Journal of Asian Scientific Research

journal homepage: http://aessweb.com/journal-detail.php?id=5003

NATURAL REGENERATION OF TREE IN ARID AND SEMI-ARID ZONES IN WEST AFRICA

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ABSTRACT

The synthesis of acquired published in this article focuses on the investigation of natural regeneration of tree in arid and semi-arid West Africa. The results showed that, even if the threat on ecosystems was ancient, research / actions in that were relatively recent. It was recognized that there was a regression of ligneous related to human activities (deforestation, overgrazing, bush fire) and weather conditions (drought). Current knowledge showed the multiple roles of natural regeneration of tree for services (soil fertility, anti erosion, shading ...) and outputs (timber, grazing, medicinal ...). There were, however, in some regions, a dynamic adaptation through the development of agroforestry systems in small and large scale farmers through the protection and management of spontaneous regeneration.

Key Words: Woody species, Dynamics, Management, Regression, Peasant.

INTRODUCTION

According to United Nations for Food and Agriculture (FAO), Africa is characterized by the largest rate of continental deforestation in the world, estimated at 0.78% per annum. Western Sahelo-Sudan of Africa (Mauritania, Senegal, Guinea Bissau, Mali, Burkina Faso, Niger and Chad), is though characterized by limited forest resources, was slightly better than the continent with an annual decline of 0.72% (FAO, 2001 cited by (Ozer *et al.*, 2010). However, it is clear that objective informations on development of forest resources are very rare in West Africa (Ozer, 2004) and elsewhere (Lepers *et al.*, 2005). Tropical dry forests are considered a high-risk ecosystem (Chamard and Courel, 1999) and the problem of deforestation is extremely important in arid, semi-arid and dry as it contributes to the expansion of desertification. This continued deforestation has greatly reduced the species richness of forest species. Senegal, biodiversity is reduced by over 30% between 1945 and 1993 (Gonzalez, 2001). In Sahel, surveys conducted in 14 village communities

in Mauritania and Chad showed that the species richness of forest species remained stable in two lands and decreased to 57% elsewhere (Gonzalez *et al.*, 2004). However, opinions on the dynamics of the timber are controversial. Boffa (2000) considers the available data is limited for quantitative evaluation of dynamics of natural regeneration of shaft in terms of density, composition and age of the extension in space. While some authors argue in favor of the resilience of Sahelian, others believe that there is a gradual degradation. The dynamics of woody cover is positively correlated with its ability to regenerate naturally, studying natural regeneration of e tree remains then important to understand the functioning and dynamics of systems production, allowing to establish restoration strategies and / or rehabilitation of ecosystems mainly with native species (Akpo and Grouzis, 1996b; Larwanou and Saadou., 2006; Diatta *et al.*, 2007). The objective of this work is to synthesize knowledge about the natural regeneration of trees in arid and semi-arid. More specifically, we will try to review the research conducted and achievements.

NATURAL REGENERATION OF TREE

In Senegal, Pelissier (1966), Giffard (1974), Lericollais (1989) have long and consistently decried the threat to ecosystems due to uncontrolled exploitation for agricultural and energy in particular. Despite the preservation of certain useful species in fields, such as *Cordyla pinnata* and *Faidherbia albida* respectively in the north and south Groundnut Basin, culling and several other passages of bushfires do not favor the maintenance of vegetation even less its reconstitution. Only a few species of shrubs with good regeneration potential are developing in areas of culture. Out of a total of 123 woody species listed in Sahel (Wezel and Lykke, 2006), 20 disappeared, 79 are in decline, 11 are stable and 13 (including 11 exotic) have increased during the past thirty to fifty years. In an attempt to provide solutions to these challenges, the first studies on natural regeneration of trees in the Groundnut Basin in Senegal conducted by the National Centre for Forest Research (NWRC) at ISRA date from 1987 and include:

• the study of the physical and socio-economic information relevant for an agroforestry development.

Following this study, a plan has been proposed for the park of *Faidherbia albida* in the West Central area of The Groundnut Basin (Samba, 1988);

• The study of different yield components of millet and peanut conducted in the parks of *Faidherbia albida* (West Central area) and *Cordyla pinnata* (South Zone) to evaluate the effect of these species on agricultural production (1988-1989);

• The study of natural regeneration in the park of *Faidherbia albida* conducted in the Centre-West in 1989(AFRENA., 1991)

These studies show that forest ecosystems are heavily dependent on natural factors and human action. *Faidherbia albida* and *Cordyla pinnata* produce litter that increases soil organic matter. The natural regeneration of *Faidherbia albida* although important in the Central West area is compromised by the removal of waste during harvest and pre-crop work.

