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Degradation of Natural Resources or Necessary Intensification of Land Use to Sustain a Growing Number of Users? - The case of the Zamfara Reserve, Northwest Nigeria

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Abstract

The rural Zamfara Forest Reserve is an important grazing area for the livestock of nomadic and transhumant pastoralists and the sedentary population living in the four designated farming enclaves and in bordering villages. Both farm sizes and the farmers' livestock holdings are larger than in intensified, densely populated systems where cropland scarcity and the diminution of common rangeland are driving land use intensification. Nevertheless, the farmers in the enclaves have developed a sustainable soil fertility management. But there is increasing human pressure on the communal grazing land, which stems from cropland encroachment, and intensive grazing, with an average annual stocking rate of 0.73 TLU ha^{-1} on the rangeland. A comparative analysis of vegetation density between 1962 and 1991 estimated that 71% to 85% of the vegetation and 50% of the trees had been removed. The present paper examines if the reserve is on the verge of irreversible land degradation like these figures suggest, or if it is sustaining the livelihoods of increasing numbers of farmers and livestock-keepers at low but sustainable levels. Cropland expansion was mapped from multitemporal remote sensing data, and land use/cover in 1999 was analysed by supervised classification of Landsat ETM+ data. Population and livestock in the enclaves were assessed in a ground survey from January to May 2003. The data were combined to derive land use profiles for the enclaves to make inferences about the current state of the farming systems in Zamfara Reserve. The results show that both degradation of the common rangeland and intensification of land use in the enclaves are taking place. It is argued that further integration of crop and livestock production is a viable long term goal of rural development in the reserve. However, nomadic and landless livestock-keepers in particular will be the greater losers in the process unless favourable institutions allow a joint use and management of common rangeland for both farmers and livestock-keepers.

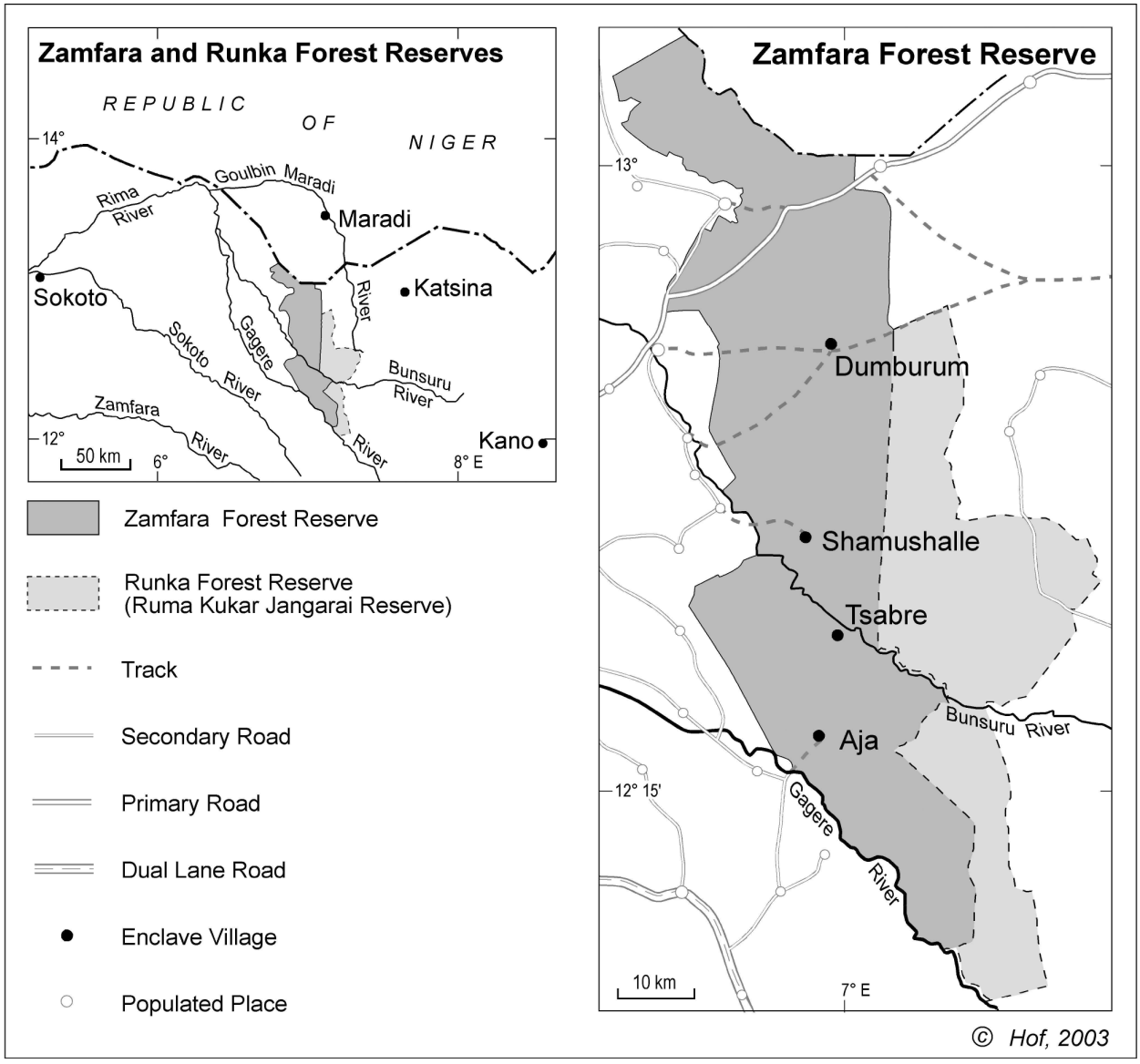
Keywords: Land use/cover change, natural resource assessment, Nigeria

