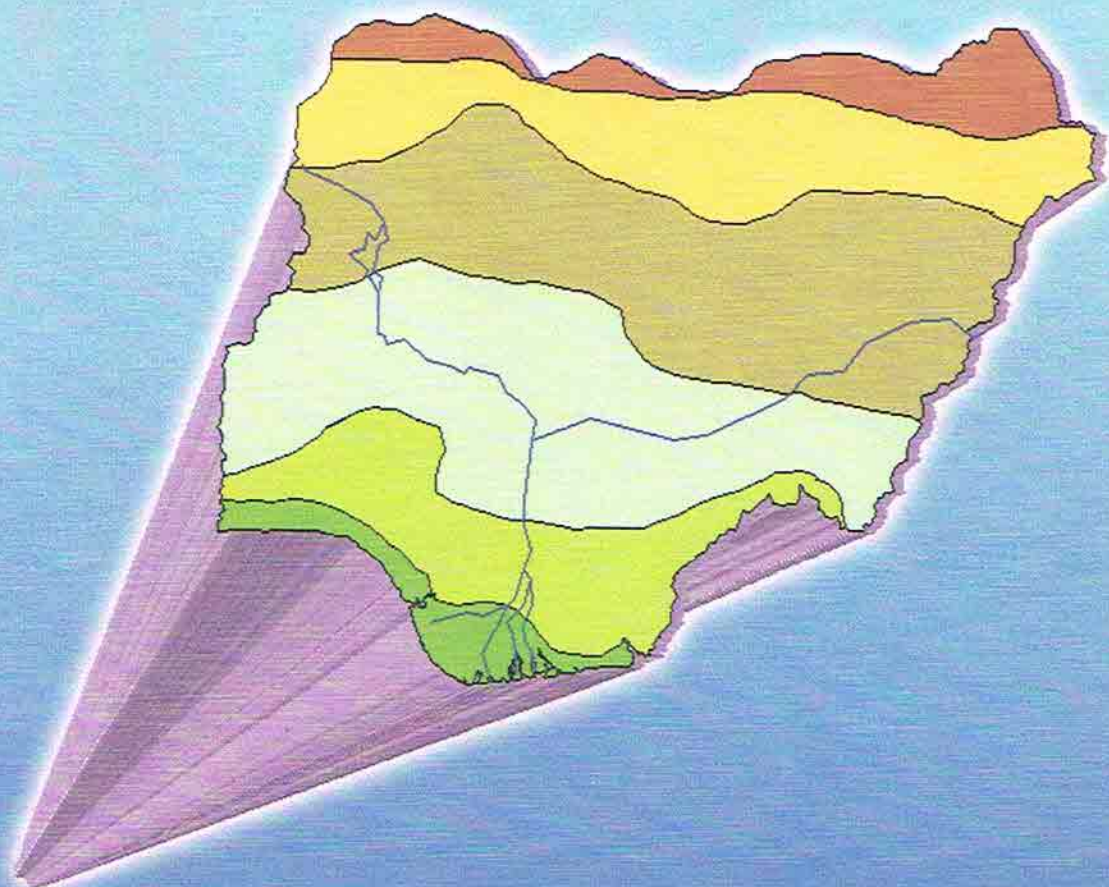
Multiscale characterization of production systems to prioritize research and development in the Sudan Savanna Zone of Nigeria



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Abstract

The Sudan Savanna Zone of Nigeria is characterized by diverse agroecological and socioeconomic conditions. The cropping systems in this zone are predominantly sorghum- and millet-based systems. A multiscale characterization approach, together with participatory research, was used to describe—at macro, semi-detailed (village) and detailed (household) levels—the physical and socioeconomic factors influencing these cropping systems, in order to identify the major constraints to agricultural production, and to describe the major production systems. Emphasis was placed on the household-level characterization to have a better understanding of the land use systems, and farmers' constraints and opportunities, so as to better target agricultural technologies and interventions in this vast agroecological zone. Large variations exist in agricultural management practices among villages and households in terms of access to resources, such as labor, fertilizers, livestock, farm equipment, and land. Intensive and extensive farming practices coexist within the same villages and households. Results were used to make recommendations for development and research, and to select benchmark sites.

