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GUSAU-NIGERIA**INTERNATIONAL JOURNAL OF SCIENCE FOR GLOBAL USTAINABILITY****Farmer Managed Natural Regeneration (FMNR) of Trees for Climate Change Mitigation in Madaroumfa Village of Niger Republic**

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ABSTRACT

Climate change has numerous impacts on biodiversity at all levels of the ecosystem. It has been shown that adaptive management unlike most conventional reforestation projects typically based on ideas developed in the western world are the most effective ways of managing climate change in Niger Republic. The study is aimed at assessing Farmer Managed Natural Regeneration (FMNR) for climate change mitigation in Madaroumfa Village of Niger Republic. Semi structured interview was used to elicit information from a total of 70 respondents FMNR practising farmers in the study area. Findings of the study found that majority of the participants (94%) practice FMNR and raised over 90 plant species in two years. The species mostly raised include *Fadherbia albida*, *Magnifera indica*, *Combretum glutinosum*, *Acacia camphylacantha*, *Ficus thonningii*, *Azadiracht indica*, *Adansonia digitata*, *Butyrespermun parkii*, *Moringa oleifera*, *Parkia biglobosa*, *Acacia nilotica*, *Proposis Africana*, *Jathropha curcas*. On the local knowledge of climate change, 45 respondents are aware that the phenomenon is real and has certainly affected their area. Also, the farmers believed that FMNR has the propensity of mitigating climate change in the area. The study therefore recommended that such local techniques should be promoted through community-based approach and grass root education.

Keywords: Adaptive management, climate change, smallholder farmers**1.0 INTRODUCTION**

The Millennium Ecosystem Assessment (2005) concluded that: 'By the end of twenty-first century, climate change and its impact may be the dominant direct driver of biodiversity loss and changes in the ecosystem services globally'. Climate change is thought to be among the major current threats to biodiversity (Jetz et al., 2007), and by the end of this century large portions of the Earth's surface may experience climates not found at present (Williams et al., 2007). Climate change poses significant threats to biodiversity, including impacts on species distributions, abundance and ecological interactions (Ackerly, 2010). Climate change has created potential major threats to global biodiversity. Climate change will have a number of impacts on biodiversity, from ecosystem to species level (Reid, 2006). The impacts on biodiversity will vary from region to region. The most rapid changes in climate are expected in the far north and south and in mountainous regions (Reid and Swiderska, 2008). Recently observed responses by many species to climate change (Parmesan and Yohe, 2003) have led to efforts to quantify the impact of future climate

change on biodiversity. Climate change impacts are expected to be severe in dry, high-temperature regions where trees are at their adaptive limit and in confined islands of moist forest that are surrounded by drier land (e.g. moist forests in Australia; Williams et al., 2003). Whereas the ranges of some tree species are expected to expand, others will diminish.

Climate change may have already resulted in several recent species extinctions. Many species ranges have moved pole ward and upward in elevation in the last century (Parmesan and Yohe, 2003) and this is likely not to cease. The multiple components of climate change are projected to affect all pillars of biodiversity, from genes over species to biome level. Local communities are disaggregating and encompassing more warm-adapted species (Heller and Zavaleta, 2009).

Of climate change impacts, studies show that phenological changes in populations, including shifting breeding cycles or deferred peaks of growth periods, are decoupling species interactions. At the very basic level of

biodiversity, climate change is able to lessen genetic diversity of populations due to directional selection, genetic drift, population differentiation and rapid migration. As a consequence, the probability of population adaptation to new environmental conditions is reduced and thus the risk of extinction increases. Furthermore, altered species compositions and interactions are considered to directly affect ecosystem functioning and resilience (Parmesan, 2006). At a higher level of biodiversity, an altered climate could induce changes in vegetation communities that are projected to be large enough to affect biome integrity as a whole.

The Millennium Ecosystem Assessment predicted shifts for 5–20% of Earth's terrestrial ecosystems (Bellard et al., 2012). Subsequently, as droughts persisted, alarming evidence accumulated of more persistent reduction in rainfall (Hulme, 2001). Such a decline, if incorporated into scenarios of global climate change, has awesome implications (Rosenweig and Parry, 1994). Africa is one of the most vulnerable regions in the world to climate change. The historical climate record for Africa shows warming of approximately 0.7°C over most of the continent during the twentieth century; a decrease in rainfall over large portions of the Sahel (the semi-arid region south of the Sahara); and an increase in rainfall in east central Africa (Desanker, 2002). Over the next century, this warming trend, and changes in precipitation patterns are expected to continue and be accompanied by a rise in sea level and increased frequency of extreme weather events. Climate change scenarios for Africa indicate future warming across the continent ranging from 0.2°C (0.36°F) per decade (low scenario) to more than 0.5°C (0.9°F) per decade (high scenario) (Hulme et al., 2001).