Introduction

In semi-arid West Africa, legal and administrative insecurity, increasing aridity, drought and population pressure have resulted in shifts in land use and put stress on common pool resources (Williams, 1998). Another trend in almost all Sahelian drylands is the appropriation of common rangeland for cultivation and the closer integration of crop and livestock management

(Mortimore, 2000). In this context, the case of the Zamfara Reserve, located in the Sahelo-Sudanian Zone of northwest Nigeria, illuminates these land use changes in communal grazing areas in a nutshell. The former forest reserve was turned into a grazing reserve under the Grazing Reserve Law of 1965. By setting aside traditional lands as grazing reserves, the Nigerian government intended to protect the traditional livestock industry and to encourage Fulani settlement (Awogbade, 1983). The Zamfara and Runka forests form the larger part of an ecosystem extending into the Maradi Department of the Republic of Niger. These lands were sparsely populated and marginal areas prior to the 19th century jihad and opening of new settlements and Fulani sedentarisation took place mainly after 1900 (Elbow, 1994). Both the establishment of the Zamfara Forest Reserve in 1919 by the British colonial regime and the conversion into a grazing reserve preserved the communal range resources and enabled the seasonal migration of pastoral Fulani from north to South and vice versa.

Figure 1. The Zamfara Forest Reserve in the Sahelo-Sudanian Zone of NW Nigeria



However, the reserve also contains four legal encapsulated farming enclaves and is surrounded by farming communities (Figure 1). About 150,000 people live in the four enclaves and the 56 bordering villages west of Zamfara Reserve (ARCA, 1995; Digital Chart of the World). Enclave

