Expl Agric. (2006), volume 42, pp. 259–287 © *2006 Cambridge University Press*
doi:10.1017/S0014479706003589 *Printed in the United Kingdom*

URBANIZATION: IMPACTS ON THE EVOLUTION OF 'MIXED FARMING' SYSTEMS IN SUB-SAHARAN AFRICA

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(*Accepted 18 November 2005*)

SUMMARY

During the past two decades or so, rural population in Africa has increased slowly while urban population has grown dramatically. The hugely increased urban demand for cereals and pulses (which produce crop residues for livestock) and for livestock products is now the main force stimulating mixed farming systems in the semi-arid and sub-humid areas of sub-Saharan Africa. Grazing land has diminished, crop residues are becoming a more important element in raising livestock and fattening penned livestock has become profitable. The changes in land use, land tenure and the shift of livestock raising southwards in West Africa are illustrated. Farmers' adaptation to rapidly changing markets for their products and the factors of production are illustrated with examples from Senegal, Nigeria, Niger, and, by way of contrast, Kenya. The main challenges this sets to agricultural scientists are described. The livestock element in mixed farming system now requires careful economic analysis and participative research if scientists are to meet the evolving needs of farming as the urban sector enlarges.

AIM

The aim of this paper is to show that increasing urbanization in sub-Saharan Africa (SSA) is affecting farming systems. It has a particularly important impact on the livestock element of the mixed farming systems that predominate in semi-arid and semi-humid SSA. (By mixed farming is meant simply the existence of crop and livestock elements on a farm under unified management). The livestock element has tended to be viewed by scientists as an adjunct to crops, to which it contributes manure and draught power. With urbanization we need to give more attention to its output of meat and milk, for which crop residues provide fodder. From Kristjanson *et al.* (2004b), we can calculate that mixed farming areas have 63 % of West Africa's Tropical Livestock Units (TLU) and 60 % of its cattle. The crop elements in the systems under consideration are permutations of maize, sorghum, millet and edible legumes. There are similar systems in southern and eastern Africa.

The paper first briefly considers the evolution of farming systems and the impact on them of increasing urbanization. This is followed by examples. It concludes by discussing the adjustments that scientists need to make if they are to help farmers meet a rapidly changing situation.

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THE EVOLUTION OF FARMING SYSTEMS

Farming systems change over time in response to changes in rural human population density, in the markets for output and in the agro-climatic environment. It is now accepted fairly generally that increasing rural population density leads to the intensification of production. Additional labour and capital have to be applied to maintain and, preferably, expand output from a land holding per farm family that has become, on average, smaller. New techniques and technologies have to be developed to maintain fertility as the possibilities either of clearing a new field, or of fallowing existing fields for several years, diminish. Boserup (1965) is the principal author of this theory. Fallowing ceases to be an option at some point when rural densities reach 20–40 persons km^{-2}. While there are still some areas with lower densities than this in central and southern Africa, in West Africa large areas already have densities over 50 km^{-2} and this is forecast to expand[1].

McIntire *et al.* (1992) examined this evolution, particularly in relation to mixed farming systems, showing how intensification leads to closer integration of crops and livestock as 'herders and farmers both become mixed entrepreneurs'. Animals provide manure (in substitution for fallows) and draft power for the crops, and, with the reduced area of free grazing, the crop residues provide essential feed. This pleasing symmetry led to official promotion of animal fattening schemes in West Africa, half of which had failed by the time of the study by McIntire *et al.* (1992). They noted the high labour costs of utilizing crop residues and sown or harvested forages for penned animals, and the alternative uses of crop residues. Where they were used, it was in connection with fattening, and planted forages were mainly associated with dairying in highland Kenya. They also noted that penning was always for animal fattening, the production of manure being secondary as it could be more easily obtained by paddocking. Ruthenberg (1980), who examined the development of various African farming systems, also noted the general failure of efforts to introduce ley systems, in which crops and pastures alternate.

The examples of these authors were mainly drawn from the 1970s or earlier. Many farmers are now fattening of their own volition, using crop residues. It will be shown that they are responding to new market conditions, amongst which are the growth of towns (and reduced European subsidies on exported meat) and the general absence of uncultivated land for grazing. More extensive systems are now limited to areas that are peripheral, either in the sense of being near the desert margin or very distant from markets.

Scoones and Wolmer (2002) criticized an evolutionary view (with particular reference to mixed farming) as implying 'a gradual, historical progression along a single pathway, ignoring the potential for more rapid change, resulting in multiple pathways and outcomes'. The feasible pathways ahead certainly differ, as they show, between households, in accordance with their resources and preferences, but it is more important to realize that the trends are not linear. There are phases of rapid general

[1] See maps of present and forecast 2050 population densities in Kristjanson (2004b) and Snrech (1995).

change. This is usually market-led, and as will be shown, increasing urbanization is currently providing the market stimulus. The urban effect is so important that Wiggins and Proctor (2001) suggest a classification of farming systems based on a matrix incorporating the natural resource base (good or poor) on one side, and nearness to towns (peri-urban, middle country-side, and remote). The latter correlates pretty well with population density, very high near towns, in the 40–200 km^{-2} range in the middle country side, and below 40 in remote areas[2].

While there are general tendencies in a certain direction, positive outcomes can be impeded or encouraged by government policies, as discussed in Tiffen *et al.* (1994). Such policy influences normally originate from the national government and sometimes from the policies of trading partners, but, in the case of weak central governments, they can also be due to local power structures, particularly in regard to land tenure and local taxation.

Another reason for this lack of linearity is that people generally have options. Boserup (1965) noted the migration option, as an alternative to intensification. In Tiffen *et al.* (1994), we depicted three options: temporary outmigration to urban areas, permanent outmigration to farm lower potential areas and sustainable development *in situ*. We would modify this now, to acknowledge that some urban migration has been permanent, with important consequences.

Climatic cycles and perturbations also affect systems. The long period of below average rainfall in the Sahelian areas of West Africa 1960–90 led to a decline of sorghum in favour of millet in some northern areas[3]. It encouraged those seeking new land to move into the middle areas between the old centres of population in the tsetse-free north and the humid coastal zone. In clearing the bush to make new farms, settlers reduced tsetse habitats, making the area fit for cattle production. By 1991, almost half Nigeria's cattle population was resident within the sub-humid zone throughout the year, well south of the former northern limit of tsetse distribution (Bourn and Wint, 1994).

In these middle belt areas population density was initially low[4], which was why they attract immigrants looking for unclaimed, cultivable land. Initially, the new immigrants will not have the requirements for closely integrated mixed farming systems. They will be short of capital, and their priority will be to clear the land roughly and plant crops. They will not need to manure newly cleared land for several cropping seasons, and, in any case, until the bush is reduced cattle will suffer from tsetse. The use of fallows, manure and chemical fertilizers are to some extent substitutable, and farmers change their use of these in accordance with the scarcity of land for fallowing, and the relative price and availability of alternative fertility enhancers. Contemporaneously with intensification in old settled areas, we will find extensification in the new. We

[2] Kristjanson *et al.* (2004b) found high rural densities near urban centres and in areas close to road infrastructure in West Africa.

[3] There seems to have been higher rainfall in West Africa since 1990. The boundaries between purely pastoral and mixed farming conditions vary over time, as do those between areas suited to millet, sorghum or maize.

[4] This was because of disease factors, slave-raiding and warfare and other matters unrelated to agro-ecological conditions.

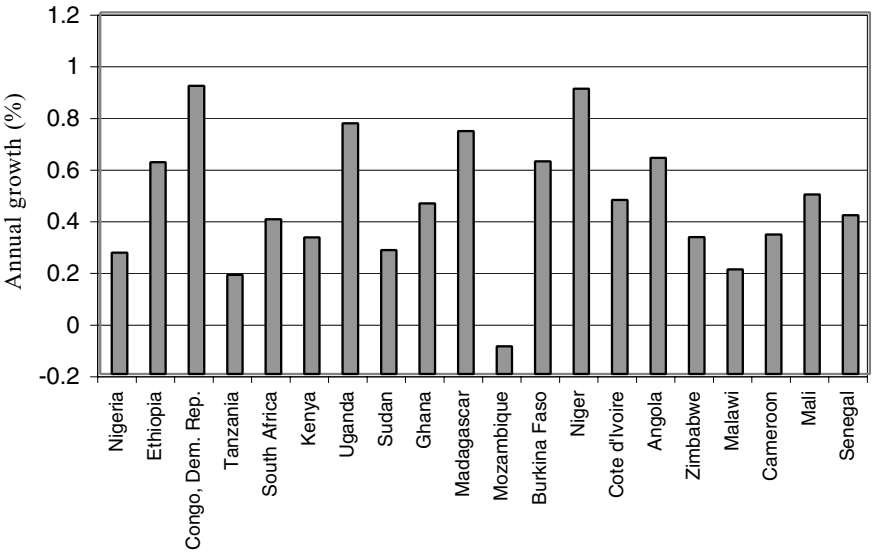

Figure 1. Annual percentage growth in rural human population, 1998–2000, in Sub-Saharan African countries which currently have a population over 10 million. Countries arranged in order of population size.
Source: Calculated from the World Bank African Database, 2002.

will also find the pathway of change for migrating farmers varies for those going into sub-humid zones and those going towards the borders between arable land and land suited only for nomadic herding.

