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Article (Accepted Version)

Usman, Muhammad and Nichol, Janet (2019) Trends in farmland tree stocks in the agroforestry landscape of northern Nigeria: reconciling scientific and stakeholder perceptions. *Journal of Rural Studies*, 66. pp. 87-94. ISSN 0743-0167

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Trends in farmland tree stocks in the agroforestry landscape of northern Nigeria: reconciling scientific and stakeholder perceptions

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Abstract

A previous study indicated at least a doubling of farmland tree densities over five decades in the agroforestry landscape surrounding Kano, the largest city in savanna Africa. This increase, observed from field and remote sensing surveys, is surprising in the face of unprecedented population growth and availability of cheap manufactured substitutes for tree products. It also conflicts with the regional narrative for West Africa, derived mainly from observations and farm questionnaires, which suggests deforestation and reduced tree densities. This mismatch has previously resulted in failed initiatives to combat ecological crises, as extension services conceived at national and international level have met with little support and non-implementation at household level. To investigate the apparent mismatch we administered on-farm questionnaires in 55 villages. Open questions about trends in farmland tree stocks over several decades indicated declining tree stocks, but closed questions requiring tree enumeration and counting, indicated increase. Responses indicated difficulty in distinguishing between concepts of 'tree numbers' and 'tree species', as declining tree species diversity was reported by almost all responses, resulting from fuel wood demand and market trends towards a cash economy. This lack of distinction between tree species and tree numbers appears due to the traditional place occupied by farm trees in Hausa culture, where a tree species is inseparable from its use, combined with a deep sense of unease at the loss of cultural values. The study indicates that, despite more trees, the wide range of 'hungry foods' available from tree products, may no longer be available to alleviate future droughts, as during the 1970s and 80s, when productivity of agricultural and woody biomass plunged. However, initiatives to improve rural livelihoods may need to balance empirical observation against understanding of the complexity of stakeholder perceptions, as in this case overall tree stocks appear healthy, and the decline species diversity is of greater concern.

Keywords: Stakeholder perception; tree density; globalisation; population growth; northern Nigeria

1. Introduction

Over the last three decades globalization has exerted unseen and often insidious pressures on rural economies in the developing world. Manufactured commodities available as cheap imports from developed countries have led to the shaping of rural landscapes externally and unpredictably. Such pressures, if accompanied by others such as population growth, declining land availability, climate change and government policies, may lead to change in traditional land management practices with associated loss of cultural heritage, and declining quality of life for rural households.

Government policies and response to external economic pressures filter down to grassroots level, triggering livelihood responses among rural households, affecting traditional ways of life. Understanding these responses and their impacts on land management practices is important in rural economies where biomass productivity is fundamental to basic survival. The added

pressures of climate change and population growth represent direct challenges to rural households. However it is how these combined threats are perceived at grassroots level, which changes behaviour, and such perceptions may not accord with external empirical observations.

Since the West African droughts of the 1970s and 80s, satellite data have been used to assess whether or not land degradation has occurred under pressures of population growth and variable climate. Case studies in the Sahel zone have first asserted (Tucker et al, 1991; UNEP, 2007), then revoked the theory of human-induced desertification, the latter based on an observed greening following the drought decades (Olsson et al, 2005; Anyamba and Tucker, 2005; Seaquist et al, 2006; Heumann et al, 2007).

By far the majority of studies of biomass trends in West Africa have been in Sahelian countries (Knauer et al, 2014), where mean annual rainfall is 75-600 mm and grazing of perennial grasses and woody shrubs is the main land use activity. Few studies are available for the moister and much more densely populated Sudan zone, where the main vegetation is dry savanna woodland. This study investigates trends in the agricultural landscape surrounding Kano, in Nigeria's Sudan zone, and the largest city in savanna Africa. The study is based on observations of trends in farmland tree stocks over the past five decades using archived aerial photographs and recent satellite images, and compares the results with farmers' perceptions of those trends, from on-farm questionnaires.