farm sizes (mean 3.4 ha) are larger than in bordering villages and livestock holdings of farmers (mean 6 TLU) in Zamfara (Hassan, 2000) are larger than in highly intensified, very densely populated systems in Northern Nigeria (Mortimore, 1998). The reserve is intensively grazed by livestock owned by transhumant and settled Fulani and the enclave farmers. Livestock densities of 1.45 TLU ha^{-1} on natural range in the wet season (June to September) and 1.04 TLU ha^{-1} on cropland in the dry season (October to May) were measured (Schäfer, 1998). Thus, the Zamfara Reserve sustains livelihoods which are based on crop or livestock production or a combination of the two. Directly (grazing, browse, firewood) and indirectly (through manure), the communal rangeland is an asset in the rural economy. But a decrease of vegetation cover due to overgrazing on natural rangeland in Zamfara Reserve was already identified as a problem in the early 1990s (FDLPCS, 1992). A comparative analysis of vegetation density between 1962 and 1991 (ARCA, 1995) estimated that 71% to 85% of the vegetation and 50% of the trees had been removed. Increasing human pressures on the communal resources include the encroachment of cropland and consequently a diminution of natural range, the increase of livestock, the absence of fallows and the cutting, heavy lopping and browsing of trees (Hassan, 2000; Küppers, 1998; Schäfer, 1998). On the other hand, the farmers in the enclaves have developed a sustainable soil fertility management (Hoffmann *et al.*, 2001). And the findings of other studies in Zamfara Reserve (Hassan, 2000; Schaefer, 1998; Omolehin, in preparation) pointed to integration of crop and livestock production in the reserve as being rather the rule than the exception. The present paper examines if the reserve is on the verge of irreversible land degradation as some of the figures might suggest, or if it is sustaining the livelihoods of increasing numbers of farmers and livestock-keepers at low but sustainable levels.

Material and Methods

The Zamfara Forest Reserve and the Ruma-Kukar-Jangarai (Runka) Forest Reserve constitute a natural ecological unit of 3367 km^2 (Figure 1). Rainfall means range from 650 mm in the North to 925 mm in the South of the reserves (New *et al.*, 2002). The predominantly sandy soils have a low nitrogen, phosphorus and organic matter content, low water holding capacity and are susceptible to drought (Ibrahim, 1998). The vegetation is of the northern Sudanian Savannah type (Bielfeldt, 1993; Küppers, 1998).

Land use change between 1965 and 1999 was analysed using historical Corona satellite photographs (U.S. Geological Survey 1995), SPOT 3 XS and Landsat 7 ETM+ images. The SPOT colour composite positives (07 November 1994) and the Corona film positives (04 November 1965) were scanned with a Vexcel Imaging UltraScan 5000 at 20 µm resolution. The SPOT colour scans were georeferenced to a 1:100,000-scale basemap (ARCA 1995). The Corona scans were geometrically corrected and co-registered in Erdas Imagine GIS 8.5 on the base of the panchromatic bands of Landsat ETM+ scenes 189-051 and 189-052 (19 October 1999), and projected into UTM. The scans were corrected using a second order polynomial, the positional accuracy is 1.3 pixel. The Corona negatives were enlarged with a Leica Fotomat 2 to paper prints at scale 1:35,000 for visual interpretation. For GIS-based measuring and representing of enclave farmland expansion and cropland encroachment, the satellite images were analysed using photographic and visual interpretation methods. The interpretation results from the Corona prints were digitised on-screen with the scans as background images. The SPOT positives were interpreted visually on a light table and features digitised on-screen in ArcView GIS. For interpretation of the Landsat ETM+ scenes, RGB 543 and RGB 432 composites were used along with 908 GPS records demarcating arable land in 2000 (Malami & Tukur, unpublished data). In all images, arable land use was mapped on the basis of its characteristic textures, which result from the field patterns.

For the Landsat ETM+ image classification, 60 GPS referenced sites from Küppers (1998) were used to generate training sites for degraded shrub savanna, savanna with shrubs and trees, savanna grassland and riparian woodland. Attribute data on the sites' species composition and the vegetation ground cover were integrated in the GIS. Further training sites were generated for settlements, dams and ponds (Legde, 2002). A supervised image classification (Maximum Likelihood) was performed in Erdas Imagine 8.5.