URBANIZATION

The population of sub-Saharan Africa is now 30 % urban (Cohen 2004). Using World Bank data, Tiffen (2003) showed that by 1998 the urban proportion of the 20 SSA countries with the largest total populations was in almost all cases over 20 %, in 12 cases over 30%, and in 5 cases well over 40 %[5]. Figure 1 shows that, concomitantly, rural population growth had declined to less than 1% per annum, and in some cases was static.

Cour (2001) suggested that 30 % urban is a critical point because subsistence farmers will generally aim to grow 20 % more than they need, for safety reasons, but have to change methods and objectives to satisfy a larger urban population. In fact, farmers always desire to sell, since they have many needs besides mere subsistence, but the interaction between town and country, or rather, between the agricultural sector and the manufacturing and service sectors mainly, but not entirely, located in towns, becomes much more effective once this level is reached. When towns are distant, the farmer gets a low price for his produce, and pays highly for manufactured goods. If towns are accessible, rural and urban people stimulate each other, and urbanization escalates

[5] Cohen (2004) and Tiffen (2003) both note the difficulty caused by varying definitions of 'urban', but the trend is clear.

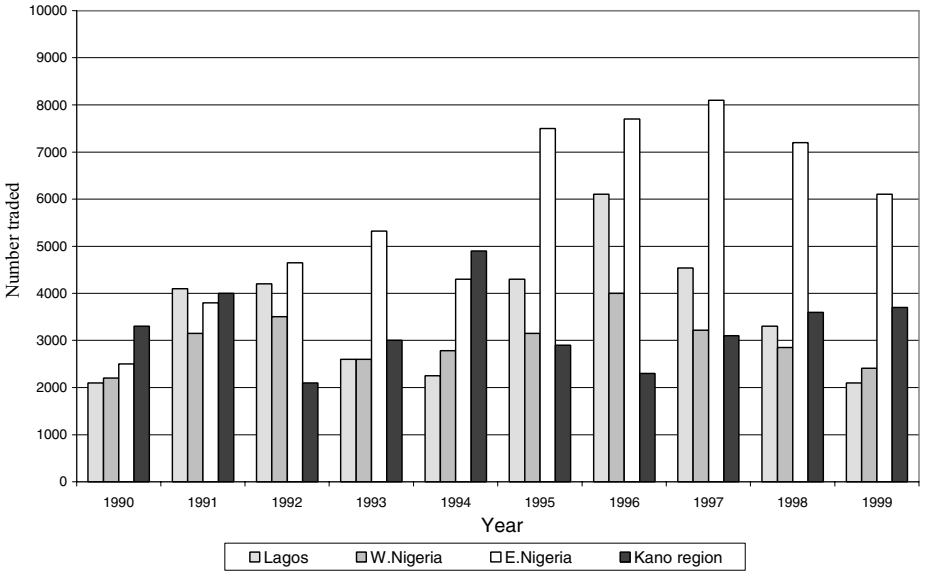

Figure 2. Number of goats purchased by 36 traders operating in three major Kano markets and three rural markets, by year and onward destination.
Source: Ariyo *et al.* (2001).

(Tiffen, 2003). When there were only a few urban centres, the major possibility of earning cash through farm sales lay with export markets. By 2000, the main markets for agricultural output were, at least potentially, the urban centres. If, as seems often the case, the urban dwellers have higher incomes than rural people, livestock products become more important in their diet (Delgado *et al.*, 1999). The urban demand for these products therefore grows at an even higher rate than the demand for staple foods, which merely keeps pace with numbers. This demand can be met either by the expansion of the meat or dairy element in mixed farms, or there may be a growth in specialist livestock enterprises, such as battery poultry farms. In so far as the towns develop industries, there is also an increased demand for agricultural raw materials, and some, such as the brewing industry, also produce animal feed as a by-product.

Ideally, the increased purchasing power of what is still a large agricultural sector stimulates further growth in the urban manufacturing and service sectors. When the latter are largely confined to informal sectors (as they are unless there is large-scale investment in the services modern industry needs, such as electricity, telecommunications and piped water) the stimulus to the livestock producer is still present, but smaller than it could be, and as it has been in many parts of Asia. Ariyo *et al.* (2001) showed that in Nigeria, real prices for cattle fell some 50 % in Kano markets between 1992 and 1995. This was in the context of an industrial depression. The number of formal industrial establishments in Kano fell from 327 in 1989 to 243 in 1993 (modern tanneries fell from 20 to nine) (Tiffen, 2001). Laid-off workers could buy less meat, and Figure 2 shows a dip in goat sales to the Kano region in 1992–3.

The Abacha regime did nothing to improve this situation. Ethno-religious crises and disruptions to north–south trade followed, with even greater tension and uncertainty following Abacha's death and the eventual election of his successor in 1998–9. Figure 2 is based on sales by particular traders, and we would normally expect a clear upward trend in their turnover as their experience and capital resources increase. However, traders reported falls in turnover by comparison with previous years in 1998 and 1999. They blamed increasing poverty in the towns, and disruptions to industry and long-distance trade due to political crises, high fuel prices and increasing exactions by officials (Ariyo *et al.*, 2001; Mortimore and Tiffen, 2004). Cattle showed a similar pattern, but Figure 2 is useful in showing that goats as well as cattle travel long distances to market, and the efforts that traders make each year to find the best destination for their products.

The past growth of the rural human population, now slowing, has made land a very scarce resource. In areas with densities of about 40 km^{-2}, it acquires a financial value, and may, in practice, be sold or rented, whatever the legal or traditional customary position. Those who inherit very small farms and cannot invest to improve productivity seek desperately for non-farm income, or work for more prosperous farmers, and some may resort to selling what land they have. They are pushed out of farming; others are attracted out by the opportunities in towns. At some point, the labour force available to farmers ceases to grow in real terms, forcing the adoption of methods that will enable them to produce more food and other raw materials not only with less land, but also with less labour. This change was captured in the impact evaluation of a rice irrigation scheme in Malaysia, where, within a few years, farmers were having to hire combine harvesters because their young people had gone off to factory work[6]. The static nature of rural population growth indicates a growing shortage of farm labour in Africa (Figure 1).

Due to transport costs, towns are fed (except in the case of some port cities) mainly from the produce of surrounding agricultural areas, in the same or a neighbouring country. Their reach depends in great part on the quality of road and rail links, but also on the storage capacity of the product. Figure 2 has already shown that goats may travel much more than 100 km. Milk, in the absence of processing plants and electricity, has a very local market.

One of the remarkable things about the livestock trade in West Africa is that it has remained entirely in the hands of indigenous traders, using customary institutions and practices (Ariyo *et al.*, 2001; Kerven, 1992) with, compared to crops, little interference from government[7]. Margins are low, distances to be traversed long and requirements for information about market status in various distant outlets are high, but the markets are supplied. In Senegal, where the government took over the trade in groundnuts, imported rice and local food crops from 1965–80, it was the ancient livestock markets

[6] IBRD (1981). Impact evaluation of the Muda scheme, consulted by the author for a report to the then UK Overseas Development Administration on *Improving the socio-economic and institutional content of irrigation feasibility studies* (Research scheme R4006), ESRC 326/307/01, June 30, 1986).

[7] There were some interventions for health reasons by the Veterinary Department, which also had a hand in improving the output of the hides and skins trade in Nigeria.

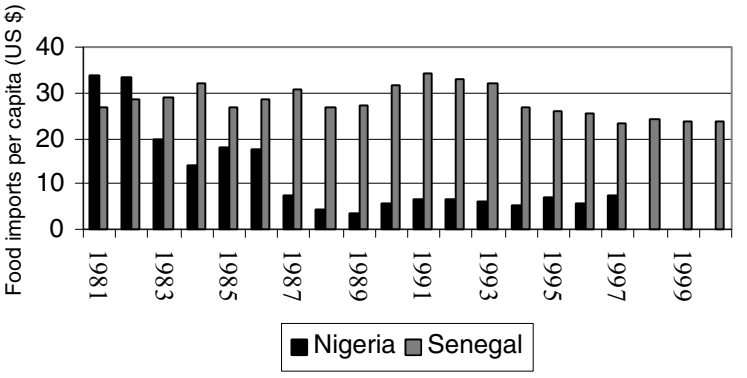

Figure 3. Food imports per capita, 1981–2000, in constant US dollars, Nigeria and Senegal.
Source: Calculated from the World Bank African Database, 2002. Nigerian data not available in constant US$ after 1997, but the current US $ series shows little change.

that provided the nucleus of a network of rural bulking markets when trade was eventually freed (Ly, 2000). In Kenya, traders have kept the expanding Nairobi market supplied, despite having to cope with high and variable transport costs, a demand and supply that fluctuates according to non-climatic events such as festive seasons and school fee payment time, and quarantine restrictions that add to holding costs, according to Barrett *et al.* 2003 and Kerven, 1992, whose studies refer to pastoral livestock. Traders will have less difficulty in collecting from mixed farmers, who are generally more concentrated and nearer to roads and markets.