2. Background

2.1 Trends in farmland tree stocks

In the area of interest in the current study, the Kano area of northern Nigeria, aerial photographs and field enumeration between 1972 and 1981, indicated an approximate 23% increase in tree densities surrounding the city, and slight decline in the outer hinterland (Nichol, 1989; Cline-Cole et al, 1990a). However, these data were collected in the early 1980s before the full effects of the 1970s to 80s drought on tree stocks, and when population was less than half that of today. Indeed the population more than doubled to 2.83 million, between 1991 and 2006, with a young population indicating potential for further growth. More recent reports from farm questionnaires have indicated declining tree stocks around Kano (Maconachie and Binns, 2006; Maconachie et al, 2009), where 82% of households surveyed reported a decline in tree numbers on their farms due to population growth, urbanization and competition for resources. This work appeared to confirm observations from the Sahel region where significant declines in tree cover in the later decades of the 20th century had been reported (Brandt et al, 2014; Gonzalez et al, 2012; Hanke et al, 2016). The authors remarked that respondents appeared to have radically different perception of the environment than our own earlier studies from the Kano region (Nichol, 1989; Cline-Cole et al, 1990a; 1990b) which suggested that tree densities actually increase with greater population densities. However, they cited the earlier work as being conducted before the onset of globalisation, and recent massive urbanization. These considerations led us to expect that a repeat remote sensing and field enumeration survey would find reduced tree densities across northern Nigeria, and especially in the densely populated Kano Close Settled Zone.

However, when the survey was repeated in 2016 (Usman and Nichol, 2018) we observed a surprising increase in tree densities surrounding Kano from the 1960s pre-drought period,

continuing through the 1970s to 80s drought years and up to 2016, with more than doubling in two study areas and tripling in a third (Table 1 and Figure 1). To understand why our results conflicted with recent reports of declining tree stocks in west Africa, and Kano region (Maconachie 2013; Maconachie et al, 2009; Naibbi and Healey, 2013), and to examine the dichotomy between empirical observation and stakeholder perception, we conducted follow-up questionnaires.

PERIOD	PRE-DROUGHT	DROUGHT PERIOD		POST-DROUGHT	
	1967	1981	1981 Field survey	2014	2016 Field Survey
Study Area 1	12.5	14.9	12.3	19	25
Study Area 2	5.6 (1972)	5.9	NA	11 (2013)	13
Study Area 3	7.8	10.6 (1992)	6.5	20.9 (2015)	22

Table 1. Tree Density from field survey plots and aerial photographs (trees/ha).

2.2 The perception-reality debate

Few studies have examined how external economic and environmental pressures on indigenous farming communities are perceived at household level, but of those available, local perceptions may conflict with those of independent observers or with physical records (Darvill et al, 2015; Zhang et al, 2016). This may lead to inappropriate or unnecessary response on the one hand (Cebrian-Piqueras et al, 2017), or lack of response when one is needed (Ruiz-Frau et al, 2018). Thus Enete et al (2011) report that farmers in Southeast Nigeria agree that variables associated with desertification such as, droughts, heavy winds, decreasing soil moisture and soil erosion have increased, but that they do not perceive desertification to be occurring. Mayekiso et al (2017) note that while indigenous farmers in south Africa perceive leafy green vegetables to have positive health benefits they are reluctant to grow them due to their cultural perception as food for old and poor people, and their perception as weeds. Amos et al (2015) reported that all farmer respondents in Southeast Nigeria perceived an increase in temperatures over recent years, whereas in fact local temperature records show no significant increase. They attribute the discrepancy to increasing humidity affecting comfort levels, coupled with the high vulnerability of the farming population to adversities of climate. All farmers in the study were considered to be highly vulnerable to climate change, and reported that they were financially incapable of combatting its effects. Studies by Mulenga et al (2017) in Zambia and Simelton et al (2013) in Botswana and Malawi contribute to this perception-reality debate, as they reported that farmers described increasing length of dry spells and decreasing length of the growing season, whereas climatic records indicated no change. Mulenga et al (2017) attribute the discrepancy partly to farmers feeling obliged to conform with dominant narratives on climate change, even if they have not perceived any change in climate. Another explanation for the conflicting views is that both farmers' recollections as well as climate records are correct, but they reference different phenomena. As factors affecting crop yield are foremost in farmers' minds, it may be difficult to

distinguish these from other factors. In Northern Nigeria interventions by international organisations, in providing free seedlings and establishment of village woodlots has been attempted in the past (Hyman, 1993; Borokini et al, 2012). For example, a World Bank project between 1979 and 1984 distributed free seedlings, of which the survival rate was only approximately 20 %, as most were never planted or given adequate care and protection from cattle, and many farmers used the soil in the plastic pots as fertilizer for annual crops (Hyman, 1993). Meijer et al (2015) report that extension workers promoting uptake of technological improvements, had more success when they were aware of differences in perception by farmers, and took them into account when promoting their use.