Other agroforestry studies helped to broaden and to deepen these previous works. Samba *et al.* (2000), Diouf (2001) led to a better understanding of the influence of various factors (regeneration mode, distance from the village, bocage) on density and height of natural regeneration in parks of *Faidherbia albida*, *Adansonia digitata* and *Borassus aethiopium* of the Groundnut Basin in Senegal.

In Mali, the elaboration and the implementation of a sustainable management strategy has involved research on factors affecting natural regeneration in parks (Cisse, 1991a; Cisse, 1991b). It is clear from this work that the density of natural regeneration depends on:

• The Land Use System (SUT). The density is higher in bush fields (236 individuals / ha) than in fields;

• Soil type: 200, 197 and 182 individuals / ha respectively on sandy loam soil, sandy clay loam and sandy clay. It is much lower on sandy soil (90 individuals / ha) and

• The technique itinerary: it is higher in manually cultivated fields (63 individuals / ha) than in the plow worked (9 individuals / ha) (Cisse, 1995).

For useful species, density per hectare is higher in bush fields (39 individuals / ha) against about 12 individuals per hectare in fields and fallow fields.

The work carried out in Niger's Maradi region (Toudou *et al.*, 2008) and Senegal (Douma *et al.*, 2007) corroborated these findings.

A study on revegetation by natural regeneration using satellite imagery concluded that, in the Seno plains (region of Bankass in Mali), areas where the density of trees is medium to high (40 to 50 s) in fields cover currently an area of 450,800 ha. The density per hectare was relatively low in the 70s has increased significantly from the 90s with the producers' commitment and support of NGOs such as SOS Sahel and Sahel ECO (Reij and Tappan, 2011).

A study in Burkina Faso, on the state of degradation of woody stands of *Afzelia africana*, *Bombax costatum*, *Boswellia dalzielii* and *Pterocarpus erinaceus* in Sudanian zone, shows that in natural environment, seedlings face to drought, fires bush and pests, barely survive (Ouedraogo *et al.*, 2006). Thus, these authors believe that the success of the restoration of these four species must necessarily pass through a better understanding of their different modes of regeneration but also the protection of young shoots. The work carried out in the Central Plateau of Burkina Faso by Ouedraogo *et al.* (2008) on the rehabilitation of degraded lands is in favor of natural regeneration. They show that natural regeneration is more developed in the managed crop plots than in unmanaged ones. In Niger, Zinder area, a study of exploration across the Managed Natural Regeneration , its impacts and the motivation of farmers to protect and manage the ups, gave interesting results. Indeed, the areas under the Managed Natural Regeneration covering about one million hectares. The ecological crisis of the 70s and 80s has led producers to better adapt to the Managed Natural Regeneration. This practice has significantly improved the social welfare of the population by increasing agricultural production because of revegetation (Larwanou *et al.*, 2006). Studies carried out in Niger have always focused on the structure and dynamics of vegetation

showed that natural regeneration is a potential indicator of change (Lawesson, 1990; Miehe, 1991). In Sahel, tree plays an important role, particularly in terms of adaptation to climate change. In arid and semi-arid in general, the physiognomy of the vegetation is influenced by these changes (Diarra, 1985) and human action (Akpo and Grouzis, 1996b; Diatta *et al.*, 1998).

Dynamics of Woody Vegetation and Natural Regeneration of Tree

The investigations carried out in West Africa in different countries showed diverse opinions. Giffard (1974) found that tree cover had fallen thirty years in all regions of Senegal. It had sometimes disappeared in some areas due to worsening climate and human action. Sahelian, Sudanian and Guinean areas were marked by a specific endemism. (Samba *et al.*, 2000), found in a study in North Central Groundnut Basin in the park of *Faidherbia albida* that 42% of inventoried species could not withstand the environmental conditions and human activities and will experience a decrease in time (*Ficus platyphylla*, *Aphania senegalensis*, *Diospyros mespiliformis* ...), some are stable (*Piliostigma reticulatum*, *Adansonia digitata*, *Faidherbia albida* ...) and others will have an increasing trend (*Guiera senegalensis*, *Ziziphus mauritiana*, *Balanites aegyptiaca* ...).