Résumé

La caractérisation multi-échelle des systèmes de production en vue de la prioritisation de la recherche et du développement au sein de la Zone savane soudanienne du Nigéria. La Zone savane soudanienne du Nigéria est caractérisée par des conditions agro-écologiques et socio-économiques diverses. La Zone est prédominée par les systèmes de culture à base de sorgho ou de mil. La caractérisation multi-échelle, conjointement avec la recherche participatoire, a été employée afin de décrire — aux niveaux macro, semi-détaillé (villages), et détaillé (ménages) — les facteurs physiques et socio-économiques qui influencent ces systèmes de culture. La caractérisation a également permis d'identifier les contraintes majeures à la production agricole, et de décrire les systèmes de production majeurs. La caractérisation a porté particulièrement sur les ménages en vue d'une meilleure connaissance des systèmes d'utilisation de terres, les contraintes et les opportunités des paysans, afin de pouvoir mieux focaliser les technologies et les interventions agricoles dans cette vaste zone agro-écologique. On constate de grandes variations dans les pratiques d'exploitation agricole au niveau des villages et des ménages en termes d'accès aux ressources telles la main-d'oeuvre, les engrais, le cheptel, l'outillage agricole, et les terres. Les pratiques d'exploitation intensive et extensive co-existent au sein des mêmes villages et ménages. Les résultats ont permis d'élaborer des recommandations pour le développement et la recherche, ainsi que pour la sélection des sites de référence.

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Introduction

Problem identification

Nigeria occupies a land area of about 98 million ha, and covers a range of agroecological zones with large variation in soils, climate, and socioeconomic and policy environments resulting in, among other things, a great diversity of cropping systems and patterns. Five agroecological zones are identified in the country, each with its own potential for agricultural development (Table 1.1). The spatial and temporal variability of climate, soil, and socioeconomic factors present opportunities to develop and recommend improved technologies for sustainable land use systems. The heterogeneity of the large geographical areas across the country necessitates a well-planned research program to develop and match technologies with requirements focused at specific problems of each given agricultural system (Manyong et al. 1996).

In the past, general technology recommendations for use of improved technologies were made for large geographical areas in Nigeria, but this 'blue-print' approach has not been quite successful. Research efforts by national agricultural research systems (NARS), International Agricultural Research Centers (IARCs), and other organizations in the region resulted in the development of improved technologies that have a low rate

Table 1.1. Main features of agroecological zones in Nigeria.

Feature	Sahel	Sudan Savanna	Guinean Savanna	Derived Guinean Savanna	Rain forest
Zone	North	North/Central	South/Central	South	South
Rainfall (mm)	<600	600–1000	1000–1500	1500–2000	2000–3000
Length of growing period (days)	<90	100–150	150–200	200–270	>270
Main crops	Millet, cowpea	Sorghum, pearl millet, groundnut, cowpea, cotton, and pigeonpea, irrigated wheat, and vegetables	Sorghum, maize, cotton, yam, groundnut, cowpea, rice, soybean, and pigeonpea	Yam, maize, cassava, rice, banana, plantain, and some tree crops	Cocoa, oil palm, rubber, coconut, yam, cocoyam, cassava, plantain, and banana

of adoption by farmers. Breeding programs for sorghum, millet, and groundnut aimed at improving yield and resistance to diseases. There is a dearth of improved groundnut cultivars to address the changing trend in weather and disease incidence. The Institute for Agricultural Research (IAR) and ICRISAT, in Nigeria, collaborated and developed improved sorghum cultivars that are early maturing and high yielding. These were not available to farmers until August 1996 because they were not officially released, and adoption is rather low. While carrying out the characterization study, opportunities exist to try out some of these varieties together with the farmers.

A major task facing research institutes is how to target ready-to-use improved technologies to relevant production areas for specific adaptation and dissemination. It is important that researchers interact and collaborate with farmers, and to keep track of changes in their needs and behavior. It is therefore necessary to know the variability in climate, soil, rainfall, farming systems, emerging enterprises, and pattern of production practices, so as to develop an effective research and development program that could have an impact on farmers. A crucial phase of a research strategy is the characterization of production systems and their physical and socioeconomic factors to prioritize research activities and implementation.