2. Materials and Methods

2.1 Study area

The research was conducted in three study areas surrounding Kano city (Figure 1), which is situated at 12° N in the northern Sudan Zone of West Africa. Kano's mean annual rainfall of 750 mm, supports a natural vegetation of tree savanna, with flat-topped trees browsed by savanna fauna and livestock, when grass is unavailable during the October to April dry season. Rainfall is highly variable both inter-annually and on a decadal timescale (Figure 2). Severe drought in the 1970s and 80s was experienced throughout West Africa, but rainfall in Kano appears to have recovered to 1960s levels (Figure 2). The Kano Close Settled Zone (Mortimore and Wilson, 1965) describes the densely populated agricultural region influenced by the proximity of Kano and serving as its hinterland in terms of interdependency of products, trade goods and services. Over 80% of land is cultivated in the April to September rainy season, with main subsistence crops of Guinea corn, Millet and Sorghum. The 'parkland' landscape is defined by the large variety of trees propagated and maintained on farmland, which are used for a very wide variety of purposes including medicinal use, food, fibre, construction and as fuelwood (Boffa, 1999; Timberlake et al., 2010). Traditionally, goods were brought to Kano markets by donkey, limiting the fuelwood hinterland to around 50 km, but replacement by pickup trucks over the last two decades has expanded this to over 100 km. Previous farm questionnaire studies in the Kano Close Settled Zone (Maconachie and Binns, 2006; Maconachie et al., 2009; Maconachie, 2013) indicate that farmers perceive declining tree cover on farmlands, as well as reductions in tree species diversity in recent decades.

Figure 1. Climatological zones of West Africa showing location of study areas.

Figure 2. Annual rainfall amount and the five-year moving average at Kano, Northern Nigeria, 1916 to 2010. Source: International Institute for Tropical Agriculture (IITA), Kano station (Mortimore, 2000).

Three study areas (Figure 1, Table 1) were selected within Kano's hinterland as follows. Study area 1, Kano West extends westwards from Kano city covering 100 km², and Study area 2, Kano East is situated in the region of the Jakara river, 30 km northeast of Kano city and covers 110 km². These two study areas represent the long-established Kano Close Settled Zone of intensive agriculture and high rural population within a day's walking or donkey distance from the city market. They were selected based on their geographical differences, with mainly red, well-drained sandy loam soils in Kano West. In Kano East dominated by the Jakara river lowlands

draining into the Hadejia river and ultimately, Lake Chad, soils are heavier, yellow-red to grey in colour, with more clay. Study area 3, Daura, covering 200 km², was selected farther north bordering the more arid Sahel Zone, where only approximately 60-70% of land is cultivated, compared with over 90 % in Kano West and Kano East. At 100 km north of Kano, Daura area has become a source of rural produce by pickup truck for Kano city over the last two decades.

2.2 Methodology

2.2 Questionnaire survey

Individual and group questionnaires were administered to farmers in 55 villages within the three study areas (Table 2). Farmers over the age of 50 were selected, to allow for recollection over previous decades. The survey was conducted by local field assistants in the local language, Hausa. Initially, in the first questionnaire (QR1) 10 questions were asked (Table 3), then based on the results of (QR1), three subsequent more focused questionnaires (QR2, QR3, and (QR4), containing only 4 questions about trends in tree numbers, were administered (Table 4). This was because the main questionnaire objective was to verify and confirm the increase in tree densities observed in our previous study, both before, during and following the 1970s to 80s drought period (Table 5). In particular, those results failed to support the regional narrative on woody vegetation i.e.. significant declines in tree cover in the later decades of the 20th century in the Sahel region (FAO, 2011; Brandt et al, 2014; Gonzalez et al, 2012; Hanke et al, 2016), as well as recent reports from the Kano region based on on-farm questionnaires, which indicated declining tree densities (Maconachie and Binns, 2006; Maconachie, 2013; Naibbi and Healey, 2013).