Markets are not perfect, and some individuals and groups are disadvantaged (Turner and Williams, 2002). However, the major distortions are at the policy level or are external. When the Naira was devalued in the mid-1980s, imports of frozen meat into Nigeria virtually ceased (Club du Sahel, 1990). European Economic Community (EEC) subsidies on frozen carcasses were estimated at FCFA 125 kg^{-1} in 1974, FCFA 355 kg^{-1} in 1984 and FCFA 345 kg^{-1} in 1988[8]. This, combined with overvaluation of the FCFA, led to falling real prices of beef in Francophone countries (Club du Sahel, 1990). Subsidies were reduced by 30 % in 1993–4. The FCFA was devalued by 50 % in January 1994. The two changes meant meat producers in Sahelian areas were able to increase their sales to coastal countries, but they took care to retain breeding stocks (Hoffmann, 1998). Moll and Heerink (1998) also noted a holding back of supply after the first two years to safeguard future capacity. Asuming-Brempong and Staatz (2004) found very substantial income benefits to cattle producers in FCFA countries, although they thought urban consumers suffered.

Increased total population and increased urbanization have not led to a surge in food imports. Imports are more affected by severe droughts (as in the early 1980s) and financial policies. Figure 3 shows that farmers in Nigeria have met the increased

[8] Equivalent to US$0.52, US$0.84 and US$1.1 at the current exchange rate with the French Franc, which equated to FCFA 50 before the devaluation to FCFA 100 in 1994. (Calculated from $/FF exchange rate available on www.tria.com/archive/exchange-en/html, accessed 10/7/2003.)

food demands, and that the level of food imports per head was relatively low after devaluation in 1987. In Senegal, food imports have continued high, though reduced by the 1994 devaluation.

EXAMPLES OF CHANGE

The case study areas

The changes are illustrated by comparative studies of three semi-arid areas in West Africa and one in Kenya, carried out by Drylands Research from 1998 to 2001. These are the Diourbel Region in Senegal, the Maradi area of Niger, the northern hinterland of Kano urban area in Nigeria and Makueni District in Kenya[9]. In Maradi and Makueni, parts of the districts are at the margin of cultivation possibilities. The studies were led by Michael Mortimore, assisted by Mary Tiffen, in co-operation with teams of national scientists. The districts were selected because of the availability of good historical data and their similarity in climate and agricultural possibilities. To have a good policy contrast, two were from Francophone and two from Anglophone countries. For financial reasons, the studies in the Kano hinterland were based on literature reviews except for the study by Ariyo *et al.* (2001) on grain and livestock marketing.

Given the importance of migration into the sub-humid zone, the case of the former Gombe Emirate, now incorporated in Gombe State in Nigeria, has been added. Gombe averaged 940 mm of rainfall in the 1950s and 1960s, when its southern parts, attracting many incoming farmers, were firmly within the tsetse-infested region. It probably averaged some 200 mm less in the subsequent dry period[10]. It has some areas of 'black cotton' soils, hard to work but suited to cotton and sorghum. It provides a representation of what can happen as the mixed farming frontier moves south. Recent studies make it possible to update the study of change in the period 1900–1968 (Tiffen 1976). An additional case from Nigeria is justified because it is the largest country in population terms in SSA, and, as Kristjanson *et al.* (2004b) conclude, 'in terms of human population density, by 2050, much of the rest of West Africa will look like Nigeria does now'.

Urbanization

Census data in SSA have their problems. Comparing data across countries is difficult due to varying definitions of 'urban'. The District-level census data shown in Table 1 are based on censuses, but as the footnotes to it show, they have been modified to standardize 'urban', and to reduce problems caused by the politically inflated 1963 census in Nigeria. Figures from the better 1962 census are only available if a contemporary researcher had sight of them before they were annulled. Table 1 shows urban growth has been rapid in the areas with high population density, and slower in

[9] Makueni is the southern and more arid half of the former large district of Machakos, studied by Tiffen *et al.* (1994).
[10] Fricke (1999) shows the shift of the isohyets southwards by about 100 km between 1949–61 and 1970–91. In the latter period the 600 mm isohyet was about 50 km north of northern Gombe.

Table 1. Rural and urban population growth in four West African districts, and densities (km^{-2}) (Urban defined as agglomerations of over 20,000 people).

	Total	Urban	Urban (%)	Urban growth rate (% a^{-1})	Rural growth (% a^{-1})	Rural density km^{-2}
Nigeria (Kano Province in 1952 & 1962 Kano and Jigawa States 1991)†						
1952	3 396 350	335 707	10			77
1962	4 080 064	NA‡	NA	NA	2.3	96
1991	8 685 995	2 516 706	30	5.3§	2.0	145
Nigeria (Gombe Emirate in 1952 and 1963 and successor Local Government Areas)¶						
1952	358 330	18 483	5			
1963	595 000	47 265	8	8.9	4.4	Ako: 74 Yamaltu 54
1991	1 121 998	288 562	26	6.7	1.5	Ako 184 Yamaltu 174
Niger (Département de Maradi)						
1960 (estimate)	561 000	13 500	2			13
1977	949 747	44 459	5			22
1988	1 389 443	110 739	8	2.7	3.2	33
Senegal (Région de Diourbel)††						
1960 (estimate)	261 000	NA	NA			50–60
1976	423 038	117 761	28			70
1988	620 197	259 973	42	6.8	1.4	94
2002	1 049 954	644 500	61	7.9	1.0	

†The 1962 data for Kano are generally considered less exaggerated than those of the 1963 census, but do not allow a count of the smaller towns.

‡NA = not available

§Urban growth rate is for 1952–91, taking into account smaller towns as well as Kano municipal area. The latter grew by 6.7% a^{-1} 1952–62 and by 6% 1962–91.

¶The 1963 figure has been adjusted, since Tiffen (1976) found that the figure for one of its six districts had probably been substantially inflated. (The other five correlated roughly with taxation figures). 1991 figures take no account of the probable growth of towns other than Gombe town. Kumo in Ako was already a very important inter-regional market in the 1950s, and market towns like Deba Habe and Dadin Kowa in Yamaltu are probably also now above the 20,000 size, but it is not possible to allow for this in calculating present rural density. A map in (Fricke, 1999) puts density in Ako in the 100–200 km^{-2} bracket, and Yamaltu-Deba in the 50–100 km^{-2}. Both Ako and Yamaltu are in the southern part of Gombe Emirate. Density figures for the northern part are not given, because boundaries have been substantially changed since the 1960s.

††1976 and 1988: Census data modified by urban agglomeration analysis in Barry *et al.* (2000). The official definition of urban depends on status as a 'commune'. Touba is not a 'commune', so can only be identified when the lowest level administrative units in the census are available. The 2002 census provisional data are available at Région level at www.geohive.com, which also gives Diourbel commune. In order to estimate the urban figure in 2002, I have added an estimate for the two smaller 'communes' (likely to have grown relatively slowly) and made a very conservative estimate for Touba. Urban growth may be higher, and rural growth less, than the estimates here.

Maradi where there is still vacant land that can be taken up by younger members of existing families, or by incomers.

Since the last fully published censuses, urbanization has continued to grow rapidly. Gueye (2002) charts the extremely rapid growth of Touba, in Senegal, a religious and trading centre, whose core area held 125 000 inhabitants in the 1988 census. It was estimated carefully at 300 000 in 1993, and is known to have continued its rapid expansion since, with surrounding villages becoming urban suburbs. In view of its importance as a marketing pole, a guesstimate of its 2002 size has been incorporated

in Table 1. Gombe town in Nigeria has rapidly expanded since it became a state capital in 1996, leading to an influx of 14 000 civil servants, providing amongst other things, higher education and medical services to its area. It is also the electricity distribution centre for the northeast. However, its function remains primarily commercial, its banks and insurance companies servicing the traders, shopkeepers and transporters who handle incoming international and inter-regional goods for the town and its hinterland, and collect its agricultural products for despatch to other Nigerian markets. Its former Central Market has been divided into three, a cattle market, a grain market and a huge urban market. Balzerek (1999) estimated its population had reached 300 000 by 2000 and that it might attain 500 000 by 2010.

Urban expansion has continued in Kenya, but due to boundary changes at and below the district level, it is not easy to tabulate change[11].

Market led change in livestock and crops in northern Nigeria

Livestock data are notoriously difficult to collect. Within Nigeria, the 1990 National Livestock Survey demonstrated that total livestock biomass was 25 % greater than the figures indicated by contemporary Federal Government and FAO statistics, while the population according to the 1991 census was 26 % smaller than expected, demonstrating the likely unreliability of per capita figures (Bourn and Wint, 1994). Their evidence suggests growth in livestock numbers along with the human population, and the case studies support this.