It is now widely acknowledged that the impacts of the changing climate amplify existing unfavourable conditions for developing countries (Adejuwon et al., 2001). Accordingly, the generality of people from poor countries are more vulnerable and have less adaptive capacity to confront such changes (Swart et al., 2009). Relatively few detailed studies have been done on how adaptive management will help reduce the impact of climate change on

terrestrial plants in Africa, only very few done demonstrate the potential extent of certain indigenous practices in mitigating climate change the study area. For example, farmer managed natural regeneration could increase the adaptive ability of range of African communities. FMNR answers the dilemma which many conventional western forestry methods were unable to achieve (Rinaudo, 2010). This case study examines adaptation measures that have been implemented in the area. These include farmer managed natural regeneration (FMNR), a very simple practice whereby existing vegetation on degraded land is identified, managed and protected.

1.1 Climate Change Adaptation: Why FMNR?

Climate change and biodiversity loss are two of the greatest global threats to human well-being. An effective climate change response requires consideration of the role of indigenous strategies and potential impacts on, biodiversity and ecosystem management. In its Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) states with 'very high confidence' that human activities since 1750 have caused global warming. For the next two decades, says the IPCC, about 0.2 °C of warming per decade is projected. Among the many knock-on effects are a sea level rise of more than 50 centimetres by 2100. It is also likely that some 20 to 30 per cent of plant and animal species assessed will be at greater risk of extinction if the rise in global average temperatures exceeds 2-3 °C (IPCC, 2007).

Farmer Managed Natural Regeneration (FMNR) is the systematic regeneration of this 'underground forest'. Tentative steps to introduce FMNR were commenced in 1983, in the Maradi Region of Niger Republic. Twenty-seven years later, the results have been amazing, with FMNR being practiced in one form or another across Niger and beyond (Rinaudo, 2010). Because FMNR can become a grass roots movement, large areas of land can be 're-treed' rapidly and for little or no cost, resulting in increased bio-diversity and benefits to people (such as firewood and building material for household use or income generation) (Rinaudo, 1999). As explained in more detail below, the

benefits of FMNR were also seen to extend to the environment, soils, crops and livestock (Rinaudo, 2008). Since its introduction in Niger in 1983, it is now used across more than 5 million hectares (LEISA, 2007). In addition to FMNR, exotic and domesticated local plant species are being promoted.

According to Rinaudo (2008) Farmer Managed Natural Regeneration (FMNR) is a simple method of reforestation that consists of coppicing and pollarding the trees on farm. While engaged in FMNR, the farmer selects the stumps he wants to leave in his farm and decides how many shoots are wanted per stump. FMNR is an example of a climate compatible development practice that evolved through a partnership among grassroots stakeholders (in these cases, farmers), external experts and supporters. According to experts the *Faidherbia albida* parkland in the Diourbel region of Senegal stores 30 tons of carbon/ha (Cameron, 2011). Today, almost half of all cultivated land in Niger is studded by trees, shrubs and crops; between a quarter and one half of all farmers have adopted and promoted FMNR, and at least 4.5 million people are reaping the benefits – on approximately five million hectares of land. Local communities are moving from vulnerability towards greater resilience as FMNR brings increased crop production, income and food security to impoverished rural communities. There is also anecdotal evidence

to suggest that FMNR has climate mitigation benefits (Cameron, 2011).

1.2 Study Area

The Maradi department of the southern Niger is one of the eight Regions of Niger Republic. It is located in south-centre Niger, east of the Region of Tahoua, west of Zinder, and north of Nigeria's city of Katsina. Madaroumfa village is located between latitude $13^{\circ} 18.222' N$ and $13^{\circ} 18.223' N$ and longitude $07^{\circ} 09.521' E$ and $07^{\circ} 09.522' E$. Madaroumfa remains the largest administrative sub-division of the Maradi department (now province) which has a population of 9791 persons in 2001 census (Abdoul and Trémolières, 2007).