The first questionnaire (QR1) included 10 questions, with the objective of obtaining a general understanding of stakeholders' perceptions of changes in tree numbers and species composition. It also aimed to understand the current role of trees in the rural economy, given firstly the continued reliance on fuelwood for energy, in both urban and rural households, and secondly the growth in availability and decreased cost of market products. These market trends would be expected to decrease the importance of trees to rural households, resulting in declining tree numbers and/or a shift in species composition. The second, third and fourth questionnaires were a direct response to answers received in the preceding questionnaires, as it was perceived that farmers had difficulty distinguishing between the concepts of 'tree species' and 'tree numbers'.

	Type	Study area	No of questions	No of responses
First (QR1)	Group	2. Kano East	10	2 groups (2 villages)
First	Group	3. Daura	10	12 groups (5 villages)
First	Individual	1. Kano West	10	20 (10 villages)
First	Individual	3. Daura	10	12 (10 villages)
Second (QR2)	Individual	1. Kano West	4	20 (6 villages)
Third (QR3)	Individual	1. Kano West	4	50 (10 villages)
Fourth (QR4)	Individual	2. Kano East	4	36 (12 villages)

Table 2. Details of field questionnaires administered.

1	Do you sell wood for fuel? “How much wood do you use compared with what you sell”?
2	In the next few years, do you want more or fewer trees on your farm?
3	If you plant or grow any new trees, what species would you chose?
4	Why would you choose this species?
5	What things can you buy in the market now that you used to get before, from trees?
6	Which one is best? Is the product from trees better or is the market one better?
7	Are there changes in number of trees on your farm over the last 20, 30, 40 or 50 years?
8	Are there changes in species of trees over the last 20, 30, 40 or 50 years? –which species are fewer now and which are more common?
9	What are the reasons for the change in species of trees?
10	Is the climate is different now from 20, 30 or 40 years ago? How is it different?

Table 3. Questions in First Questionnaire (QR1)

1	Are there changes in species of trees over the last 20, 30, 40 or 50 years? –which species are fewer now, and which are more common?
2	What are the reasons for the change in species of trees?
3	Are there changes in total number of trees on your farm over the last 20, 30, 40 or 50 years – are there more total trees now or fewer trees now?
4	What are the reasons for the change in total numbers of trees?

Table 4. Questions in Second, Third and Fourth Questionnaires (QR2, QR3 and QR4).

3. Results

Results of the questionnaires are discussed below and summarized in Appendices A-D.

3.1 Changes in the number of trees on farmland

The high value which farmers have traditionally placed on trees and their products was evident from question 6 which asked farmers if they prefer market bought, or tree products, with 92% stating either an outright preference for tree products, or that they prefer market products only because tree products are no longer available (Appendix A). Question 5 identified such products, including stock cubes and spices replacing the African locust bean (*Parkia biglobosa*) for soup stock, polyester stuffing replacing kapok from the silk cotton tree (*Ceiba pentandra*), Vaseline and other skin products replacing the shea tree, (*Vitellaria paradoxa*, Vitamin C replacing tamarind, (*Tamarindus indica*) and baobab, (*Adansonia digitata*), sweets replacing the black plum (*Vitex doniana*), and manufactured glues replacing gum Arabic (*Acacia nilotica*). These responses would be consistent with a decline in tree numbers on farms due to tree products now being inessential, despite being preferable. However, for Question 7 which asked about changes in tree numbers over recent decades, only 28% stated reduction in tree numbers, and all others gave an ambiguous response, with many farmers mentioning tree species rather than tree numbers and listing those species which had disappeared. For example when asked about changes in numbers of trees on the farm over recent decades, one typical reply was “Yes, over the last 40-50 years there were more tree species than nowadays – even the horseradish tree, (*Moringa oleifera*) cannot be found.” In the group discussions in study area 3, all 5 farmer groups answered the question about trends in tree numbers by listing traditional species which had disappeared, without differentiating between the concepts of ‘tree numbers’ and ‘tree species’.