Gombe Emirate began the twentieth century raising food crops for subsistence, and livestock for cash needs. In the 1930s and 1940s, groundnuts were important for cash. By the 1950s, it was viewed by the Department of Agriculture as one of the leading cotton areas of the north. This was from the point of view of a government interested in exports. In fact, livestock sales continued, and food crops (mainly sorghum) began to be sold to Nigerian towns, thanks to a better road connection and the end of the wartime lorry shortage. In 1965–6 these were jointly providing an estimated 70 % of farm cash incomes, cotton and export-destined groundnuts the remainder. Groundnuts, of course, featured in both the export and urban markets (Tiffen, 1976). By the 1990s, the Nigerian home market completely dominated sales. An investigation in three villages found the most important crop was beans, followed by maize (a new crop since the 1960s), millet and sorghum. In two of the three villages, nearly every field had beans in its crop mixture. In the third village nearness to Gombe town meant that peppers, onions and tomatoes were substituted for the beans (Malchau, 1999). Gombe town was absorbing a greater proportion of local production, but its main market was still despatching two-thirds of incoming crops to markets outside Gombe State boundaries. The second biggest market, at Kumo, sent about two-thirds of crops dealt with to Gombe town, and one-third to other Nigerian markets. Kano was the main destination for millet, but maize and beans had a wide variety of destinations, in the north, the middle belt and the south.

[11] There have been changes both through the creation of new districts, and within districts, by the creation of 'municipalities' which include large peripheral rural areas. The full results of the 1999 census are not available.

Malchau (1999) unfortunately does not mention the livestock component of the farm economy, but Bourn *et al.* (1994) found that Bauchi State, in which Gombe was then incorporated, had an average density of 27 cattle, 54 sheep and 44 goats km^{-2} in 1990 and that the Gombe area contained five major livestock markets dealing in 100 to 500 cattle per week, and large numbers of small stock. Maps of the within-state distribution show cattle densities in the Gombe area to be mainly in the 20–50 km^{-2} range in the dry season, with some in the 50–100 km^{-2} range. In the wet season there were more of the latter, concentrated in the less farmed western half of the Emirate[12]. It was probably not far from the average figure for Bauchi State; if so, it had raised cattle density from about 8 to about 27 km^{-2} between 1963 and 1991[13].

This brief history of one area shows both the rapidity of change that can occur in the range of annual crops grown and marketed, and the way both home market crops and the livestock element can be overlooked by outside observers and officials. It is also important to note that all the crops currently grown provide livestock fodder.

In the three northern states of Kano, Jigawa and Katsina, the grain needed for urban consumption increased from 62 000 t in 1952 to 585 000 t in 1991 – more than nine times (Tiffen, 2001). In this time, the rural population had barely doubled. Farmers had therefore a strong incentive to increase their output, and to improve yields per hectare and the percentage of land under crops. That they succeeded is shown by the long-term trend in prices. These fluctuated considerably due to weather, and policy changes on imports and currency levels, but the trend for 1960–1998 has been down, rather than up. In the case of maize, for which price data are only available from 1979, the downward trend was particularly marked from 1979 to 1986, when maize grain was massively imported. Grain imports were curtailed by devaluation and other policy reforms after that date, since when the real price of maize stabilized, although inflation disguised this (Ariyo *et al.*, 2001). Groundnut production plummeted after disease outbreaks in the early 1970s had ended exports. Since then, it has revived to a limited extent as a local food crop, but the main pulse is cowpeas.

In the 1960s, the main grains were sorghum and millet. A coincidence of several factors in the 1970s and 80s caused an increase in maize in suitable areas. In the mid 1970s, research introduced a new higher yielding open-pollinated cultivar, which was taken up rapidly. At the same time, road networks were being improved and urban centres growing, due to the oil boom, increasing effective demand in an enlarged trading zone (Smith *et al.*, 1994). Farmers wanted to increase their farm size and to plant at optimum times, and the seemingly high prices obtainable for food crops in the 1970s and early 1980s provided the means to purchase ploughs.

Ploughs had been adopted not only in Gombe but also in the neighbouring and ecologically similar Katsina State, in the 1950s and 60s, much earlier than in Kano, in association with groundnut production. (Anthony *et al.*, 1979). The plough was adopted in Kano only after a populist party came into power in Kano State, further

[12] A deep water table makes it difficult to find village sites, and very porous soils reduce the effectiveness of rainfall on crop growth. Eastern and southern Gombe have loams and clays.

[13] 1963 figure calculated from estimated cattle population of 140 000 in the Emirate in 1966–7 (Tiffen, 1976).

Table 2. Percentage of households keeping livestock in Kano State, Nigeria, 1984.

Household livestock owners (%)	Zones			
	NE	NW	SE	SW
Having livestock	93	95	92	83
Cattle	22 (8)†	39 (7)	29 (7)	41 (6)
Sheep	75 (7)	81 (8)	73 (6)	78 (7)
Goats	86 (8)	88 (8)	82 (7)	81 (8)
Poultry	73 (18)	71 (14)	68 (14)	63 (12)
Donkeys	36	39	38	25

†Numbers in parentheses indicate mean numbers per keeper.
Source: World Bank (1995), Table 3.8, quoting Kano State Agricultural and Rural Development Authority (1986).

diminishing the power of the Emir and the old aristocracy. The old local tax on farmers was abolished (Mustapha and Meagher 2000). Powerful Emirs like those of Kano and Bauchi could oblige colonial officials to turn a blind eye to extortionate tax demands, particularly on peasants making presumptuous shows of wealth, as in the purchase of a plough. A weak Emir wishing to boost his prestige by attracting immigrants to swell the population under him, could deliberately collect taxes in a less oppressive manner (Tiffen, 1976). This is an example of the importance of local political conditions and polices.

Plough oxen can be trained quite quickly, and, as they are specially fed in the dry season to keep them in condition for ploughing, they fatten up quickly. After two or three years, it is profitable to sell them, and start again with younger beasts. From that point, it is a small step to stall-fed cattle and sheep for sale rather than work, both for tribes traditionally associated with cattle and others. Thus, ploughing leads to fattening, and sales by farmers not previously associated with the cattle trade (Tiffen, 1976). Bourn and Wint (1994) mapped the substantial overlap of animal traction and animal fattening in Nigeria.

The increased use of ploughs has led to an increase in cattle keeping by a large minority, while the great majority keeps sheep and goats. Table 2 shows livestock ownership in Kano State in 1984. Amongst a sample of farmers with *fadama* (low-lying land) interviewed in 1994, 78 % said they held more livestock than 10 years previously (an increase over the position shown in Table 2). Only 15 % said they had less livestock (World Bank, 1995). Farmers with *fadama* are probably better able to invest in livestock than those without the high-value crops that can be grown there in the dry season. However, this finding gives no grounds for thinking there would have been a decrease in livestock holdings elsewhere. In Kano and Jigawa States, the overall densities of cattle, sheep and goats were 23, 63 and 60 km^{-2} respectively in the 1990 National Livestock Survey (Bourn *et al.* 1994).

Table 2 shows that although only 20–40 % of farm households kept cattle in 1984, numbers owned per household were quite high at 6–8. Almost all households kept goats, sheep and poultry. Cattle numbers would have risen as more farmers acquired

ploughs. Evidently, despite the lack of free grazing in most parts of Jigawa and Kano, farmers could still feed their animals. A study of the use of crop residues by 54 *fadama* farmers and 11 pastoralists in Sokoto and Zamfara States (Baba and Magaji, 1998) gives some indication how. They found 93 % of the farmers owned livestock, and 49 % had cattle. Farmers maintained 0.6 and 0.37 TLU ha^{-1} in the two study locations (using 1 head of cattle = 0.68 TLU). All farmers and pastoralists used crop residues: 100% of farmers used sorghum straw, followed by cowpea hay (81 %), groundnut hay (44 %), rice straw (39 %) and some others. Pastoralists preferred a slightly different mix: rice straw was used by 100 %, cowpea hay by 45 %, groundnut hay by 27 % and pearl millet straw by 18 %. All pastoralists purchased rights to use crop residues on the farms their animals grazed, at a price of N1250–N1879 ha^{-1}[14]. Bundles of crop residues were also sold in markets. Cowpea and groundnut hays realize considerably higher prices per kg than sorghum straw, but prices varied by location. Transport costs are high for these bulky products, so the markets are not well integrated. Farmers felt prices were rising. Crop residues are used even when grazing is relatively available. In the Zamfara grazing reserve, herders took sheep and goats to graze daily in the wet season, but in the dry season browse is supplemented with crop residues and bran (Hassan *et al.*, 1998).

Where the land is fully occupied, caring for livestock penned for fattening or to prevent crop damage consumes a lot of labour time. Mortimore and Adams (1999) compared labour expended on livestock and crops during the farming season in two dry Sahelian villages, with relatively low population densities and two Sudanian villages with much higher population densities. In the Sahelian system, a few small children took the animals to graze on common pastures. Caring for livestock took only 20 units of labour in the cropping season, when other farming tasks peaked at 280 units $week^{-1}$. In the Sudanian system, animals were stall-fed in the wet season on weeds and hedge-cuttings that had to be gathered daily. Livestock care took 30–70 units in some weeks, which had to be combined with other farming tasks taking 80–160 units.