ICRISAT's mandate area covers the semi-arid tropics that occupy most of the states in northern Nigeria, encompassing about 30% of the country (Kowal and Kassam 1978). Predominant features of the semi-arid zones include rainfall and soil types, resulting in a specific length of growing season and type of natural vegetation. Unlike the other agroecological zones in Nigeria (FAO 1984), and elsewhere, the Sudan Savanna Zone has been characterized only to a limited extent. This zone, the focus of this study, occupies a land area of about 22.8 million ha in Nigeria (Manyong et al. 1996) and constitutes the traditional areas of production of virtually all ICRISAT mandate crops (millet, sorghum, groundnut, and pigeonpea).

Most characterization studies involving the Sudan Savanna Zone (Andriesse et al. 1994, Manyong, et al. 1996) have dealt only with the macrolevel, or only the farm level (e.g., Bdliya 1991, Yusuf 1996). Targeting of technology cannot be done at the macro scale (1:1 000 000–1:5 000 000), while at the farm level, it is much too site specific. The quest for an effective way of developing relevant technologies to alleviate poverty and to increase food security on the basis of sustainable land use systems requires wide and active participation by the farmers. Farm- or micro-level understanding of agricultural production constraints and potentials as well as changes in farmers' behavior and preferences are important in helping to target technologies to different production systems in the country, and to determine research priorities. A multiscale characterization approach, together with some on-farm experiments could capture not only the macro-level situation but also farmers' needs, and identify constraints to and opportunities for agricultural development.

Given the extent of geographical coverage of the Sudan Savanna Zone in Nigeria and the restricted resources available for agricultural research, it is important to select a limited number of sites (benchmark sites) where participatory research can be conducted [i.e., collaboration between IARCs, NARS, extension services, nongovernmental organizations (NGOs), and farmers]. These locations will serve as sites to collect diagnostic data and validate new and improved technologies.Their results will subsequently be extrapolated to other areas with similar agroecological and socioeconomic conditions. These benchmark sites can be selected on the basis of a multiscale characterization of the production systems.

This work was designed as part of the former Integrated Systems Projects (ISPs) of ICRISAT on strategies for enhanced and sustainable production of millet/sorghum/legume- based production systems for the various agroecological zones. In West and Central Africa, four major zones relevant to ICRISAT's work were identified, based on the length of growing period (LGP) (Figure 1.1, see page 1C of color insert). The zones include the Sahelian (LGP 75–100), Northern Sudan Savanna (LGP 100–125), Southern Sudan Suvanna Zones (LGP 125–150), and northern Guinea Savanna Zones (LGP 150–180).

Goal and objectives

The main goal of this study is to make a comprehensive description of the agricultural production systems in the Sudan Savanna Zone of Nigeria, to better understand the environment in which farmers operate, and to propose appropriate technologies. The four objectives were to:

- Document the characteristics of major production systems at different levels of scale, resource endowments of households, and patterns of resource use by farmers.
- Identify physical and socioeconomic constraints to production and opportunities for sustainable agriculture in this zone.
- Introduce new sorghum cultivars to farmers, accelerate the release of improved groundnut cultivars, and to test the performance of a new pearl millet variety GB 8735.
- Recommend benchmark sites where collaborative research among NARS, IARCs, extension services, NGOs, and farmers will be conducted.

Area of study

Nigeria is organized under a Federal Government and was divided in 1991, into 30 states including the Federal Capital Territory of Abuja (Figure 1.2, see page 2C of color insert). Each state is divided into Local Government Areas (LGAs), mainly for political

and administrative purposes. The LGA is the third level of government with the responsibility for, among other things, agricultural and rural development.They are small administrative units of government closer to the people at the grassroots. There were, at the time of the study, 774 LGAs in Nigeria.

This study was carried out in Kano, Jigawa, and Katsina States, which are considered representative in terms of biophysical characteristics and population density for the larger part of northern Nigeria. In addition, these states are considered to have a high agricultural production potential (NARP 1995).