3.2 *Changes in the species of trees on farmland*

Farmer responses to the question about changes in species of trees were markedly similar to the question about changes in numbers of trees. When asked about changes in species of trees, 100% of farmers stated the disappearance of traditional species, including the silk cotton, *Ceiba pentandra*, *Vitellaria paradoxa* (shea), *Faidherbia albida*, *Parkia biglobosa* (African locust bean), *Vitex doniana* (black plum) and *Moringa oleifera* (horseradish tree) and their replacement with new species especially Neem (*Azadirachta indica*), Camel's foot tree, (*Piliostigma thoningii*), and Mango (*Mangifera indica*). Reasons given for the shift in species more often than not, did not satisfy the question about species, but seemed to be about tree numbers. For example, reasons given for shift in species were better able to explain fewer trees than species shift, including the need for more farmland, to make space for crops or new settlements, and population increase. The single most common reason given however was the high demand for fuelwood.

In order to clarify evident ambiguity in distinguishing between tree numbers and tree species, we decided to administer a second, simpler questionnaire (QR2), with only four questions which focused on either tree numbers on the one hand, or tree species on the other (Table 4).

3.3 *Second questionnaire*

The second questionnaire (QR2) was administered to 20 farmers in 6 villages in Kano West, but ambiguity was still present in the responses, with 13/20 ambiguous responses to question 1 about the number of species, and 10/20 ambiguous responses to question 3 about tree numbers (Appendix B). For example, when asked if tree numbers had changed over recent decades, one farmer stated "Thirty years before there were 22 species of trees, now there are fewer tree species only 8 in number".

3.4 *Third and fourth questionnaires*

The third questionnaire (QR3) was administered to 50 farmers in 10 villages in Kano West, with the same four questions, but the questioner was instructed to prompt farmers to give an estimate of the actual numbers of trees and species previously and now.

As with the first and second questionnaires, almost 100% of farmers pointed out that the number of tree species had reduced. However, ambiguity was still evident for Q3 "Have you noticed any change in the total number of trees on you farm; are there more total trees now, or fewer trees now?" The responses were again similar to the response to question 1 about change in tree species. Typical responses to Q3 were "There are 8 different species, now reduced to 5 species, which adapt and tolerate the environment, and multiply faster and increase the tree population", and "Several species were on the farm in olden days, but due to environmental changes some species faded away, leaving the tolerant ones to multiply", and "Yes, there are 7 species of tree on the farm now reduce to 4 species which now adapt to the environment and multiply to 15 trees on the farm". Many farmers continued to list the traditional species which had disappeared, although they had already listed these in their response to question 1 which specifically asked about species. In spite of the ambiguity however, 34 out of 50 farmers (64%) now indicated that tree numbers had increased (Appendix C).

These responses indicated that concepts of ‘tree’ and ‘species’ were inseparable to indigenous farmers, due to the importance of trees in the local culture, and at a time of insecurity due to the perceived loss of valuable assets, loss of species was foremost in farmers’ minds. To confirm this we administered a fourth questionnaire (QR4) in which the enumerator would explain the difference between tree numbers and tree species, and request farmers to count the actual numbers of trees on the farm in previous decades and now. This fourth questionnaire, interviewed a total of 36 farmers in 12 villages in Kano East study area. The results were less ambiguous in that farmers now distinguished between trees and shrubs, and gave specific answers about tree numbers and tree species. A total of 25 out of 36 (69%) of farmers indicated that tree numbers had increased (Appendix D), the answers indicating an average 20 % increase in tree numbers. The main reason given for the increase in numbers was a demand for income from farm implements and fuelwood. Also that trees regenerating naturally were allowed to grow. Reasons for declining numbers were mainly to make space for crops, new buildings or settlements, and to remove thorny trees.

Round of questionnaire	QR1	QR2	QR3	QR4
Number of questionnaires	46	20	50	36
% respondents stating tree <i>species</i> increased since 20-50 yr ago	0%	0%	0%	0%
% respondents stating tree <i>species</i> decreased since 20-50 yr ago	69% *	55%*	96%	97%
% respondents stating tree <i>number</i> increased since 20-50 yr ago	0%	0%	68%	69%
% respondents stating tree <i>number</i> decreased since 20-50 yr ago	30%*	20%*	32%	29%

Table 5. Percentage of farmers stating change in tree species and numbers. *Many responses ambiguous so percentage uncertain