The climate of the study area is the 'Aw' type as determined by Koppen in which distinctive wet and dry seasons are caused by the fluctuations of the ITCZ (Inter-tropical convergence zone) or the ITD south to north (rainy season), vice versa (dry season) and meeting at a front. The peak of rainfall in such environments is always August as noted by Mortimore (2001) and the rainfall is mostly insufficient, unreliable and unpredictable (Mortimore, 1989). Temperature is more extreme in the Maradi area during the dry season reaching over $42^{\circ}C$ in the day (travellingluck.com). The distribution of rain in the Maradi department greatly influences vegetation resources of the area

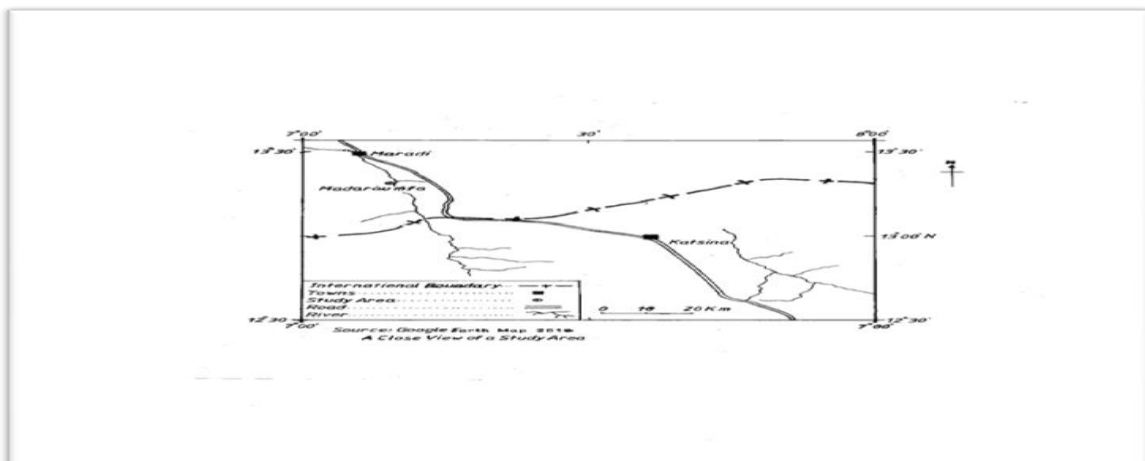


Figure 1: Showing of Madaroumfa Village

The vegetation of parts of Maradi (where Madaroumfa is situated) is composed of

indigenous species which grow spontaneously. The trees found include *Parkia biglobosa*,

Adansonia digitata, *Khaya senegalensis*, *Fadherbia albida*, *Tamarindus indica*, and *Borassus aethiopicum*, and exotic species *Azadirachta indica*, *Eucalyptus camaldulensis* (Danjuma, 2010).

2.0 MATERIALS AND METHODS

2.1 Sampling Procedure

A list of smallholder farmers enrolled by the community based agricultural scheme was obtained from the chief de canton of Madaroumfa (350 farmers) in July, 2014 and

updated in 2018 (1750 farmers) (Table 1). This list was used as sampling frame from which participants for the study were sampled. For fair representation, the sampling frame was sorted into three strata three based on number of years spent by participants utilising FMNR in Madaroumfa village and their gender. Using systematic sampling procedure, any 5th order individual (in the male and female strata) was sampled. This gives a total of 70 participants (58 males and 12 females respectively) (Table 1).

Table 1: Sample of Interview Participants

SN	Number of Years Utilizing FMNR	Males	Females
1	0-5	80	24
2	6-10	99	30
3	11-15	111	06
	Total	290	60

2.2 Procedure for Data Collection and Analysis

Semi-structured interview checklist which comprises of 10 questions was used to elicit information from the participants. Data collected

was analysed using percentage and discussed in appropriate sections.

3.0 RESULTS

This section presents the findings of the study and discussion in appropriate sections.

Table 2: Local Perception on the Impact of Climate Change

SN	Perceptions on Impact	Number of Participants	Percentage
1	Adverse	270	77.14
2	Mild	59	16.86
3	No effect	8	2.29
4	Don't know	13	3.71
		350	100.00

Table 3: Level of Participation of FMNR

Respondents	Gender		Total	Patronage/Group	Remarks
	M	F			
Group A	19	4	23	23	Including all female respondents
Group B	20	4	24	22	Including 2 female respondents
Group C	19	4	23	21	Including 2 female respondents

Table 4: Type of Species raised Through FMNR

Respondents	Type of Species raised by Interview Groups
Group A	Fadherbia albida, Magnifera indica, Combretum glutinosum, Acacia camphylacantha, Ficus thonningii, Azadirachta indica, Adansonia digitata,
Group B	Fadherbia albida, Magnifera indica, Butyrespermum parkii, Moringa oleifera, Azadirachta indica, Parkia biglobosa,