Methodology

General aspects and definitions

The essential elements to assess the potential of an area for agricultural development are the physical properties of the natural environment (climate, soils, water availability, land cover, and form of the landscape), socioeconomic components and processes (labor, capital input, management, population, marketing, land tenure, temporary migration) and their spatial differences (van Duivenbooden et al. 1998). Characterization is the comprehensive description of agroecosystems (or land use systems) on the basis of biophysical, socioeconomic, and policy parameters (Andriesse et al. 1994, van Duivenbooden 1997). Land use is defined as human activity directly related to land, making use of its resources or having an impact on it.

A land use system is thus the combination of specified land uses (or production systems) practised on a given land unit (FAO 1976).

Scale levels are introduced into characterization and land use systems analysis for various reasons (van Duivenbooden 1997). Some of them are:

- To create more or less homogenous units of analysis; the heterogeneity observed at one scale level is a result of inadequate resolution.
- Patterns seen at one level may only be explicable on the basis of processes functioning at lower levels.
- Characteristics of agroecological processes can simultaneously be exogenous forces and a variable of the system.
- Characterization and data are linked to one level of scale.
- Statistical studies have only limited value, if any, when the scale is not given.
- Risk is a phenomenon with spatial and temporal dimensions.
- Understanding of relations within systems and extrapolation of results requires a systematic approach.
- The type of processes that influence the production potential of a land use system is scale dependent.
- A (technical) solution may be efficient at one scale (e.g., field), but at a higher level of scale, may cause constraints of a different kind (e.g., socioeconomic).

At each scale level, the characteristics of land use systems and their inherent variations are different (Andriesse et al. 1994; Fresco 1995). With the change in scale, the unit of analysis used for comparison within a scale, and the degree of detail of information changes—at smaller scales, e.g., at 1:2 000 000, less details are presented than at larger scales (e.g., at 1:100 000). Zooming in (scaling down to a lower level of characterization, or desaggregating), implies greater detail of increasingly dynamic parameters. On the other hand, during scaling up (or aggregating), details distinguished

for variables at a lower level (e.g., crop rotations) are disregarded at a higher level. Compared with soils and climate, land use involves the most dynamic set of variables: cropping and farming systems. At the detailed level, characterization of land use systems includes the sequence of operations, their timing, the applied inputs, the implements and traction sources used, and the type of output.

In this study, a distinction is made between crop and animal production systems, although they are, to a certain extent, dependent on each other. Within a crop production system at household level, various types of cropping systems can be observed.

Multiscale characterization is thus the comprehensive description of land use systems or production at different scales. In general, five major levels are distinguished: macro (agroecological zone with scales between 1:1000 000 and 1:5000 000); reconnaissance (e.g., district at scales between 1:100 000–1:250 000); semi-detailed (village at 1:25 000–150 000), detailed (e.g., household at 1:5000–10 000), and micro (e.g., plot at 1:1–5 000) (van Duivenbooden et al. 1998).

Each level of scale has a different unit of analysis with its own boundaries. In general, there are two approaches for the selection of the boundaries: (i) using biophysical or morphological units (e.g., watershed or other more-scientific-units), and (ii) using units at which decisions are made (e.g., administrative boundaries). Each has its own advantages and disadvantages, but it is beyond the scope of this paper to discuss them in detail. Here, the administrative boundaries are used to relate better to the various stakeholders (district , village, and household heads) who have to take decisions, and because secondary data are linked to LGAs. Further, villagers in West Africa have agricultural activities in more than one watershed, while village territories are administrative areas governed by the village chief, with boundaries set in the past, and known to mostly all villagers. Boundaries can be morphological units (plateau), rivers, or roads, but less visual boundaries, e.g., somewhere in the natural vegetation, are being respected. Therefore, in the context of this study, within an agroecological zone, states are the units of analyses. At lower levels, there are LGAs within states, villages within LGAs, households within villages, and finally cropping systems within households.

Methods

Multiscale characterization is predominantly carried out on the basis of secondary information, surveys, and on-farm trials. On- farm trials are included in this study to obtain more viable and reliable information from the villagers, rather than having interviews only, and to facilitate the choice of benchmark sites.