4. Discussion

4.1 Overall interpretation of questionnaires

The difficulty of differentiating concepts of tree numbers and tree species was evident throughout the series of questionnaires, but was facilitated when further prompted to think in terms of number counts. Thus both QR3 and QR4 returned a clear majority of farmers stating an increase in tree numbers over past decades (Table 5), which was more in agreement with our field and remote sensing observations, although still not supporting our observed doubling in study areas 1 and 2, and threefold increase in study area 3. The fragmentation of land due to population growth may explain some of the remaining mismatch, as many respondents now have less land area (Maconachie et al, 2006). The lack of distinction between tree species and tree numbers also appears due to the traditional place occupied by farm trees in Hausa culture, where a tree species is inseparable from its use. For example, local people add ‘Dorawa’ to soup, and put ‘Kadanya’ on skin, ie. the ‘tree’ is the product. In northern Ghana the importance of Dorawa (*Parkia biglobosa*) is linked to social status, with Dorawa owners holding superior social rank (Tomomatsu, 2014). The replacement of these traditional staples by cheap market products such as stock cubes replacing *P. biglobosa* and Vaseline replacing *B. paradoxum*, represents a loss of autonomy, in that households now have to raise cash to procure these items, mainly through wood sales. The initial questionnaire result (QR 1 and 2) suggesting declining tree densities, may also result from a defensive response to outsiders, as deep unease about changing ways of life, heritage loss, and uncertainties of climate and economic forces, farmers are reluctant to indicate that they are happy with their situation. As Cline-Cole remarked, field foresters in Kano region

were reluctant to admit that claims of healthy tree stocks were unlikely to attract assistance from donor and funding agencies (Cline-Cole, 1998).

On the other hand, questions 1 and 2 about trends in tree species and reasons for this, obtained similar responses for all four questionnaires (Table 5), with all farmers indicating a decline in species and loss of many valuable traditional species. This species shift and decline in biodiversity has been noted from studies in the less densely populated Sahel zone (Vincke et al, 2010; Gonzalez et al, 2012; Hermann and Tappan, 2013; Brandt et al, 2014; 2018; Hanke et al, 2016), with the main reasons related to increasing aridity. In the current study, reasons given focused on the high demand for certain species such as those preferred for fuelwood, implements and furniture, which also required them to be fast-growing. The loss of seed bank due to scrub and brushland clearance was also mentioned, which explains loss of some naturally regenerating species (Appendices A-D).

Thus we view the farmed parkland landscape as stable and self-sustaining in terms of tree densities at the present time, even in the face of rapid population growth, which supports our initial empirical observations from remote sensing images over five decades. It also agrees with Cline-Cole et al's (1990b) observations in Kano region from 4 decades earlier.

4.2 *Impacts of globalization and population growth*

In addition to understanding stakeholders' perceptions of changes in farmland tree stocks, questionnaires were also devised to examine the impacts of globalization on the landscape and farming practices. The growth in availability and decreased cost of market products over the last 25 years (Eternike et al, 2015) would be expected to decrease the importance of trees to rural households, resulting in declining tree numbers and/or a shift in species composition. Results indicated a variety of tree products replaced by similar market ones, included for soup, vitamin C, sweets, cotton stuffing, skin products, medicine and food. A majority (63%) of farmers actually preferred tree products, but tended to use market products because tree products were no longer available or because there were no processors ie. loss of local knowledge about how to produce the product from the tree. Apart from a few ambiguous responses, all farmers indicated decline in the number of species as well as shift in species composition, and move towards fast-growing, rapidly regenerating species such as Neem, *Azadirachta indica* and Camelsfoot tree, *Piliostigma thonningii*. This would support the assertions by over 90% of farmers that reasons for the species shift were the high demand for fuelwood and wood for building and implements, which provided cash income from sale of wood. Another reason for declining species diversity cited by over 60% of farmers was given as increasing aridity and/or climate change, which is surprising, as rainfall trends (Figure 2) indicate recovery from the droughts of the 1970s and early 1980s, with a continuous increasing trend across northern Nigeria since 1982, and decreasing length of dry spells (Usman et al, 2018). Mulenga et al's (2017) report that farmers in Zambia feel obliged to conform to the dominant narrative on climate change even if they have not perceived any change in climate, may also apply here. In the present study, as only farmers over the age of 50 were selected, memory of the 1970s and 80s droughts may also influence their responses, and the longevity of trees means current tree stocks may partially represent response to those droughts.