Markets thwarted in Senegal

The Diourbel Région, inhabited by the Wolof and Serer peoples, became the centre of the groundnut basin of Senegal early in the twentieth century. By 1960, its two eastern departments, Diourbel and Bambey, were fully occupied. Groundnut was the main crop and cash source. Farmers also grew pearl millet for their own consumption, but government policy encouraged the import of broken rice for urban households. The Serer, who had difficulty in expanding their farms as they were surrounded by Wolof, already practised integrated agriculture in which soil fertility was maintained by cattle and small-stock manure and the protection of *Faidherbia albida* trees that also provided browse. This was much admired by French observers (Pelissier, 1966). The Wolof kept few cattle and tended to meet expanding family needs for land by establishing new farms in the western department, Mbacké. They were also noted traders, and their reliance on non-farm income was already evident in

[14] The official exchange rate then was US$1 = N21.895, so the rates were equivalent to US$57–$86.

https://doi.org/10.1017/S0014479706003589 Published online by Cambridge University Press

1960. Both their trade networks and their new farming establishments were facilitated by membership of a religious brotherhood, the Mourides, whose leaders accumulated capital not only for commerce and farming but also for urban developments in their headquarters, Touba, in Mbacké Department, and in Dakar.

Soon after independence in 1960, the Government took over the French trading establishments and tried to drive groundnut output upward by compulsory co-operatives, providing, on credit, inputs of improved seed and appropriate fertilizer, and a range of animal-drawn tools via an intensive extension–research system. However, they kept the producer price of groundnuts substantially below the world market price, at a level which they felt just sufficient to encourage production. The difference funded the expenses of an expanding bureaucracy, and subsidies on fertilizer for the farmer and rice for the consumer. In bad rainfall years, the peasants were unable to repay their credits and the system was bankrupting state organizations. Hence, during 1980–85, Senegal was driven reluctantly into structural adjustment, entailing the abolition of all credit and the subsidies on fertilizer. Thenceforward it took about 1.2 kg of groundnuts to purchase 1 kg of fertilizer, instead of the 0.4 to 0.6 kg in the 1960s and 1970s. This was unattractive. Yields of groundnuts tended downwards, while those of millet tended upwards, as farmers concentrated their limited supplies of manure on the millet. (Variations in rainfall always had a greater effect on yields than the level of inputs). As the government price for groundnuts remained low, sales to the government became less attractive. Annual groundnut production in the Diourbel was over 117 000 t from 1960 to 1966 but fell steadily under the influence of lower rainfall and low real producer prices to a low of 80 000 t in the early 1970s. Production recovered to 140 000 t annually in 1974–80 when prices were raised, only to plummet again when structural adjustment policies in the mid 1980s withdrew the subsidy on fertilizer and credit for seeds. Recorded output fell to an average of 57 000 t in the first half of the 1990s. Even though rice was no longer subsidized, the long established urban preference for rice meant that the market for millet did not expand. The overvalued exchange rate that encouraged food imports was only corrected in 1994. Farmers grew millet only for home consumption (Faye *et al.*, 2000).

The only buoyant sector of the agricultural economy was livestock, and especially sheep. Livestock data, dependent on veterinary campaigns, is not available for all years, but Figure 4 shows that small ruminants formed a growing proportion of the whole. The increased preference for small ruminants is explicable by several factors. First of all, their meat is in great demand at Muslim festivals and sells at a higher price than beef. Touba was expanding rapidly as a *de facto* urban centre. Its market was the main focus of Diourbel's agricultural production, particularly on the occasion of the major pilgrimages and religious feasts commemorating its founder and the end of Ramadan.[15] Mutton prices took another upward jump after the 1994 devaluation of the FCFA. Secondly, small ruminants multiply quickly, so that when numbers are

[15] Its huge markets were also the centre of an import trade, partly contraband goods, smuggled in from Gambia, part financed by payment in kind of remittances by overseas Senegalese. The writ of the Senegalese customs does not extend to Touba because of its holy status (Gueye, 2002).

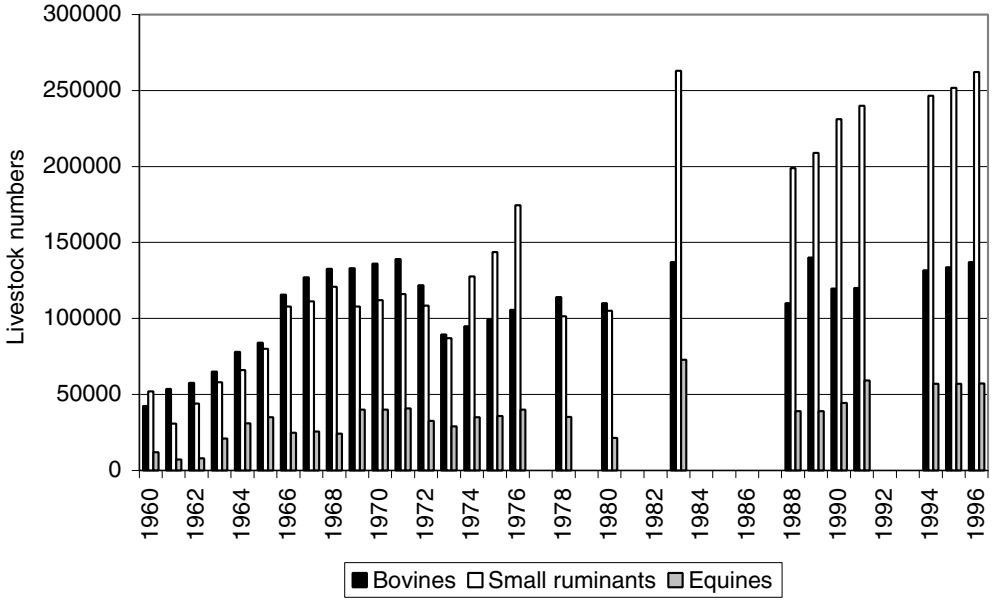

Figure 4. Numbers of livestock, 1960–96, Diourbel Region.
Source: Faye *et al.* (2000) Data from Veterinary Department records.

reduced by droughts, the herd is more quickly reconstituted than are cattle herds. Thirdly, there is less of a capital barrier to ownership, and small-scale farmers and women wanting an independent income can enter into livestock ownership by this route.

By 2000, local off-farm, seasonal urban migration, and remittance incomes from young migrant members were the main cash source for many rural families, followed by livestock fattening for those with the capital to enter this area. The failure of the education system to attract rural parents has meant that the main off-farm occupations are in low paid informal jobs. The one exception is that a successful street seller with the right connections can migrate abroad in which case he is better able to help his family through his remittances (David and Niang, 1995).

Our researchers classified farmers into three groups according to the number of months they could feed their household from their own production. The considerable differences between families are shown in Figure 5, while Table 3 shows the patterns of expenditure for the same three groups. Faye and Fall (2000) found some 30 % of 'farmers' in the villages investigated produced less than six months millet supply for their families (Group 1). They bought food using non-farm earnings and remittances. Very little of their low incomes could be spent on livestock or crop inputs (Table 3). Some 40 % of farmers fell in Group 2, who produced between six and 12 months of their millet needs. Table 3 shows they spent 12 % of their incomes on buying in animals for fattening, and over 4 % on animal food and medication. Group 3 were the most successful (30 %), with double the income of Group 1. They covered their

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Table 3. Use of money income in Diourbel villages, by household group (percentage).

	Household group†		
Expenditure	1	2	3
Buying for consumption			
Pearl millet	16.9	7.5	5.4
Rice	15.2	13.1	10.3
Other food	22.0	11.7	26.6
Other products	5.6	2.7	3.2
Clothing	14.3	19.2	9.0
Investing			
Equipment	0.5	0.6	2.1
Animals	0.8	12.0	18.9
Animal food or medication	1.1	4.4	2.9
Crop inputs	1.9	1.9	2.4
Payments for services			
Services	1.6	1.8	2.0
Health and education	3.6	4.1	2.7
Ceremonial expenses	16.6	21.0	14.5
Total	100.0	100.0	100.0

†Types:
1: Farm provides less than six months cereal need.
2: Farm provides 6–11 months cereal need.
3: Farm provides 12 months or more of cereal needs.
Source: Faye and Fall (2001), WP 22, Table 13