Secondary information collection

Although production systems in the Sudan Savanna Zone have been characterized only to a limited extent, some literature exists (Mortimore 1993a,b, Norman et al 1982; Ogungbile et al.1995). It is available at IARCs, NARS, NGOs, and development projects, often in the so-called 'grey' literature, but mostly in qualitative rather than quantitative form. This literature has been reviewed as much as possible, given the time available. In addition, selected projects such as the Agricultural Development Projects (ADP) have been visited to gather information. Finally, collaboration was established with the Institute for Agricultural Research (IAR, Samaru), extension agents, and officials of state ministries of agriculture in the three selected states to discuss and share existing data.

Participatory Rural Appraisal survey (PRA)

A PRA survey was conducted between September and October 1996 in selected villages of Jigawa, Katsina, and Kano States of Nigeria.

The villages were selected using the following procedure. First, in each state, three LGAs were selected on the basis of rainfall distribution, soil fertility, and types of production systems. Some preliminary interviews were held with farmers' groups and individual farmers in several villages. Subsequently, in each LGA, one village was selected along a North-South gradient in the state (Figure 2.1, see page 3C of color insert) on the basis of five criteria.

- Annual rainfall in the last 5 years.
- Major production systems for the northern Sudan Savanna Zone and the southern Sudan Savanna Zone.
- Ethnic groups.
- Village geographical position within the state.
- Village accessibility (number of roads and their quality).

In the PRA survey, no formal questionnaires were used, but there were intensive interactions between a multidisciplinary team consisting of an agronomist, a socioeconomist, and a soil scientist/agroclimatologist, and the villagers for 2 days in each state. The timing of the visit was such that crops were still on the field, so that crop identification could take place and farmers could easily recall their agricultural activities. Subsequently, semi-structured interviews with farmers, groups and key informants were held. In some villages where on-farm experiments were carried out, discussions regarding these trials were also held. Villages were further characterized by monitoring the farming activities of some randomly selected households for 4 months (September to December 1996). The households were selected after initial interviews with a group of farmers in the villages.

A total of 144 households in nine villages distributed among the three states (Kano, Jigawa, and Katsina) were selected. A formal survey method involving the use of questionnaires providing a systematic, ordered way of obtaining precise, statistical data from respondents was used. The survey consisted of several visits to the respondents, mainly to obtain information on their general family background and farming activities. For analytical purposes, the nine villages were regrouped into three subzones based on their latitudinal locations and the amount of rainfall, as follows:

- Southern subzone: Kofa, Panda (Kano), Kantoga (Jigawa), and Gora (Katsina)
- Central subzone: Badume (Kano) and Rimaye (Katsina)
- Northern subzone: Dalari, Gijigami (Jigawa), and Barhim (Katsina).

On-farm trials

The aim of this study was to introduce new sorghum cultivars to farmers, accelerate the release of improved groundnut cultivars, and test the performance of a new pearl millet variety GB 8735 using on-farm diagnostic trials, which were initiated jointly by ICRISAT, IAR, and the ADPs.

The objectives of the varietal trials were to:

- Introduce new improved cultivars of groundnut, millet, and sorghum
- Identify constraints and potential of the new cultivars in the different production systems.
- Involve farmers in the process of development and choice of relevant technologies.
- Strengthen collaboration between ICRISAT, NARS, extension agents, and farmers.

The following cultivars were tested:

Sorghum: ICSV 111, ICSV 400, and ICSV 247. These ICRISAT varieties are all early maturing (100–110 days) and drought tolerant. ICSV 111 and ICSV 400 were among the cultivars released in 1996.

Groundnut: ICGV 86015, Fleur 11, and UGA2; the first two varieties are from ICRISAT and are early maturing (90–110 days), while UGA2 is from IAR, and is early maturing and rosette resistant.

Millet: GB 8735 is early maturing (80 days), high yielding, with grey seeds, susceptible to stem borer attack, and resistant to head miner and downy mildew.

The study was carried out in Kano, Jigawa, and Katsina States within the Sudan Savann Zone (Figure 2.2, see page 4C of color insert). The sites represent either the northern or the southern Sudan Savanna Zone. The same nine villages that were selected for the characterization study were used for these on-farm trials. There were three sites in each state for sorghum, millet, and groundnut. In case of millet, 34 farmers—12, 15, and 7 in Kano, Jigawa, and Katsina States, respectively, participated in the millet trials.