The last population census in 2006 indicated that Kano's rural population almost doubled in the previous 15 years, and Kano city itself more than doubled (Tiffen, 2001; National Population Commission, 2006). Since 47% of the population was below 15 years of age in 2006 there is potential for rapid future growth. Indeed Nigeria's population is expected to be 2.5 times its current size by 2050 and to account for 10% of all births in the world (UNICEF, 2014). The agroforestry system surrounding Kano appears to be withstanding the unprecedented population growth, at least in terms of tree densities, due to high demand, and farmers' need for cash from wood sales. However, the shift in species composition and loss of biodiversity may represent a more insidious trend, as concentration on a few preferred fuelwood species forces households to become reliant on the external cash economy for a wide range of products.

5. Conclusion

Our empirical observations from series of archived aerial photographs, satellite images and fieldwork led us to investigate through farm questionnaires, a possible mismatch between these empirical observations and reports from other studies. The questionnaires did not initially resolve the mismatch, but subsequent rounds of questionnaire gave deeper insight into farmer perceptions and attitudes to farm trees. To indigenous farmers, the concept of 'species' appears inseparable from the concept of 'tree', and questions about how many trees, require further guidelines from the interviewer. The steady and increasing demand for wood fuel due to population growth in both urban and rural areas, generates the planting of more trees for cash income, and in addition, subdivision of land holdings means that more trees per unit land area are required to support rural households. At the same time, agricultural intensification means that faster growing species and ones that meet market needs, especially for fuelwood, are selected.

It is important to know how external economic and environmental pressures on indigenous farming communities are perceived at household level. If local perceptions conflict with those of independent observers or with physical records, this may lead to inappropriate or unnecessary response on the one hand, or lack of response when one is needed. With predicted climate warming in dryland Africa greater than the global average (IPCC, 2014), a return to severe drought conditions of the 1970s and 80s could initiate a severe social and economic crisis, where interventions are needed. However, such interventions for management and protection of trees at local level, requires stakeholder participation, which has often been missing, leading to low success rates. Renewed efforts are required to ensure effective synergy and understanding between scientific and stakeholder viewpoints, to preserve seedbanks and generate alternative income sources from tree products.

Appendix A

Questionnaire 1

Individual surveys; Kano West (20) and Daura (12) merged responses

Question	Summary of Responses
1. 32 replies	Do you sell wood for fuel? How much do you use compared with what you sell? 10=no – use large amount for own family, 22=yes, 6=same, 11= use double, 1=use 3-times, 2=use 4-times, 2=use 10-times
2. 20 replies	In the next few years, do you want to have more or fewer trees on your farm? 14=more (but outside farmland) , 6=fewer (shading crops causing lower yield)

3. 32 replies	If you plant or grow any new trees, what species would you chose? 9=C. glutinosum, 17=M.oleifera, 27=Neem, 9=P. biglobosa, 14=Mango
4. 32 replies	Why would you choose this species? 32=fuelwood, 20=food, 6=medicine
5. 32 replies	What things can you buy in market now that you used to get before from trees? Vitamin C, Soup, 5=sweets, cotton stuffing, 10=skin products, 3=medicine, food
6. 27 replies	Which one is best? Is the product from trees better or is the one from market better? 17 prefer tree, 2 prefer market, 8 prefer market because tree not available
7. 32 replies	Have you noticed any changes in number of trees on your farm over the last 20, 30, 40 or 50 years 12=fewer trees now, 14=fewer indigenous species now, others ambiguous
8. 23 replies	What are the reasons for the change in numbers of trees? 10=urbanization and settlement, 12=to make space for farmland, 7=for fuelwood, 6=population growth
9. 32 replies	Have you noticed any changes in the species of trees over the last 20, 30, 40 or 50 years? 32=yes, P. biglobosa, B. paradoxum, V. doniana, C. pentandra, F. albida disappearing, Neem and P. thoningii appearing
10. 29 replies	What are the reasons for the change in species of trees? 12=fuelwood, 12=demand, 11=urbanisation, 1=market products available, 7=increasing aridity (Daura), 4=climate change (Daura), 3=overcutting