Current population or livestock census data for NW Nigeria is not accurate enough to allow analyses of human environment relationships and anthropogenic pressures on natural resources. To improve the data base, a survey was carried out in the enclaves Zamfara Reserve in the dry season from January to May 2003. Both the core villages of the enclaves were surveyed and the Fulani hamlets located on the enclave cropland. In both locations, data on human population and livestock were collected. Residential compounds in each enclave were counted by walking along the streets and visiting each compound, interviewing the residents about the number of households and family members living in the compound. The hamlets were counted and in 47% of all hamlets, informal interviews on households and family members were held. The number of cattle, sheep and goats were assessed. In Dumburum and Shamushalle (Figure 1), animals were led to the same fields for afternoon grazing every day. Thus it was comparatively easy to count them on the fields. In Tsabre and Aja, semi-structured interviews were held with household heads for animal numbers. In the hamlets, interviews were held with the head of the household to arrive at the total number of animals. Adapting Mortimore's (1998) land use profiles, the land use/cover assessment and survey data were combined to make inferences about the current state of the farming systems in Zamfara Reserve with regard to land use intensification.

Results

From 1965 to 1999, total enclave farmland expanded 4190 hectares and exceeded the land officially allocated to the enclaves by 1975 hectares (Table 1). Despite the legal restrictions in the grazing reserve, total cropland surface cover in the reserve increased by 29.6 % between 1965 and 1999.

Table 1. Agricultural expansion in the enclaves of Zamfara Reserve (hectares)

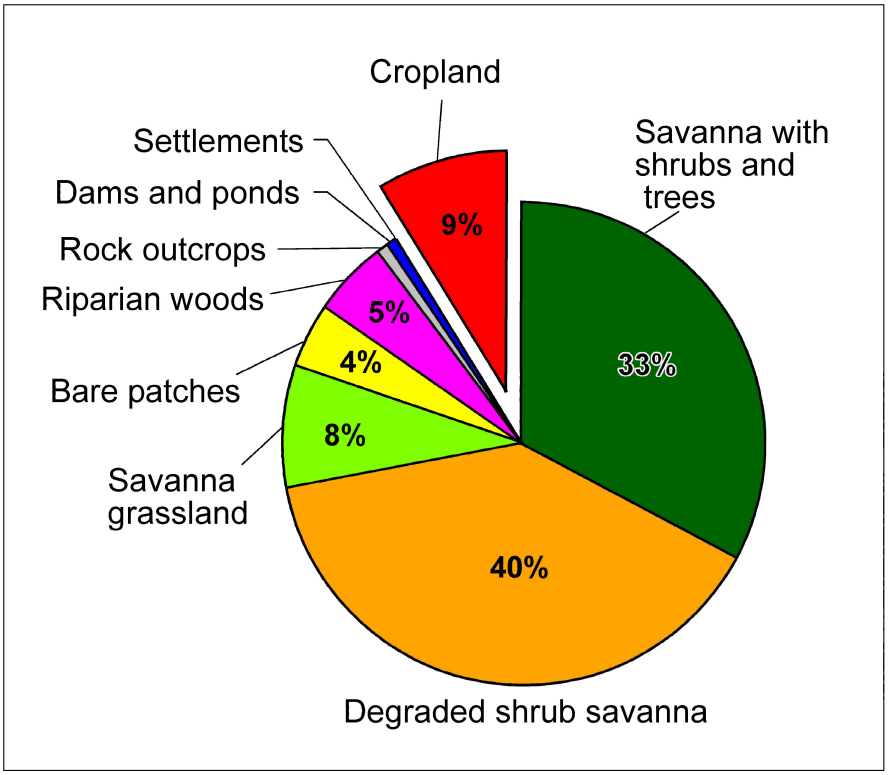
Name of enclave	Cropland 1965	Cropland 1994	Cropland 1999	Increase of cropland 1965-1999 (%)	Cropland exceeding official land allocation of 1980
Dumburum	1050	1240	1604	52.7	-60,3
Shamushalle	687	1706	2010	192.8	729,5
Tsabre	359	1522	1693	371.8	245,7
Aja	564	1413	1543	173.4	1060,1
Total	2660	5881	6850	157.5	1975