Group C Azadirachta indica, Parkia biglobosa, Adansonia digitata, Acacia nilotica, Proposis Africana, Jathroph curcas

Table 5: Benefits of FMNR in Madaroumfa Village

Benefits	No. of Respondents	Remarks
Ecological	26 (including 3 females)	Control of erosion, pollination, increase water retention on farms, increase organic manure along tree dense areas,
Socio-economic	44 (including 9 females)	Animal Fodder, income from products marketing, source of medicinal products, source of seed (gene bank), increase yield of crops noticeable around <i>Fadherbia albida</i> and other nodule plant

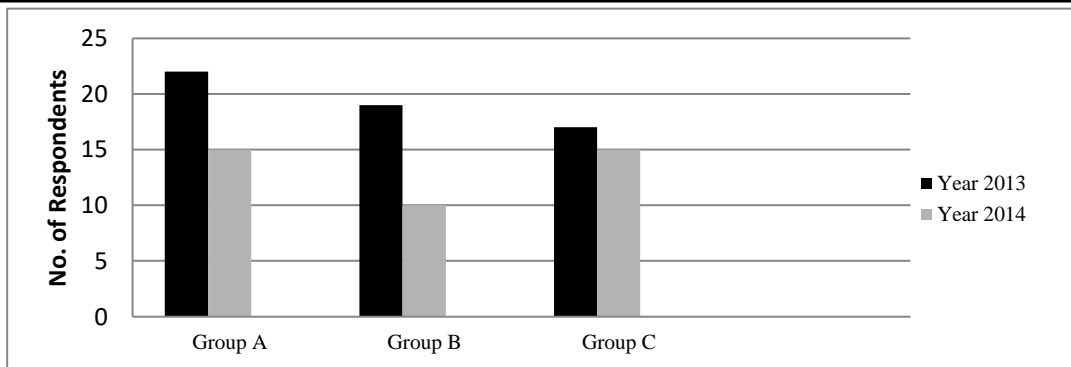


Figure 1: Number of Trees Raised by Participants

4.0 DISCUSSION

Local perceptions on climate change were studied in the area with a view to determine responses of the interviewees on the issue and possible impact. A total of 45 respondents are aware of the phenomena even though they cannot explain what it means as a concept of international debate. Figure 2 below shows respondents’ perceptions on the impact of climate change in the area.

About 90% of the respondents are aware that the climate has changed but could not clearly explain what that means. They believed that climate in terms of rainfall, temperature and harmattan components have already change and has adverse effects on their lives. They maintained that amount of rainfall has shrunk this year and the season shortened from the usual four months to less than that. This to some respondents has lasting effects on farming systems and the type of trees planted in the area. In spite of the early warnings and proper planning, this year (2018) was a bad as per as

regeneration activities are concerned. These responses are in line with most studies conducted in this decade about climate change in the Sahel. An exposure to gradual climate change mainly temperature and precipitation and extreme climate changes such as drought and flood significantly impacted the performances of agro-biodiversity and the effectiveness of the traditional cropping mechanisms on Ethiopian farmers (Deressa et al., 2008).

These drivers are obtained from the informal interview conducted with some key informants (Malam Gambo, pers.comm. 2018).The drivers were listed down after which we categorise them in Figure 3 based on the responses obtained during interviews.

In table 3 the respondents vary in terms of drivers of climate change in the area. The result showed that 70% of the respondents believed it is the acts of God while the remaining attributed it to increasing human activities in the area such as urbanisation, land use and population

dynamics. This is in line with Tiffen (2001) and Mortimore et al. (2001) who reported that the high population trends of the area are consistently high and has effects on the environment in terms of degradation especially where the density is more than 100 persons per km². Results indicated that even with stiffer forest laws and heavy fines on defaulters, illegal cutting of species is still a driver of climate change. Species in the forest fields far from the compounds are constantly deforested for various reasons to include wood fuel, construction and wood marketing. This study is in consistence with the result of many previous studies on drivers of vegetation change. Notably, Kowero, Njuki and Nair (2009) found out that deforestation and land use change are the main drivers of forest and species change in Africa. Raynaut et al., (1988) also contended that diminished rainfall was causing a loss of biodiversity as Sudanian species of trees and grasses retreated southwards before a more Sahelian flora. Reid and Swiderska (2008) maintained that poverty is the main driver of biodiversity loss and coupled with climate change, species are most degraded. It is difficult to separate the effects of grazing (and cutting) from those of the droughts which have ravaged the area since the early 1970s (Mortimore et al., 2006).