Single superphosphate (SSP) was supplied at the rate of 29–30 kg P_2O_5 per ha. Seeds of sorghum varieties were supplied to selected farmers, and at least four farmers grew a given variety in each village.

In the case of groundnut, seeds and fertilizer were provided free of charge. In addition to the three varieties, some quantities of RRB and RMP 12 were provided as controls, and each participating farmer contributed his own variety as a control. No agronomic packages were specified apart from the seeds, and farmers managed their plots according to their usual practices.

Enumerators were stationed in each village to take records. All the scientists involved—breeders, agronomists, crop protectionists, and socioeconomists—inspected the fields and made observations periodically.

Crop Area and Yield Survey (CAYS)

The Agricultural Project Monitoring and Evaluation Unit (APMEU) carries out Crop Area and Yield Survey annually. In their survey, a selected number of households is monitored, and for selected plots yields are determined. Results are given per average household, and using the total number of households per LGA, the production and cropped area for an LGA is calculated. It was observed that for Kano State, the number of selected farmers was in the order of less than 1% of the total number of households per LGA. Therefore, that the accuracy and representativeness of the results should be interpreted with caution.

Characterization of the Agroecological Zone

Agroecological delineation and zonal boundary

The Sudan Savanna Zone in Nigeria extends between latitudes 9°30' and 12°31'N and longitudes 4° to 14°30'E, being roughly 2 700 000 km^2. Nine states have part or all of their territories located in this agroecological zone (Figure 1.2). These states include: Kano, Jigawa, Katsina, Sokoto, and Kebbi in the Northwest; Bauchi in central Nigeria; and Borno, Yobé, and Adamawa, in the Northeast. The Sudan Savanna Zone consists of two subzones: the drier northern Sudan and the wetter southern Sudan, which is considered as the transition zone between the Sudan and the northern Guinea Savanna Zone. Table 3.1 lists some biophysical and socioeconomic characteristics of the nine states within this zone. The Sudan Savanna Zone is one of the main areas producing sorghum, millet, and groundnut.

Climate

Rainfall

The Sudan Savanna Zone has distinct dry and wet (unimodal rainfall) seasons with peak rainfall in August. Annual rainfall ranges between 600 and 1000 mm (Figure 3.1, see page 5C of color insert) and virtually all the rains are received within 4–5 months. Annual rainfall from 1990–95 is presented for selected stations in the zone in Table 3.2. Although long-term (30 years) averages would have been preferred, they are not all available, and the recent averages are better in order to understand farmers'current decisions. Figure 3.2 (see page 5C of color insert) shows that in this zone, there has been a dramatic decline of rainfall during 1960–90. It also shows a substantial increase in rainfall in the last few years (1991–95). The period is too short, however, to consider this an established pattern.

Rainfall variability, especially late onset and early cessation of rain, often results in a shortened growing season. This in turn, leads to seedling death, low yields, or even crop failure. The torrential nature of tropical rain during the short humid season has also made the zone susceptible to flooding and erosion (Owonubi and Abdulmumini 1984), while the reduced quantity of rainfall has increased the desertification process, leading to, among other things, lower crop yields and grazing problems for livestock. The amount and distribution of rainfall, and the length of the growing season are constraints to certain crop varieties actually grown by farmers.

Table 3.1. Biophysical and socioeconomic characteristics of the nine states in the Sudan Savanna Zone of Nigeria (ADP Annual Reports, 1990–1995).