The values in Table 1 show the marked increase of cropland in Tsabre, Shamushalle and Aja. Additionally 11,950 hectares of rangeland had been appropriated for cultivation at the western fringe of the reserve by 1999, indicating strong pressure from neighbouring communities and accelerated encroachment in the 1990s (compare Hof *et al.,* 2003). In the southwest of the reserve

the diminution of common rangeland is therefore most drastical, driven from the inside –Tsabre and Aja- and communities outside of the reserve.

Results of the Landsat ETM+ classification show that vegetation cover in the reserve is generally patchy. Degraded *Combretum micranthum* shrub savanna already covers large areas of the rangeland (Figure 2), especially in the north of the reserve.

Figure 2. Land use/cover in the Zamfara Reserve in 1999



NDVI values show a north to south gradient of vegetation cover and field studies proved that the density of tree/shrub savanna patches is higher in the centre and south of the reserve. However, mean tree density (18 trees/ha) (Malami, 2003) is very low compared to forest reserves (538 trees/ha) or farmed parkland (22 trees/ha) (Mortimore, 1998). Together with the findings of floristic and phytosociological studies (Bielfeldt, 1993; Küppers, 1998), the analyses of the vegetation cover of Zamfara Reserve suggest a steady decline in available forage resources for livestock. This is caused on the one hand by cropland encroachment and on the other hand by overuse of the remaining land, which is reflected in a reduction of fodder species and perennial grasses (Bielfeldt, 1993; Küppers, 1998).

The population survey in Zamfara reserve demonstrates that the ratios of core village compounds to hamlets as well as the ratios of households in core villages to households in hamlets are highest for Tsabre, followed by Aja , Dumburum and Shamushalle. Data from the livestock survey in the enclaves showed that households in the core villages of Dumburum and Shamushalle have larger stocks of small ruminants while in the other two enclaves, farmers keep more cattle and slightly fewer sheep (Table 2). Table 2 also illustrates that in comparison livestock holdings in the hamlets households are generally larger, but most markedly so in Tsabre, Shamushalle and Aja, respectively.

Table 2. Dry season livestock in enclaves 2003 (as number of animals per household)

Name of enclave	----Livestock in core villages----			-----Livestock in hamlets-----		
	Cattle/HH	Goats/HH	Sheep/HH	Cattle/HH	Goats/HH	Sheep/HH
Dumburum	0.7	6.8	10.0	6.3	4.3	5.3
Shamushalle	0.9	4.0	10.4	17.1	14.4	9.7
Tsabre	2.9	8.2	2.1	35.0	20.4	17.6
Aja	2.2	6.4	8.6	11.1	11.9	10.2

The population data and the values in Table 3 reflect the relatively higher presence of pastoralists in Tsabre and Aja, and also a higher importance of cattle keeping in the core villages of these two enclaves.