Results indicated that almost all respondents practice FMNR in the area. This is not surprising because it has been in existence in area since 1983 and its benefits are recorded in all areas of Maradi including the study area. It was further revealed that the practice is not male dominated but rather mixed with even the females more into it. A total of 66 respondents of the 70 interviewed engage into FMNR in various responses they offer (Table 3). It's a good indicator of both patronage and adaptive strength of the practice.

In spite of the shortcomings of the authoritarian forestry codes of Niger (remnants of French laws), observations across Madaroumfa show that although naturally species are becoming increasingly protected by farmers and tree densities are now rising on farms (Moussa, 2000). The practice of *défrichement amélioré* (FMNR in French) (Joet et al., 1996) is widespread across the Maradi department,

especially in its northern parts around Madaroumfa (Awaiss, 2000). This practice, which consists of protecting valuable species when clearing land for cultivation, is an indigenous form of management that was promoted by the PDRM and forestry services during the 1980s (Mortimore et al., 2001). In fact, farmers actively manage the selective preservation of tree shoots and trees, and the harvest of bushes, on their fields.

The trend now is to preserve more shoots until they grow to their full tree height (Moussa, 2000). In order to support farmer to practice FMNR, over the past decade, naturally regenerating woody species have begun to receive a greater level of protection through national legislation (Mortimore et al., 2001). The practice of protecting naturally regenerating trees on farmland has become widely accepted in Magami and Serken Hausa. In Dan Kulu, the most marginal of the villages, many tree species and perennial grasses here reach or pass the northern limit of their distribution (Mortimore et al., 2006). In Niger, the widespread adoption of FMNR was similarly facilitated by the governments and NGOs (WRI, 2008). In the Maradi region, FMNR practices have also allowed to developed new profitable activities, such as beekeeping (WRI, 2008).

Though increasing tree densities of vegetation are recorded in the Maradi Area as a result of protecting natural tree regeneration (*défrichement amélioré*), villagers recognised that this does not necessarily result in a much more diverse flora. However, there is high diversity of species in Madaroumfa which are conserved for long through ancestral techniques such as FMNR. This is in conformity with several studies of biotic strength of the area. Awaiss (2000) mentioned that biodiversity among tree species is apparently greatest in the northern parts of the Maradi department (Figure 1), where *défrichement amélioré* is most widespread.

Although literature is filled with the outcomes of FMNR in Niger Republic, it has not yet provides site specific number of local practitioners that embrace the practice. FMNR was started in 1983 in the Maradi area and since then, many

individuals were said to have engaged into the system in Niger Republic. Mortimore et al. (2006) reported that the practice of protecting naturally regenerating trees on farms is known to all farmers in Niger Republic and this create awareness of threatened species and the economic value of trees as well as the evolution of integrated, small-scale cropping and silvicultural systems.

Table 4 depicted that FMNR has been tool of species management in the area. Interview with all groups revealed that the technique is cherished by many because its cost effective and already improving yields and income of the farmers. Most species raised were found to be resilient ones which is an indication of their wide knowledge of the changing ecological conditions of the area. It also further showed that despite unpromising economic and climatic conditions of the area, people were able to adapt by holding to their ancestral techniques. A study conducted by Danjuma (2010) found out that there are more than 78 indigenous woody species of various socio-economic and ecological values in Madaroumfa which are relatively managed through FMNR in the area. Among them, the Acacias, Fadherbia and some enclave species (*Citrus spp* and *Psidiumguajava*) are most cherished because they form part of livelihood of the rural population of the area. Thus species tending is a usual practice of the area even without stiff laws as people of the area are conscious of the benefits of vegetation for long. Among species eventually raised through natural regeneration in several studies e.g Joet et al. (1998), Danjuma (2010) and Larwanou (2011) are: *Acacia nilotica*, *Adansoniadigitata*, *Annona senegalensis*, *Azadirachta indica*, *Bauhinia rufescens*, *Detariummacrocarpa*, *Faidherbiaalbida*, *Ficus gnaphalocarpa*, *Prosopis africana*, *Khaya senegalensis*, *Mangifera indica*, *Tamarindus indica*, *Terminalia spp*, *Ziziphus mauritiana*, *Ziziphus spina-christi*, *Citrus spp*, *Eucalyptus spp* and *Psidium guajava*.