NB. All farmers over 40 years old

Group surveys (Kano East = 2 groups, Daura = 5 groups) merged responses

7. 7 replies	Have you noticed any changes in number of trees on your farm over the last 20, 30, 40 or 50 years All 7 groups say fewer trees now but all 7 groups continue to answer in terms of <u>species</u> which have disappeared
8. 7 replies	What are the reasons for the change in numbers of trees? 2=urbanization and settlement, 3=to make space for farmland, 4=for fuelwood,
9. 7 replies	Have you noticed any changes in the species of trees over the last 20, 30, 40 or 50 years? 7=yes, disappearing=P. biglobosa, B. paradoxum, V. doniana, D. mespiliformis, A. nilotica, S. birrea, C. pentandra; appearing=Neem and P. thoningii
10. 7 replies	What are the reasons for the change in species of trees? 4=increasing aridity (Daura), 3=overcutting for fuelwood, need fast-growing species

Appendix B

Questionnaire 2 (QR2). Kano West, 4 questions to 20 respondents in 6 villages

1.	Have you noticed any changes in the species of trees over the last 20, 30, 40 or 50 years? –which species are fewer, and which species are more common now? 11=fewer species now; 13=stated change but ambiguous as to direction of change. Disappearing=B. paradoxum, F. albida, B. aegyptiaca, V. doniana, S. birrea, Z. spinachrista, C. pentandra; appearing=Neem, P. thoningii, Mango, A. digitata
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2.	What are the reasons for the change in species of trees?
	Population growth and need more space for crops: need faster growing trees:
3.	Have you noticed any changes in the total number of trees on your farm over the last 20, 30, 40 or 50 years – are there more total trees now or fewer trees now?
	10=fewer trees now, 10=answer in terms of species which have disappeared
4.	What are the reasons for the change in total numbers of trees?
	Need space for farming, need fast growing trees because of population growth

Appendix C.

Questionnaire 3. Kano West, 4 questions to 50 respondents in 10 villages

1.	Have you noticed any changes in the species of trees over the last 20, 30, 40 or 50 years? –which species are fewer, and which species are more common now?
	49=fewer species now; 1=no change. Disappearing=B. paradoxum, F. albida, B. aegyptiaca, V. doniana, S. birrea, Z. spina-christa, C. pentandra; appearing=Neem, P. thoningii, P. biglobosa
2.	What are the reasons for the change in species of trees?
	Increasing aridity, loss of seed bank due to loss of unmanaged forest lands, population growth creates demand for certain wood products such as tools and fuelwood, need fast growing species for income
3.	Have you noticed any changes in the total number of trees on your farm over the last 20, 30, 40 or 50 years – are there more total trees now or fewer trees now?
	34/50 increase, 16/50 decrease, 10=still answer in terms of species which have disappeared, many say shrubs have been cleared
4.	What are the reasons for the change in total numbers of trees?
	farmers plant useful trees as income, fast growing trees replacing slow growing ones, increasing aridity, need space for farming,

Appendix D

Questionnaire 4. Kano East, 4 questions to 36 respondents in 12 villages

1.	Have you noticed any changes in the species of trees over the last 20, 30, 40 or 50 years? –which species are fewer, and which species are more common now?
	35=fewer species now; 1=no change. Disappearing=B. paradoxum, F. albida, B. aegyptiaca, V. doniana, S. birrea, Z. spina-christa, C. pentandra; appearing=Neem, P. thoningii, P. biglobosa, A. indica
2.	What are the reasons for the change in species of trees?
	Increasing aridity, loss of seed bank due to loss of unmanaged forest lands, population growth creates demand for certain wood products such as tools and fuelwood, need fast growing species for income
3.	Have you noticed any changes in the total number of trees on your farm over the last 20, 30, 40 or 50 years – are there more total trees now or fewer trees now?
	25/36 increase, 11/36 decrease, 20% increase in overall tree numbers, 10=still answer in terms of species which have disappeared, many say shrubs have been cleared
4.	What are the reasons for the change in total numbers of trees?
	farmers plant useful trees as income, fast growing trees replacing slow growing ones, increasing aridity, avoid shading of crops and thorny trees removed

Acknowledgments

Thanks are due to Dr Asma Ibrahim of the National Centre for Remote Sensing, Abuja, Nigeria, and Dr Murtala Badamasi of the Centre for Drylands Agriculture, Bayero University, Kano, Nigeria, for assistance during field data collection.

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