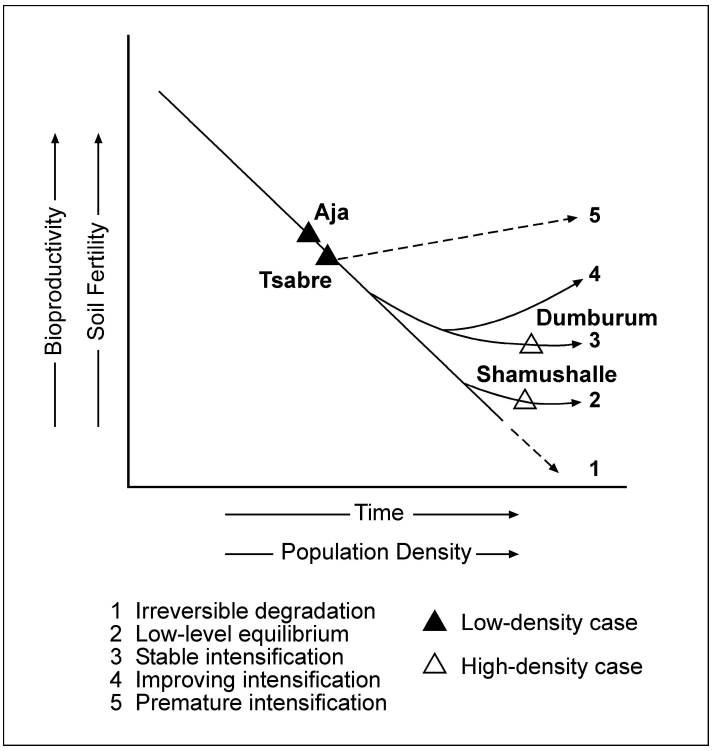
Table 3. Proportion of transhumant population, cropland area per capita, livestock and population density

Name of enclave	Hamlets per enclave compound	Cropland person^{-1} (ha)	TLU ha^{-1}	Population density (persons km^{-2})
Dumburum	0.27	0.21	1.8	466.1
Shamushalle	0.06	0.29	1.2	345.6
Tsabre	0.49	0.73	3.8	137.7
Aja	0.41	0.96	1.1	103.7

The land use profiles for the enclaves in Zamfara Reserve were based on the following indicators: the ratio between settlements of transhumant pastoralists and enclave compounds, cropland per person, livestock density, and population density (Table 3). Dumburum and Shamushalle scored high on population and livestock densities and presence of pastoralists (Table 3) but lower on long term cropland expansion (Table 1). Tsabre showed the highest cropland expansion (Table 1), livestock density and presence of pastoralists, but ranked only third in terms of population density (Table 3), whereas Aja had the lowest population and livestock densities but scored high on agricultural expansion (Table 1) and cultivated land per person (Table 3).

It can be deduced from these results (Table 1, 2 and 3) that settled livestock specialists, who are engaged in crop production, have contributed considerably to farmland expansion in the enclaves, especially in Tsabre and Aja. In Tsabre and especially Aja, remoteness from roads and consequently, local markets (Figure 1) are a disadvantage. However, the denser vegetation and open access water sources has made sedentarisation more attractive for Fulanis and less strict controls by authorities than elsewhere in the reserve has made it easier. These factors contributed to the accelerated acquisition of land by farming households in the south of the reserve (compare ARCA, 1995 and Umar, in preparation). The market access through the road (Figure 1) explains the strong presence of Fulani hamlets in Dumburum. Translating these data into a land use profile and deriving a land use intensification score, the individual enclaves were plotted into a transition model (Figure 3).

Figure 3. The transition from degradation to intensification in a dryland farming system (adapted from Mortimore, 1998)



The enclaves' positions in the transition model suggest a heterogeneous development in the reserve: in Tsabre and Aja, the factor ratios (labour to land, with 12.8 ha and 17 ha cropland per core enclave household, respectively) do not yet seem appropriate for intensification. In Dumburum and in Shamushalle, high population and livestock densities and low cropland expansion indicate land use intensification and crop-livestock integration, along a trajectory of improved land use practices (Figure 3).

Discussion

The current development of the farming enclaves, and most probably, the villages on the western fringe of the reserve, is sustained by the adjacent communal grazing areas. The reserves sustain large livestock densities and allow the nutrient transfer from the rangeland to the croplands. Maintenance of soil fertility depends on the availability of sufficient amounts of manure and a net nutrient import from the rangeland (Hoffmann *et al.,* 2001). Thus, the ongoing appropriation of open access rangeland for cultivation puts pressure on the shrinking resource base of both livestock and crop production and threatens to increase rangeland degradation. This process affects especially the more densely vegetated south and southwest of the reserve. Degraded shrub savanna covers 40% of the reserve area but neither the land use/cover assessment (Figure 2) nor recent vegetation assessments (Küppers, 1998; Malami, 2003) support a linear degradation scenario for natural resources or the drastic accounts on vegetation decrease and deforestation reported by ARCA (1995). The ecological effect of the generally high grazing pressure is rather a change in vegetation quality than cover. The species composition of the herbaceous and woody vegetation and the low rejuvenation of ligneous species due to browse and lopping (Küppers, 1998) are signals for the degradation of the natural vegetation.