FMNR is a practice with the potentials to adapt to climate change while positively impacting the welfare of communities. Despite several benefits little known or appreciated as far as FMNR is concerned. It has enormous ecological and

socio-economic values that compel practitioners to its practice. The practice is increasingly becoming widespread as estimates from high-resolution images acquired during 2003 to 2008 put FMNR at nearly 5 million hectares (Reij, Tappan, and Smale, 2009).

Table 5 was able to add to the literature that although ecological and socioeconomic benefits of FMNR as commonly reported, benefits such as pollination are rarely mentioned in areas where the practice is widely in existence. Individuals noted that farm yields are better where there are more trees, partly because leaf litter contributes to soil fertility but also because trees reduce wind speed and soil erosion (Mortimore et al., 2006). At a time of unprecedented forest destruction and increased demand for agricultural land, FMNR has much to offer not only Africa but also the world. Rinaudo (2010) mentioned that because of FMNR, large areas of land can be 're-treed' rapidly and for little or no cost, resulting in increased bio-diversity and benefits to people in form of firewood and building material for household use or income generation.

In a twelve-year period, it was conservatively estimated that US\$ 600,000 worth of wood was sold as a result of practising FMNR in Maradi(1994-1997 MIDP Summary Report)and by 2008, total gross income in the region had increased by between 17 and 21 million dollars per year due to FMNR (Haglund et. al, 2009).Using satellite imagery, researchers at the United States Geological Survey have been able to identify where tree densities and tree cover in Niger have increased over time and where these changes are likely attributable to FMNR. One of the more immediate and obvious benefits of FMNR is the availability of fuelwood from pruned tree branches. FMNR has had especially important benefits for women, who have been relieved significantly of the burden of gathering fuelwood, with average time spent on fuelwood collection falling from 2.5 hours to half an hour.

Number of trees raised in various parts of Niger Republic courtesy of FMNR differs along major issues such as proper knowledge of the technique and commitment to it. While certain areas fails to achieve more, most have taken its

advantage and raised many trees per farmland/area.

Despite erratic nature rainfall in 2013 and 2014 as mentioned by the respondents, number of species raised in the area is better. Most of the respondents have raised one or more than in their farms using silvi-cultural techniques and enclaves so as to stop animals from browsing it during the dry seasons. Not less than 10 species are raised by the three groups in the rainfall seasons of 2013 and 2014 as indicated in figure 2. This shows the level of acceptance of the technique among the farmers and further demonstrates adaptive strength of coping with climate change impacts on plants in the area. In an area, east of the village where continuous cover of *Fadherbia albida* trees over take the landscape and farmlands are more fertile, more than 20 trees are raised as indicated in figure 2 (Group A).

This is not new revelation in Maradi area because in a study by Mortimore et al. (2006), the number of woodland and grassland species identified in the Maradi region is reported to be >400 and in 1984. However, sequel to the famine of 1984 in Maradi, some 500,000 trees was managed through FMNR in approximately 100 villages. This increased to about 2,000,000 trees in 1988 through a second food-for-work program. These records have provided sufficient evidence that since the start of FMNR in 1983 and its promotion by the PDRM (Projet de Developpement Rural de Maradi) densities of trees and shrubs raised on farms have increase dramatically. This has been a success story in an else while much discussed degraded region of West Africa. FMNR has dramatically changed the landscapes of West African Sahel from bare lands to woody and better profiles.

5.0 CONCLUSION

Obviously, FMNR is key to how well people can adapt to climate change. People must be able to adapt in an appropriate way towards increasing knowledge, raising public awareness and responsibility and thus towards changing conditions. Adaptive management systems as well as farmers' innovations are clearly at the cutting edge in climate change mitigation. While scientists and policymakers work to find

solutions, local farmers have already amassed considerable experience of how to cope, based on their observation and experimentation in the field. Yet compared to activities such as agroforestry and farmer managed natural regeneration, widely noted as a way of sequestering carbon and cutting greenhouse gas emissions, biodiversity conservation is a neglected area. That must change: urgent support is needed for local solutions to biodiversity loss that provide benefits on all counts.

A lingering global crisis has to be addressed by formulating institutional frameworks on governing biodiversity and climate change. Such are in place; the establishment of the Convention on Biodiversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC) but could not suffice in the on-going and unprecedented biodiversity-climate change nexus. The framework should concrete the construction of various global networks as well as through national and local initiatives. The local stakeholders should be the gear with which all efforts should move with in as much as good intention of saving biodiversity is the objectives of all.

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