In rural landscapes and in systems of land use, density generally declined significantly over the past decades (Akpo *et al.*, 2004), especially since the droughts of the 70s (Nicholson, 2000; Tappan *et al.*, 2004). Currently, a dominance of old trees and a lack of natural regeneration for several species are found (Albergel *et al.*, 1985; Dembele, 1996). This situation is compounded by clearing for agricultural activities with population growth (Cabrera *et al.*, 2008), the uncontrolled exploitation of timber and service (Faye *et al.*, 2008) and drought (Diallo *et al.*, 2011). It follows very random natural regeneration (Gijsbers *et al.*, 1994) for most species, including reproductive seedling (Ouedraogo *et al.*, 2006) and also the vegetative (Vincke *et al.*, 2010). In the land of the Sob in North Central Groundnut Basin of Senegal, the density of trees in fields varied from 10.7 individuals per hectare in 1965 to 8.3 in 1985 (Lericollais, 1989). Some research conducted by ORSTOM at Fété Olé indicated that woody stratum, after an average mortality of 20% in 1970-1973, probably required to regenerate a decade under full protection. Where mortality reached 50%, it would take 30 years of total protection to bring the woody stand production to its level before 1970.

In Senegal, Ndour and Sene (1992), Louppe *et al.* (1994), Sall (1996) estimate that almost all of the studies conducted in the parklands of groundnut showed a drastic decrease in the density of trees per hectare, the disappearance of several species characterized the aging of parks a virtual absence of natural regeneration. The main causes of this degradation are: drought (Tiffen and Mortimore, 2002), inappropriate agricultural practices, overgrazing and bush fires (Vincke, 1995; Diatta *et al.*, 1998). Besides these works that highlight a regression of natural regeneration of tree, some authors argue that the development projects in natural resource management (NRM) have a local stand dynamics that reduces woody vegetation degradation Botoni and Reij (2009) reversing the trend by location (Olsson *et al.*, 2005). In Sahel, in regions with high population density, natural formations

disappeared progressively replaced by agro-forestry systems: Zinder and Maradi in Niger (Toudou *et al.*, 2008), North Central Plateau of Burkina Faso (Ouedraogo *et al.*, 2008), in Gondo plain in Mali (Sahel ECO., 2008).

The comparison of aerial photographs from 1975 with satellite images of high resolution of 2005 for the same areas in Niger shows a sharp increase in tree densities in fields (15 to 20 times more trees in 2005 than 1975). The revegetation is worth at least five million hectares with 200 million trees (Reij *et al.*, 2009). If the dimensions of natural regeneration in Senegal are less impressive in terms of scale, the development of local initiatives exists in some localities (Dieye *et al.*, 2008). In Senegal, PREVINOBA (Village Reforestation Project Northwest of the Groundnut Basin) with the development of its research component - action in the department of Tivaouane, found that the density per hectare of 9 trees before the project intervention increased to 27 by the adoption of Managed Natural Regeneration by the population (Diallo, 1992). In most woody species that are declining in the semi-arid (Dieye *et al.*, 2008; Diallo *et al.*, 2011) and dry (Akpo and Grouzis, 1996b; Vincke *et al.*, 2010) the potential regeneration exists, but have environmental disturbances and intrinsic factors to the species that threaten their reproductive patterns. Men and animals, mechanization, and decrease the variability of rainfall, harvesting premature fruit pests (termites, grasshoppers) and the old topics are major constraints to regeneration (Sène, 2000; Diouf, 2001).
In Senegal and Burkina Faso, the work of Lawesson (1990), Nouvellet (1992) and Diatta *et al.* (1998) shows that the evaluation of the density of multicaules species such as *Combretum glutinosum*, *Combretum nigricans*, *Combretum micranthum*, *Guiera senegalensis*, and *Heeria insignis*, is sometimes difficult to determine whether several emerging seedlings belong to the same strain. There exists an uncertainty for the ideal would be to work with strain.

Woody Species Used in Reforestation

Some research conducted in Senegal justified the choice of certain species in local resettlement initiatives. It is *Faidherbia albida* (Samba *et al.*, 2000); NWRC / ISRA, 1997; NWRC / ISRA, 1998), *Balanites aegyptiaca* (Akpo and Grouzis, 1996b) *Acacia raddiana* (Akpo and Grouzis, 1996b), *Acacia tortilis*, (ISRA/AHDIS., 1998), *Maerua crassifolia* (Diatta *et al.*, 2007) in the north-central groundnut basin and Ferlo. *Combretum glutinosum* (ENSA – AGROCONSULT., 1998) and *Guiera senegalensis* and *Piliostigma reticulatum* (F. *et al.*, 2006; Dossa *et al.*, 2009), *Zizyphys mauritiana* (ENSA – AGROCONSULT., 1998) are recommended in North Central, South East and South-West of the Groundnut Basin. *Cordyla pinnata* (Samba, 1997) and *Parkia biglobosa* (ISRA/AFRICARE., 1998) are favored in the south of the Groundnut Basin.