The results presented here suggest that both degradation and intensification are taking place. In the context of Zamfara Reserve, rather the limits and the consequences of cropland expansion and rangeland diminution are of further interest. While an assessment of the ecological limits can hardly be derived from the present data base, the impacts on different users groups are less elusive to deduce. The perceived scarcity of inorganic and organic fertilisers (Hoffmann *et al.*, 2001) and importance of income from livestock for sedentary producers (Hassan, 2000) are driving crop-livestock integration. Exchange relations especially with nomadic and transhumant livestock-keepers are increasingly monetised and will probably lose further ground. For landless livestock specialists in particular, access to communal resources (pasture and water) will become increasingly difficult, restricting their ability to react to temporally and spatially fluctuating resources.

For the development of the livestock sector, projects carried out by governments and donors focussed on the 'improvement' and 'modernisation' of the traditional nomadic and semi-nomadic cattle-breeding livestock sector, neglecting the animal production by farmers and envisioning a spatial division between farming and livestock production, land uses and access rights (compare Mortimore, 2000). Range development projects carried out in the Zamfara and Runka Reserves by USAID in the 1960s to 1970s and the EU and Nigerian government in the 1990s were also guided by such premises (ARCA, 1995), but a development of the livestock sector separated from the agricultural sector has never become a reality in the reserves. Partly this was due to the fact that the enclaves' croplands were always seen as dry season fodder resources for livestock. In addition, the remoteness of the area and the surrounding rangeland were conducive to the keeping of livestock by farmers, out of opportunity, but also out of necessity. To some extent, the high increase of total cropland area, especially in Tsabre, but generally for all enclaves except Dumburum (Table 1), and the results presented here on cropland area, population and livestock densities could be considered a result and success of the policy to encourage Fulani settlement by establishing grazing reserves (Awogbade, 1983). Land use intensification as it seems already be well on the way in the northern enclaves should be strengthened, e.g. by a better supply of external inputs, to prevent further cropland encroachment from within. But such supporting measures are even more important for the communities at the western fringe of the reserve as they are causing a much larger cropland encroachment. The Zamfara and Runka reserves are still the largest reserved area of natural vegetation in northwest Nigeria that has regional importance for livestock production and mobility. Nevertheless, the customary rights to grazing or passage are increasingly eroded by the successful claiming of land within the grazing reserve and the failure of top-down grazing reserve management approaches that were meant to support the sustainable participation of non-sedentary users (Awogbade, 1983; ARCA, 1995). From an analysis of the forces affecting the livestock sector in Northern Nigeria, Mortimore (2000) recommends closer integration of livestock and farming: "the future of livestock producing systems rests with enabling closer forms of integration with farming, rather than with attempting to stop the inevitable, and in ensuring a place for those who lack the necessary resource entitlements to find them before they disappear." (*ibid.*, p. 110). For the development of the Zamfara and Runka Reserves, this quotation includes both a viable development goal and a timely warning. The challenge is to recognise the rights of all existing users and care has to be taken not to exclude mobile herders from future land use (planning), especially with regard to access to the most contested resources. An approach focussing on the more powerful groups or the sedentary population runs the risk of appropriation of key resources by some and the increasing exclusion of others (compare Williams, 1998). To provide the institutional support to allow a joint management of the communal grazing resources by farmers and livestock-keepers will be the key challenge to prevent the Zamfara Reserve from developing towards the degradation trajectory.

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