Characteristic	States								
	Adamawa	Borno	Yobé	Bauchi	Katsina	Kano	Jigawa	Sokoto	Kebbi
Climate									
Rainfall (mm)	759	500–800	500–1000	600–1200	600–700	816	635–890	690	751
Length of rainy season (days)	105	80	120–140	NA[1]	NA	NA	NA	NA	NA
Temperature (°C)	21–32	22–33	23–33	12–25	NA	26–33	31–33	NA	21–26
Land area (km^2)	38 780	76 050	38 220	66 355	25 938	20 400	22 600	42 662	36 220
Arable land area (km^2)	11 885	26 985	9 660	46 448	1726	1632	1 695	4563	2 042
Cultivated area ('000 ha)	1 189	2 699	966	2 610	1537	1626	1627	2 065	979
Farm size (ha)	0.6	1.0	1.0	1.7	2.7	1.6	1.9	1.8	1.3
Population									
Total ('000)	2 124	2 597	1 410	4 294	3 878	5 632	2 830	4 492	2 062
Density (p km^{-2})	55	34	31	67	162	276	125	72	57
Vegetation type	Southern Sudan Northern Guinea	Sahel Northern Sudan	Sahel Northern Sudan	Sudan Northern Guinea	Sahel Sudan Northern Guinea	Sudan Northern Guinea	Sahel Northern Guinea	Sudan Northern Guinea	Southern Sudan Northern Guinea

Continued.

Table 3.1. *Continued.*

Characteristic	States								
	Adamawa	Borno	Yobé	Bauchi	Katsina	Kano	Jigawa	Sokoto	Kebbi
Ethnic groups	Were Botatiye Laha Hausa Fulani	Kanuri Bura/ Burbur Shuwa	Balle Manya Kanuri Fulani	Gerewa Ningawa Hausa/ Fulani	Hausa/ Fulani	Hausa Fulani	Hausa Fulani Kanuri	Hausa Fulani	Hausa Fulani Kebawa
Farm household									
Average household size	10.8	5.6	5.6	7.0	9.7	8.2	8.0	9.3	8.2
Average household income (Naira)[2]	2 750	2 950	2 300	2 000	3 200	4 000	3 500	3 800	2 000

Source: Adapted from NARP, 1995.
1. NA = Data not available.
2. US$1= 85 Naira

Table 3.2. Annual rainfall (mm) at selected stations in the Sudan Savanna Zone of Nigeria (1990–95).

Location	Year						
	1990	1991	1992	1993	1994	1995	Mean
Bagauda	556	924	914	762	986	854	842
Kaduna	534	826	887	627	988	757	770
Kano	541	905	926	802	778	556	751
Minjibir	380	787	675	632	903	627	667
Albasu	633	966	964	526	847	652	765
Wudil	660	873	775	713	960	592	762
Dutse	361	731	765	561	1100	686	701
Jahun	508	678	683	479	623	420	565
Gumel	520	611	740	660	529	461	587
Hadejia	511	679	450	647	838	NA[1]	625
Kefin Hausa	332	638	557	605	NA	645	555

1. NA = Data not available.

Length of growing period (LGP)

The Sudan Savanna Zone is characterized by a length of growing period of about 100–150 days. Although the pattern of the decline is not consistent, the overall tendency within the last 30 years is lower annual rainfall due to the late onset and early cessation of rains. Yayock and Owonubi (1986) demonstrated that a location with a cropping season of about 140 days in the 1960s, may have had its LGP reduced by as much as 25%, or 35 days by now. As a consequence, a shift in poduction systems and practices is expected.

There is a difference between the date of the first rainfall and the beginning of the growing season. The growing season starts when the soil profile is sufficiently recharged with moisture, or when water accumulation total exceeds 75 mm of rainfall (Owonubi and Abdulmumini 1984). There is therefore a risk in planting in the very early part of the rainy season due to the very low soil water reserves. However, the farmer's desire to plant early is due to the fact that he wants to take advantage of early releases of mineral nitrogen. In the same vein, the growing season certainly extends beyond the date of the last rainfall because water continues to maintain crops for many days depending on the soil type. Table 3.3 shows the long term mean dates of the first rains, rainfall establishment, and end of rains at some locations in the Sudan Savanna Zone

Table 3.3. Long-term mean dates of first rain, rainfall establishment, and end of rains at some locations in the Nigerian Sudan Savanna Zone.

Location	Latitude (N)	First rain	Rainfall establishment	End of rains
Kano	12°03'	14 April	9 June	1 October
Bakura	12°33'	17 April	18 June	27 September
Katsina	13°01'	23 April	23 June	24 September

Temperature

The temperatures are relatively stable during the growing season at 20–25°C, the lowest temperatures occurring in December and January. During the dry season, the minimum temperatures can fall below 10°C. A major characteristic of the North-East wind in the region is the erosion and transportation of fine powdery dust. Table 3.4 shows typical weather characteristics of the Sudan Savanna Zone in Minjibir in Kano State.