The species selection by farmers is guided by their multiple uses including food, medicine, firewood, service, fodder and soil fertility (Sène, 1994; Akpo and Grouzis, 1996a; Bakhoum *et al.*, 2001; Akpo *et al.*, 2003). The roles of certain species in the restoration of ecological balance (Akpo, 1992; F. *et al.*, 2006) and on the social and economic life of these people give a privilege to deliberate preservation (Abdoulaye and Ibro, 2006).

In the north-central Groundnut Basin of Senegal, *Adansonia digitata*, *Ziziphus mauritiana*, *Balanites aegyptiaca* and *Tamarindus indica* for their economic role (fruit) *Faidherbia albida*, *Celtis integrifolia*, *Guiera senegalensis* and their fertilizing function *Faidherbia albida* and *Celtis integrifolia* popular in animal feed is protected (Samba *et al.*, 2000). In Niger lands, species like *Faidherbia albida*, *Adansonia digitata*, *Ficus platyphilla*, *Prosopis africana*, and *Piliostigma reticulatum* with certain virtues are protected and thus spared from any form of uncontrolled exploitation (Baoua, 2006).

In arid and semi-arid *Faidherbia albida*, *Guiera senegalensis*, *Balanites aegyptiaca*, *Moringa oleifera*, *Zizyphus mauritiana*, *Gardenia sp* and *Combretum aculeatum* unlike *Aphania senegalensis*, *Sclerocarya birrea*, *Diospyros mespiliformis*, *Ficus iteophylla* , *Parinari macrophylla* are species that have generally no problems of natural regeneration (Dieye *et al.*, 2008; Ouedraogo *et al.*, 2008; Sahel ECO., 2008; Toudou *et al.*, 2008).

Management of Natural Regeneration of Tree

In Senegal, Ndour (1997) and Fall (1999) have defined several operations lead to the practice of natural regeneration to better respond to the degradation of woody stand. It is successively tracking; size, the wiring; marking seedlings, installation of iron gates and gabions to protect them. These operations must necessarily be accompanied by a maintenance (weeding) around regeneration during and after the rainy season to avoid attacks by termites and competition for water and nutrients from the soil.

Clavreul (2003) indicates that the tree was well integrated into the farming system but because of the peanut monoculture farmers have killed many trees that were useful to wind up leaving with its effects on soil and cultures. At Fandène (Senegal), the management of tree in the park of *Borassus aethiopium* is governed by a code of conduct scrupulously respected by the people. Also operating products palmyra follows very specific rules that set the age, period and subject to the same use. The protection of the woody stand including *Faidherbia albida* and *Combretum glutinosum* at the implementation of the project PREVINOBA (1986 - 1999) in Senegal was part of a process of restoring the equilibrium of ecosystems. It has contributed to the development of agricultural and pastoral.

In Niger Maradi and Zinder, farmers maintain and protect local woody species due to the ecological crisis of the 70s and 80s. This explains the high wood density currently observed (Larwanou *et al.*, 2006). In the region of Bankass (Mali), and the central plateau of Burkina Faso, similar results were observed (Ouedraogo *et al.*, 2008; Sahel ECO., 2008).

In the Sahel, actions promoting natural regeneration are shallow plowing or scraping, plowing late winter, mulching fields, animal holding and manual forest seeds spreading used in the field when it is devoid of trees. The practice of tree management in fields involves different types of cuts based

on objectives. These include pruning or lopping, coppicing or felling, pruning and pollarding or gaulage. The periods of trees cutting or favorable match the dormant period and after fruiting (O. *et al.*, 2011).

DISCUSSION

In arid and semi-arid West Africa, the regression of woodlands due to uncontrolled exploitation by people (Khresat *et al.*, 1998) and climatic (Ouedraogo *et al.*, 2006; Diallo *et al.*, 2011) is widely accepted. The qualitative and quantitative production of shoots and seeds to ensure natural regeneration of many species is so compromised. This depends on the productive characteristics of each species. There are, however, positive trends in some regions that show a dynamic of adaptation which is justified by the multiple roles of tree regeneration (Reij *et al.*, 2009). Farmers have invested in development of agroforestry systems at small and large scale especially in Zinder and Maradi regions in Niger and Seno plain in Mali with high density of populations. Trees were not planted but were the result of the protection and management of spontaneous regeneration by farmers. They recognize the multiple impacts of the revegetation. Trees are part of the production system and allowed greater integration of agriculture, livestock and forestry (Larwanou *et al.*, 2006; Toudou *et al.*, 2008). When certain conditions are met, it is possible to get farmers to invest in trees at field level and transform lands and production systems to large-scale (Reij, 2011). The study on tree natural regeneration of allows us to understand the functioning and dynamics of trees based production systems , in order to establish strategies for restoration and / or rehabilitation of ecosystems mainly with native species (Akpo and Grouzis, 1996b; Larwanou and Saadou., 2006; Diatta *et al.*, 2007).