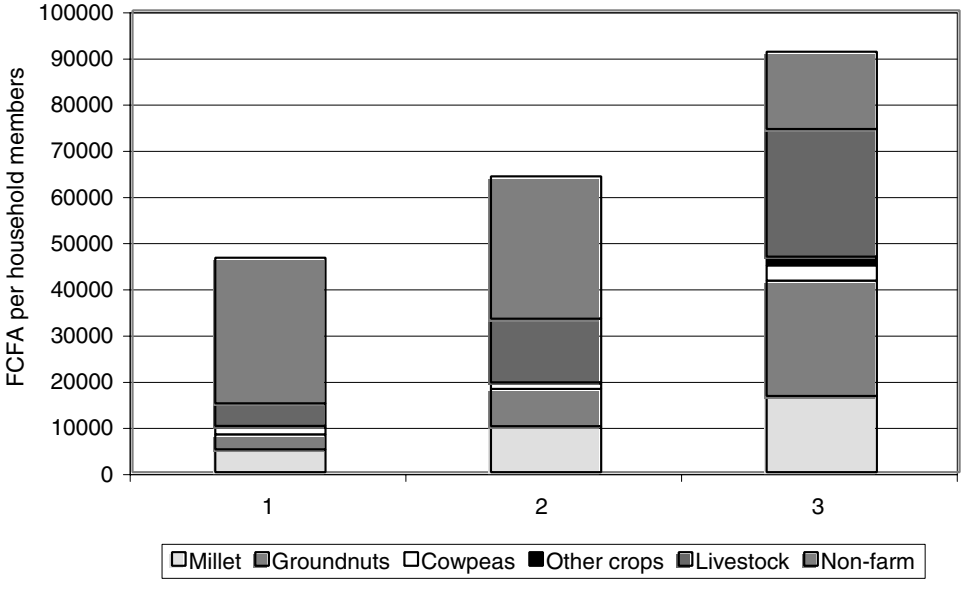

Figure 5. Total income and income sources in Diourbel for three groups of farmers (see Table 3), agricultural year 1999–2000, in FCFA per household member.
Source: Faye and Fall (2000). US $1 = FCFA 615.7 in 1999. Income per head was low, but possibly not quite as low as this chart suggests, as household heads would not have counted 'private' income earned by adult wives, sons and daughters.

https://doi.org/10.1017/S0014479706003589 Published online by Cambridge University Press

family food needs completely, spent 19 % of their incomes on buying in livestock, and 3 % on animal food and medication.

This illustrates well the importance of capital for intensifying livestock production, and the difficulty the poor have in developing this activity. It should not be surprising that groundnut hay became a tradable commodity, highly valued for fattening. However, official eyes remained fixed on groundnuts (in shell) for export. Deceived by this, even outside researchers could write on the 'profitability' of groundnuts without once mentioning the value of their hay (Kelly *et al.*, 1995). Our own researchers, most of whom had connections with the Senegalese Institute for Agricultural Research, were surprised to find that although farmers still grew and valued the crop, they did so firstly because it provided food for their household, secondly for its value as fodder (meal and hay) for the animals that brought in their main cash and manured their millet, and only thirdly as a source of cash. Many farmers did not sell any groundnuts, and if they did, it was to internal markets as locally processed oil and meal as well as to the government for export (Mortimore and Tiffen, 2004).

Developments in Maradi Department, Niger

In Maradi, the government never had the same control over trade as did the Senegalese government, due to the easily crossed border with Nigeria. Maradi town remained comparatively small, government aid having tried and failed to develop an industrial sector. Some 20 % of its food was from farms belonging to its inhabitants (Grégoire, 1990; Tiffen, 2001). As in Senegal, the main source of cash was groundnuts in the 1960s, but by 2000, it had become a variety of grains, pulses and livestock for the large Nigerian towns just over the border. These included a new crop, tiger nut, for the Nigerian market (Fr: *souchet*: *Cyperus esculentis*) (Hamadou, 2000a). Early expansion of production was by opening new farm land, but recently in the south, there have been signs of a change to a more intensive type of agriculture, with manuring and the privatization of crop residues. In 1988, population densities in the south were 50 km^{-2} and upwards, in the north only 10 to 40 km^{-2}. Fertilizer was used until its price increased. As in Senegal, heavy ox-drawn equipment and fattening techniques were introduced by government, and credit provided, under the *Projet de Développement Rural de Maradi* 1978–84. Fattening and use of draft animals increased, without credit, after 1994. Farmers used their own resources once the devaluation of the FCFA had made farming more profitable. They then showed their preference for a lighter type of plough (Hamadou, 2000b, Mortimore *et al.*, 2001).

Most families own livestock, numbers varying as usual according to the socio-economic category of the family. With rising livestock prices in 1993–97, more livestock sales were being made, especially of cattle (Mortimore *et al.*, 2001). Milk was a valued product, often sold locally, but according to CARE International au Niger and Université d'Arizona (1997) revenues from animals were much less than those from crops and non-farm activities. CARE also found that livestock ownership was nearly three times higher amongst recently settled Fulani than among the Hausa majority. Former nomads are taking up farming, and Hausa farmers

investing in cattle are using transhumance in the wet season, sending an older child to accompany the herder (Banoin *et al.,* 1996). Batterbury and Baro (2005) also found increased livestock sales in an area with much lower population density in western Niger.

Makueni District, Kenya

The fourth study was in Makueni District, in Kenya. The district takes it name from the Makueni settlement of 1946–62. The colonial authorities established it to relieve pressure on the degraded highlands of the then Machakos District. The new settlers were supposed to establish classic mixed farming under strict supervision. They found it impossible to establish leys, which demanded heavy labour to clear the bush for pasture, and even more labour to break up the pasture for crops. They moved instead to permanent pasture and permanent cropping, retaining ox ploughs and expanding their holdings of the despised goat (the goats helped keep down the bush) (Tiffen *et al.,* 1994). The remainder of the district was settled as people saw fit. Livestock development has taken a different route to West Africa, partly due to topography, and partly to different tenure traditions. Local custom allowed people to claim exclusive grazing areas by marking trees and establishing a cattle post, and with the push towards land demarcation and registered land titles since the 1950s, the new settlers have established farms that include both cropping and grazing areas (Tiffen *et al.,* 1994). In time, they improved these with terraces for crops, and hedges or fences for the grazing areas. The latter may also get selective bush cutting, and some grass replanting (Gichuki 2000; Gichuki *et al.* 2000), but the cropped area receives attention first, as it gives better returns. By the 1990s there was no longer any unclaimed land, and the only free-access grazing was on the borders of a national park. A minority of settlers own cattle, but most have goats. If anything, cattle ownership has declined in recent years, but people blame this on disease rather than on droughts. The government Veterinary Service does not have the resources to combat many of the current common cattle diseases. There is a market for everything – farmers rent in or out grazing, and buy bull services to improve their stock (Fall, 2000).

Since the collapse of the monopolistic Milk Marketing Board in the early 1990s, private dairies have sprung up and raw milk sales in rural areas and small towns have also expanded greatly (Owango *et al.,* 1998). In Makueni, there are only limited areas where topography allows the building of small dams and ponds, in which some farmers have invested. These farmers have then upgraded to cross-bred cattle, protecting them from parasites with their own spraying equipment, but, because they are not so concentrated as the dairy farmers in the high potential areas, they are unable to form co-operatives to hire veterinary services. However, some shops now sell some medicaments and other inputs.

The poor cannot take part in the dairying industry, because of the high initial costs and high disease risks, but chickens and goats are extremely important to them, both financially and as providers of manure. Small stock enable people to meet expenses like school fees (that are an absolute parental priority) and they can be sold when

the harvest fails (Fall, 2000). Unfortunately, the chickens which are often the poor person's first step in building up livestock holdings are at risk from Newcastle Disease. A non-farm job in the family is regarded as a better insurance against crop failure than livestock, and education is seen as essential to this, and the gateway to the better paid occupations (Gichuki *et al.*, 2000).

Small farmers in the more arid areas manage their livestock very intensively. Thus, one woman at our concluding workshop in 1999 said she had 8–10 acres of cropped land, and one acre of pasture[16]. This is for one cow, two bulls and seven goats. Therefore, her fencing must be very good, to keep animals out of the crops. In the dry season, they are tethered in the grazing area and rotated around it. She replants bare patches with *ikoka* (star grass – *Cynodon plectostachyus*). She looks for this just before the rains begin. She also has some on part of her crop land (0.5 acre). She collects all crop residues from her maize and stores cowpea leaves in sacks. She collects and stores grass from her terrace edges. In the rainy season, her animals use the stored food. She also buys acacia pods to give them. A village elder with 25 acres of crops and 6–10 acres of grazing land for four oxen and 55–60 goats also emphasized the importance of good fences (which are costly in time or money) but was able to make more use of grazing on his own land. He reseeds a portion annually, using a different native grass to star grass. (Farmers demonstrated a good knowledge of these in the discussions). Boys or hired workers herd the animals to protect the new grass for two years, and then it is used in September–October to feed the bulls used for ploughing. Another example of grazing management strategies is given in Tiffen *et al.* (1994).

