your field, before sowing?
3. Do you burn crop residues before planting and why, or you sow on top of residues?
4. What tools or equipment do you use to cultivate your farm, and why?
5. Do you intentionally (or involuntarily) plow young seedlings in your field, why?
6. Do you think having many trees in your farm take up lots of arable lands?
7. How can you compensate for that, if any?

J. Questions for Women only:
1. Do you own a farm, and if yes, what do you grow in it?
2. Is there fuel-wood shortage in your household and the village, and why?
3. If yes, what do you do about it?
4. How and where do you get your fuel wood?
5. Have you thought about planting trees to have firewood?
6. If yes, where and what kind, if no, why not?
7. What's the most preferred tree for firewood, and why?

# APPENDIX B

## PRINCIPAL TREE SPECIES AND THEIR USES

| Tree sp. | Serer name | Fuel wood | Hut Construction | Living fences | Fodder | Other uses (*) |
|---|---|---|---|---|---|---|
| *Acacia albida* | saas | X | X | | X | D, G, E |
| *Adansonia digitata* | baak | | | | X | A, B, F |
| *Anogeissus leiocarpus* | ngojil | X | X | | | G |
| *Acacia ataxacantha* | ngol | | | X | | G |
| *Acacia nilotica* | nenef | X | | X | X | |
| *Acacia sieberiana* | suul | | | | | D |
| *Azadiratcha indica* | Mim | | X | | | B, E |
| *Balanites aegyptiaca* | model | X | | | | F |
| *Bauhinia rufescens* | njambayargin | | | | | B |
| *Borassus aethiopum* | ndoff | | X | X | | A, E, F, G |
| *cordyla pinnata* | nar | | | | | B, F |
| *Celtis integrifolia* | ngaan | | X | | X | F |
| *Diospyros mespiliformis* | nen | | | | X | F |
| *Euphorbia balsamifera* | ndamul | | | X | | |
| *Ficus gnafalocarpa* | ndun | X | | | X | F |
| *Ficus iteophylla* | mbelegn | X | | | X | |
| *Ficus platyphylla* | mbadatt | X | | | X | D |
| *Guiera senegalensis* | ngud | X | | X | | D |
| *Khaya senegalensis* | ngarign | | | | | G |
| *Mitragyna inermis* | ngawul | X | | | X | A, B |
| *Prosopis africana* | somb | X | X | X | X | E |
| *Selerocarya birrea* | aric | X | | | X | B, F |
| *Tamarindus indica* | sob | X | X | | | A, F |
| *Ziziphus mauritania* | ngiic | X | X | | X | B, G, F, E |
| | xorol | X | | | | A, D |
| | sebe | X | | X | X | A, C, E |

| | | | | | | |
|---|---|---|---|---|---|---|
| | ngaax | X | | | X | A, E |

(*) Uses: A: Ropes, fibers; B: Medicines; C: Tannins, dye, resin; D: Fertilizers; E: Fences, construction; F: Human food; G: Tools, implements.

## APPENDIX C

## GLOSARY OF FOREIGN WORDS

*Acacia albida*: or *Faidherbia alba*, a native leguminous tree

Baadolo: simple peasant

Ba'see: A sauce made out of peanut, herbs, meat etc…

Bissap: species of Hibiscus grown for cooking and beverage

Communautè rurale: territorial administrative division in Senegal composed of a number of villages

Depense quotidien: (French) daily household expenses.

Duxum: witch-weed, a pest of millet plant

Griot: (French) low-status caste people, who master the drums, praise noble-farmers and preserve village oral histories.

Hilaire: (French) traditional hand tool for weeding and thinning crops

Kaynack: herd boy who looks after the livestock day and night

Laman: the traditional land custodian who allocated land and supervised traditional farming practices before the advent of the "National Domain Law."

Marabout: (French) supposedly koranic teacher, but are mostly thought to be endowed with powers (religious, magical) which attract lay-persons.

Mbind: household or compound in Serer

Mouride: largest sufi Islamic brotherhood in Senegal, founded by Cheikh Ahmadou Bamba Mbacke in the 1880s

Ndap: granary where ear of millets or sorghum are stored

Ndar: diameter of a granary

Nding: living fences that border farmlands

National Domain Law: 1964 land tenure legislature, which takes land for those with surplus for legal distribution to the landless people.

Pangool: ancestral or spiritual beings in the Serer animist religion

Peanut basin: areas of intensive cultivation of peanuts for export in the west central Senegal.

Pech: path used by livestock or farm border

Raan: annual rain and fertility festival in Toukar

Rural council: locally elected council governing a communautè rurale

Saas: serer name for *Acacia albida*

Sadje: couscous made out of millet

Serer: third largest ethnic group in Senegal (15%)

Siin: south central portion of the peanut basin

Siidee: person who owns lots of cattle

Sous-prefet: official appointed by Senegalese government to manage affairs in an arrondissement.

Wolof: largest ethnic group in Senegal (43%)

Tabaski: Islamic religious ceremony in which a sheep is slaughtered as offering

Tayle: land or valued object given in exchange, as security for cash or another valued commodity

Toukarois: inhabitant of Toukar

Toss: fallows land or rotational grazing

Yal bakh: "master of cutting"

Yal naay: "master of fire" the settler who first sets the fire to delimit its land ownership

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