Natural regeneration is an opportunity that requires special attention to ensure parkland sustainability. The promotion of these parklands which are systems of land use more productive and more stable ecologically, allows optimal management of land through interaction of tree-crop-animals. The latter is a factor of food self-sufficiency by increasing productivity and product diversification through improved soil fertility by providing organic matter, presence of rhizosphere and accumulation of nutrients in trees (Diedhiou *et al.*, 2009; O. *et al.*, 2011).The shaft acts on the microclimate attenuating radiation, air temperature, wind speed and evaporation into the air. Potential evapotranspiration of annual crops in particular and herbaceous vegetation in general is mitigated by the tree. It promotes better water infiltration (F. *et al.*, 2006). Natural regeneration of e tree can play windbreak effect according to some observations made in semi-arid area by reducing the risks associated with winds in rainy season and dry season wind erosion (Banzaf *et al.*, 1992; Michels *et al.*, 1998; Sanogo and Epouse Diaité., 2000). A study in northern Burkina Faso showed that the presence of 6 trees / ha already beginning to influence the wind speed (Leenders, 2006). However, in southern Senegal, Akpo (1992) show that the tree, at high density, can inhibit the production of the herbaceous layer by intercepting a large part of the radiation absorbed. The

increase of herbaceous production under shade can also be due to an adaptive response of herbaceous species to shading.

Tree or shrub vegetation is capable to restore degraded soil. It raises, in fact, the existing mineral reserves, enriches the upper horizons in organic matter, improves their physical properties, increase their nitrogen content and eliminates certain weed species which are formidable competition for crops (Schmid, 1960). Studies on scattered trees in fields in arid and semi-arid showed that they improve soil fertility through organic matter inputs (phosphorus, exchangeable bases, etc ...). It is *Faidherbia albida* (Kamara and Haque, 1992), *Prosopis sp*. (Agarwal, 1980) and *Acacia sp.* (Belsky *et al.*, 1993) for nitrogen fixers; *Parkia biglobosa* (locust) and *Vitellaria paradoxa* (shea) (Kater *et al.*, 1992; Tomlinson *et al.*, 1995) as non-nitrogen-fixing species and other species (Campbell *et al.*, 1994).

In general, under trees, chemical constituents concentrations such as C, N, P (Belsky *et al.*, 1989; Akpo, 1993), Ca, Mg, P (Isichei and Muoghalu, 1992) in soil are significant higher .
Sustainable management of trees must go through empowerment of farmers compared to trees in their fields, dissemination and training on best management practices.

Agroforestry is mainly based on field experience and knowledge which may be located outside the scientific context. Scientific research has certainly contributed to knowledge and improvement of species and agroforestry techniques, but it is first in fields we find the agroforestry practices and knowledge (Rocheleau *et al.*, 1994). There is still a gap between science and practice of population on the one hand, and the results of the most advanced scientific research on the other hand it is necessary to fill. It is in this dynamic that adaptation to climate change and sustainable environmentally friendly by people in rural arid and semi-arid can be built from existing achievements. If the forecast for the Sahel climate change and agricultural production are respectively a temperature increase of 3 °C, a decrease in rainfall of 20% and a decrease in yields of 20%, it is important to build strategies adoption of prior research in NRM (Reij *et al.*, 2009). It emerges from this synthesis of knowledge about the tree and its natural regeneration that investigations should be pursued:
On the current state of woody stand diversity through tree structure in order to determine their importance in arid and semi-arid.
To examine the timber stand types and their characteristics in rural arid and semi-arid.
To assess the benefits regeneration capacity of species in lands of arid and semi-arid.
To acquire more relevant information on native species and their uses
For a better appropriation of the producers perception of the current state of timber based on dynamics and species management in an attempt to propose models for more sustainable environmentally.

ACKNOWLEDGMENT

This work was performed under the project "farmers managed natural regeneration" of World Vision Senegal. It received financial support from the Australian Government (AUSAID) and technical.

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