CHANGES IN LAND USE, TENURE AND LOCATION OF LIVESTOCK

The growing scarcity of land in the past 50 years can be inferred from the changing rural population density shown in Table 1. By 1991, it was 972 km^{-2} in peri-urban Kano, 313 km^{-2} in the middle zone and 150 km^{-2} in the outer zone. This also implies little land available for free grazing. The increase in population, the expansion of the farmed area, and the changes in farming practices mean that more animals now live in the enlarged farming zone, and a smaller percentage are in the exclusively pastoral zone. The positive correlation between livestock and roof tops in semi-arid areas was shown by Bourn and Wint (1994) using aerial surveys of livestock distribution in Mali, Niger, Sudan, Chad and Nigeria. (An even more positive correlation was obtained with the percentage of land cultivated). Hence, when population density maps of Kano State show how the population density of the southern zone increased from an average density below 38 km^{-2} to the range 76–150 km^{-2} in 1991 (Tiffen, 2001), we assume that it was accompanied by a concomitant increase in livestock. Naturally, cultivation varies by area. Jigawa State, the northern half of the former Kano Province, experienced a small increase from 78 % cultivated in 1976–9 to 81 %

[16] Farmers in Kenya think in terms of acres. Like the Arab *donum*, 1 acre approximates to what an ox team can plough in a day, and equals 0.4 ha.

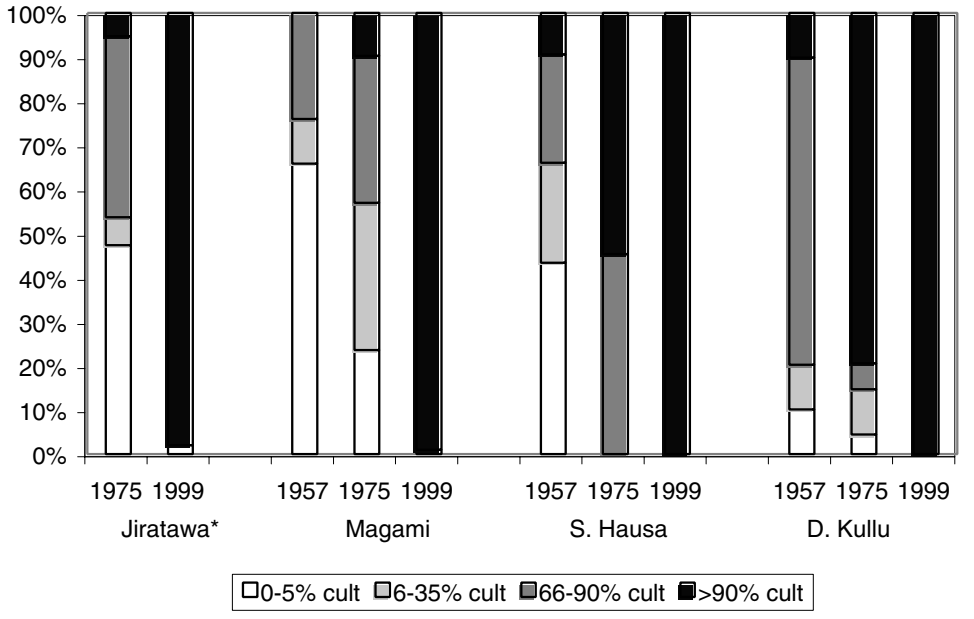

Figure 6. Percentage of *terroir* falling into different cultivation classes (less than 5% cultivated, 6–35% cultivated, 66–90% cultivated, more than 90% cultivated), for four villages, Maradi Department, Niger, 1957, 1975 and 1999. Villages arranged from south to north.
Source: Analysis of remote sensing data in Mahamane (2001).

in 1993–5. In the less densely populated Adamawa State, that was still attracting immigrant farmers, cultivation increased from 49 % to 55 % (Mortimore, 2000).

Bourn and Wint (1994) noted that in Nigeria the compound annual increase in cropped land 1976–90 was 2.1 %, while the areas under grassland and forest declined by 2.3 % and 2.1 % respectively, with scrub and wood falling by 1.1 % and 0.6 % annually. They also noted that the increase in cultivation and reduction in grassland, scrub and woodland had the further effect of reducing the habitat of the tsetse fly, enabling cattle to be kept far further south, in parts of the middle belt that had hitherto been inhospitable[17]. They quoted the Federal Government's Resource Inventory and Management survey of 1992 as showing that almost half of Nigeria's cattle population of some 14 million head was resident in the sub-humid zone throughout the year.

Aerial photographs and satellite imagery showed that the two western districts of Diourbel in Senegal were predominantly under cultivation in the 1950s (Ba *et al.*, 2000). Animals were and are sustained on the few fallows, crop residues, browse and by putting them in the care of transhumant herders for part of the year. In Maradi, in Niger, the closing of the land frontier has been more recent. Figure 6 shows the expansion of cultivation to over 90 % in the whole of the village area, even in Dan

[17] Farmers settling in Gombe in the 1960s also remarked that when they first arrived they had to consign their cattle to Fulani herders to keep in north western Gombe, but, as the bush was cut, they could bring them to their farms in south Gombe (Tiffen, 1976).

Kullu, on the borders of what is officially regarded as the pastoral zone. Due to the expansion of cultivation there is less land available for free grazing within the village territory.

Changes in land tenure and custom, and the impact on pastoralists

Accompanying this growing scarcity of land are parallel changes in rights to land and its products. Farmers privatize their crop residues, either by hoisting them into trees, fencing or adopting other measures to preserve them for their own use. Similarly, if they leave a field fallow (increasingly unlikely in the high-density areas), they regard the weed growth as private pasture for their own animals. The increased commercialization and individualization of land in Maradi has led to pledges, sales and rentals becoming more common in recent years (Boubacar, 2000). In Gombe Emirate in the 1960s, village heads were asked what happened to the land if a family left the village. The replies varied according to the state of demand for land. In an area with very low density, and poor soils unattractive to immigrants, the answer was 'Nothing. Nobody cares about it'. Elsewhere, village heads gave it out to a new family after seven, three, or one years. A one year interval endangered a semi-settled Fulani family who might or might not want to return to the plot they had cultivated. In the most densely settled, market-orientated villages, the reply was 'Naturally, they sell it before they go' (Tiffen, 1976).

This situation has led to conflicts between farmers and pastoralists. In Nigeria, where there are links between elite Fulani in powerful positions and their herding kinsmen, some attempt was made to create grazing reserves. However, less than 1 % of the area originally intended was so gazetted (Gefu, 1998). Within what is reserved, pastoralists are using some land for farming (Mortimore, 2000). It seems unlikely that grazing reserves provide a future for livestock in Nigeria. The more likely future scenario is of mixed farmers, some of whom will be ex-pastoralists, who combine crop production and livestock raising in an integrated system. Pastoralism may well survive for several more decades in the low population density parts of the Sahel (less than 20 persons km^{-2}), where it is a logical response to large land resources and few marketing points. However, slowly growing rural populations are likely to nibble away at any land that has the potential for crop production, which gives higher returns per hectare.

It cannot be pretended that the expansion of new farms in very risky semi-arid regions leads to healthy farm incomes. It leads instead to the development of non-farm income, especially by seasonal or permanent urban migration, as an insurance and as an essential supplement to variable agricultural production. In contrast, migration into the sub-humid areas can allow both the improvement of farm income, with intensification and livestock development financed out of growing farm profits, and the development of new market towns offering a variety of local services. This has already been illustrated for Gombe town. Balzerek (1999) found 68 % of the household heads in the town engaged in trade and services, with only 18 % still in agriculture. Few were in industry, cotton and groundnuts no longer being produced in sufficient quantity to provide raw materials.

THE NEW CHALLENGES FACING NATURAL AND SOCIAL SCIENTISTS IN CROP–LIVESTOCK DEVELOPMENT

Population growth and urbanization are driving a livestock revolution. Mixed farming systems are the present and near future of west and east African livestock systems, with concurrent changes in livestock feeding systems and the role of grazing, fodder and penning. These systems have evolved, and are evolving, to meet changing land:labour:capital ratios and changing markets. Urbanization and the market changes it brings are accelerating. Farmers have adapted and researchers need to do likewise. They need to put aside old stereotypes and understand what present-day livestock keepers are doing and why, and to work with them on solving current problems, in the context of their need to earn profits and improve livelihoods.

The need for a better understanding of livestock economics

As we were carrying out historical studies, we searched out previous reports on farming systems and farm economics in order to track change. Regrettably, we found that the livestock element in a farming system was almost always very cursorily treated. For example, livestock income was often given in terms of sales made in the previous year, without regard to input costs, and without testing if such sales represented a drawing down of the capital stock or were taken from the natural increase. Frequently, there was not even a reference to the state of the rains in a particular year, although in semi-arid areas farmers in bad years may get cash mainly from sales of livestock (depleting capital), whereas in good crop years they may deliberately not sell the whole natural livestock increase, in order to rebuild capital. Milk income, whether home-consumed or sold, was generally ignored. Studies seldom reported how the livestock were fed or how feed sources differed between seasons (except if the study was of purely pastoral systems). In regard to crop income, the value of residues, whether used as inputs or sold, was ignored. There are few studies of fattening economics, or the current market value of crop residues or of access to stubble on farm land. While the use of animal power for ploughing may be noted, the hiring out of donkeys or ox carts for general transport is not. How long is the working life of a draft animal, and what is the optimum age at which to sell an ox?

The estimation of livestock income is not easy, but it is essential if farmers' strategies are to be understood. The primary need is for a realization that livestock are capital[18]. Upton (2004), in re-emphasizing this, treats the animals as fixed capital (lasting more than a year) requiring circulating capital for their maintenance (wages, purchased inputs) and provision for eventual replacement. The need for circulating capital to meet recurrent costs is greater in meat production than in milk, where sales replenish cash outflow on a daily basis. Moll (2005) goes further and suggests that allowance should also be made for the undoubted fact that livestock play a role both as insurance and as means of meeting cash flow requirements without taking loans. Farmers frequently mention the usefulness of having livestock that can be sold at any time of year to meet

[18] Indeed, the word capital derives from the Latin, *caput*, head of cattle, and live*stock* is part of a farmer's stock in trade.

essential expenditure. The income flows derive from sales of animals (provided these do not eat into capital), and the recurrent income that may come from, for example, milk, hiring out, bull services, after the deduction of expenses (which as Table 3 has shown, may include purchase in of young animals). Some 'income' will be reinvested – where sales are not made in order to increase the size of the herd.

Moll *et al.* (2001) and Moll (2005) start with net recurrent cash income, i.e. marketed items minus purchased recurrent inputs; recurrent income in kind, which is consumed, exchanged or invested; and embodied production, realized only if animals are sold (sale value of animals at beginning and end of year). Herd increase or herd decrease is then taken into account, increase being an investment resulting from the decision not to sell animals (or to buy in), while herd decrease is a capital loss. To understand the reason why farmers may not sell, they then examine the possible role of livestock as insurance or as an inflation-proof bank. Their examples range from dairy farmers in Kenya, who both consume and sell milk, for whom animal sales are a by-line, beef cattle raisers in Zambia, for whom milk is a by-product useful for the family and some local sales, and Sri Lankan farmers responding to a milk market in Colombo, but not using it themselves.

Fodder, manure, legumes and fertility

Animals provide services to the crop enterprise (manure and draft power), but to do this require fodder. Non-edible forage legumes provide high quality animal fodder and soil nitrogen. Hence, they have been researched for decades. There has recently been a dispute as to how effective this has been with Sumberg (2002) questioning its value, and Lenné and Wood (2004) disputing his arguments. Much of the initial work that the latter cite on grasses and legumes in east and southern Africa was in the context of large-scale European farms for which leys were feasible or large European ranches with permanent pasture. Most attempts at introducing fodder legumes and leys for small farmers failed either because the farmers lacked the necessary labour, or because it was not the most profitable use of their scarce resource, land. Small Kenyan farmers in dairy areas have found some non-edible legumes useful as niche crops, particularly leguminous shrubs used as boundary markers or in hedges. However, most of the forages suggested for reducing poverty and the degradation of natural resources in a recent review were utilized in the Americas and could not be shown to meet the needs of the semi-arid areas in Africa (Peters *et al.*, 2001). More recently, very limited adoption of fodder bank technology by pastoralists or agro-pastoralists is confirmed by Elbasha *et al.* (1999), who concluded that crop residues are becoming the most important source of fodder. Sumberg is surely right to argue that research must take account of the bio-physical and socio-economic context in which farmers are working. Planted forage (legumes or grasses) may be useful to dairy farmers producing high value output on a daily basis, but this paper shows that the majority of mixed farmers producing meat animals now have little alternative to crop residues. It would seem sensible to give more emphasis to food legumes, which Delgado *et al.* (1999) also expect to be the main future fodder source. Farmers need practical methods to improve the animal

nutrition qualities of their food crop residues. Practical means taking into account costs, access to materials (e.g. urea) and labour availability. Fattening activities often involve sheep rather than cattle, and in researching dual or treble purpose leguminous crops, it is well to consider the animal for which they are intended.

Food legumes have been used in Africa for centuries. While the residues have always been grazed, their value as quality animal fodder is ever more appreciated, as we have seen with Senegalese groundnut farmers. McIntire *et al.* (1992), note that fattening becomes profitable 'when population pressure on land restricts extensive livestock production, where feed conversion is better, or where the ratio of meat to feed prices is relatively high'. In northern Nigeria, the price obtained for cowpea haulms ranges between 50 and 80 % of the grain price. The International Livestock Research Institute, International Institute of Tropical Agriculture and International Crops Research Institute for the Semi-Arid Tropics are now developing varieties and cultural methods with their dual purpose specifically in mind, and the results are popular with farmers in the test areas (Singh *et al.*, 2004). In parts of Zambia farmers may have the land to devote to a crop such as *Crotalaria juncea* recommended there for soil restoration, but given the appalling rates of chronic malnutrition in rural areas, it would seem better to concentrate scarce extension resources on food legumes (Tiffen and Mulele 1994). The same applies in Maradi, Niger, where the CARE report showed widespread malnutrition, even before the most recent drought and food shortage.

More fodder, as the Seneglese farmers remarked, leads to more manure. We found farmers everywhere conscious of fertility problems, associated with high fertilizer prices and shortages of manure. They were already using the latter as well as they knew. Given the cost of fertilizer, research into methods of increasing the utility of manure, with inorganic fertilizers as additives, would be welcome. Sumberg (2003) is one of several pointing out that even efficient recycling cannot supply elements deficient in the original soils.

Animal health

Animals need protection against disease. McDermott *et al.* (2004) provide an important review of disease in the mixed farming systems of West Africa, in the context of increased urban demand and the move into more humid zones. The need to control disease far exceeds existing resources, and poses institutional and policy challenges, including finding the right balance between health and safety and market access. Standards adopted in developed countries may well be too high for developing countries and could impede traders and farmers in bringing produce to market; unpasteurized milk may be a better option than no milk, for example.

The question of how to finance veterinary services given reduced government resources has attracted some attention, particularly in such areas as the training of para-vets. Farmers may well be willing to pay more for effective vaccination services against current disease risks, which need to be identified and prioritized. Artificial insemination services seem less essential, especially if farmers can use bull services. They may help in the initial establishment of cross breeds, where these have the required qualities for specific environmental and economic contexts.

Breeding

One of the drawbacks of an open grazing system is that it makes control over breeding difficult. If cows, sheep and goats are increasingly kept in enclosures what are the implications for breeding? Are farmers already developing a market in the services of good sires, as in Kenya? Are research services taking advantage of this development?

Semi-humid areas

In all these matters, current recommendations for semi-arid areas need to take account of different conditions as people and livestock move into the semi-humid zone, with its different environmental opportunities and constraints. Initially at least, there are also changed land:labour relationships compared with the place of origin.

LIVESTOCK IN THE CONTEXT OF RURAL LIVELIHOODS AND URBAN DEVELOPMENT

Change is inevitable and increasing urbanization will increase its speed. Rural livelihood systems, as illustrated here, and attested other studies too numerous to cite, already incorporate a variety of non-farm work, as well as work on other people's farms. Many studies show, as in the Senegalese case referred to above, that the poorer farmers are particularly reliant on scraping a living from a variety of ill-paid occupations, while the richer farmers are more likely to have one or more family members in a well-paid occupation, who may help out with farm investments. Bahiigwa *et al.* (2005) make the interesting suggestion that the best way to help 'the poorest of the poor' may not be through farming, but by encouraging urban growth poles that provide alternative occupations. A study of pathways out of poverty in western Kenya suggests this is indeed the case. It found that 73 % of those who had climbed out of poverty did so by getting a household member into a non-farm job. However, in 42 % of cases, the improvement was through livestock, ranging from poultry to dairy animals (Kristjanson *et al.,* 2004a). Table 3 has shown the middle group of Senegalese farmers struggling to take this route, using part of their small incomes to buy in livestock. It is this middle group of farmers, rather than the poorest, that can best be helped by well-directed livestock and fodder research.

While increased attention to urban and transport infrastructure and good governance will do much to assist the beneficial interaction of town and country, it will not obviate the need for government or aid-funded agricultural and veterinary research, producing information as a public good. It will, however, require new priorities, and a careful watch on the changing contexts in which farming is taking place. It makes sense to seek complementarity between government investment and services and private investment, when most governments are facing reduced public resources per capita (Drylands Research, 2001). However, research will have no lasting result unless it generates good profits under the land, labour, financial, and agro-climatic constraints under which people are operating. Farmers have to be good

businessmen – if they are not, they are, in current conditions of land scarcity and land commercialization, more and more apt to end up as landless labourers.

Acknowledgements. This paper has benefited from the long collaboration between Michael Mortimore and the author most recently in two research projects funded by the Department for International Development, (DFID) UK: R7072CA *Policy requirements for farmer investment in semi-arid Africa* and R7221 *Kano–Maradi study of long-term change*. The scientific teams in Senegal were led by Drs. Abdou Fall and Adama Faye, in Niger by Dr. Yamba Boubacar, in Kenya by Dr Francis Gichuki and in Nigeria, by Dr J. A. Ariyol. DFID is in no way responsible for the opinions expressed. An earlier paper on this theme was presented at an international conference organized by The International Livestock Research Institute, held at Ibadan, Nigeria, in 2001, (Tiffen 2004), and is expanded and updated here.

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