Soils

The soils in this agroecological zone combine the ferruginous tropical soils of the south with weakly developed brown and reddish-brown soils, particularly within Katsina, Kano, and Jigawa States (Maduakor 1991). The soil tends to be porous and fairly well

Table 3.4. Monthly mean of weather indices at Minjibir, Kano (Nigeria) during 1992–95.

Month	Potential evaporation (mm)	Wind speed (km h^{-1})	Solar radiation (MJ day^{-1})	Temperature (°C)		Relative humidity RH (%)
				Maximum	Minimum	
January	5.9	2.3	22.4	27.0	12.4	18
February	8.8	3.8	23.5	31.2	14.4	16
March	10.5	3.8	22.8	36.9	20.4	19
April	11.3	4.6	23.7	39.2	23.6	22
May	8.4	7.7	22.5	38.3	24.2	35
June	8.0	5.6	22.1	35.2	23.9	50
July	6.8	4.5	19.2	32.1	22.0	60
August	6.1	3.3	18.8	31.3	21.6	65
September	6.4	2.6	20.1	32.4	21.1	58
October	8.3	2.5	21.4	35.8	19.3	43
November	7.9	1.4	20.8	34.5	14.8	26
December	7.6	2.8	20.0	30.6	12.3	18

Table 3.5. Texture (%) of some upland soils in the Sudan Savanna Area of Nigeria (Maduakor 1991).

		Particle size analysis (%)		
Location	State	Sand	Silt	Clay
Kadawa	Kano	85	11	4
Kano	Kano	87	9	4
Dambatta	Kano	92	4	4
Gumel	Jigawa	94	3	3
Hadejia	Jigawa	92	4	4

structured. However, as a result of fire and cultivation, the natural structure of the surface soil is rapidly destroyed due to a reduction in biological activity in the soil, a decrease in soil organic matter, an increase in rain splash, and soil erosion. The organic matter is very low and the total nitrogen content never exceeds 0.1%. The soils have a low buffering capacity.

Farmers generally differentiate between upland soils and those located in valley bottoms (or fadama). By far, the highest fraction used is the upland soil, consisting of ferruginious tropical soils, and generally used for rainfed crops. The soils in the fadama are heavier, and on the lower slopes, soils are hydromorphic. Brown and reddish-brown soils are found in the northern Sudan Savanna Zone. Some of the physical characteristics of the soils have been studied by Maduakor (1991), and details relevant to this survey are listed in Table 3.5.

Cropping systems

The farming systems in the Sudan Savanna Zone are generally cereal-based, dominated by maize and sorghum in the south, sorghum in central Nigeria and millet towards the north. The three states (Kano, Jigawa, and Katsina) selected for the study constitute a leading area of production of sorghum, millet, and grain legume crops (cowpea and groundnuts) in Nigeria as shown in Table 3.6. In addition, a great potential for irrigated agriculture exists given the World Bank-assisted fadama development program in these states (NARP 1995), and the presence of the Hadejia-Jama're large-scale irrigation scheme (20 000 ha) serving both Kano and Jigawa States. Farmers in these zones, therefore, take advantage of fadama to invest in dry season production of vegetables, mostly tomatoes, onion, and pepper, but more recently, also groundnuts and cowpea. Major constraints to the cropping systems comprise drought and soil erosion. Overgrazing of fallows and grazing land has also been occurring.

As in other parts of the country, small-scale farmers produce the bulk of total output in the zone. The size of the farm holding varies from 1 to 3 ha. The general belief is that

Table 3.6. Crop area, production, and yield of millet, sorghum, cowpea, and groundnut, in Kano, Jigawa, and Katsina States (1993–1995) (ADP 1990–95).

		Millet			Sorghum			Cowpea			Groundnut		
State	Estimate	1993	1994	1995	1993	1994	1995	1993	1994	1995	1993	1994	1995
Kano	Area ('000 ha)	502.6	36.3	148.9	613.0	50.7	110.9	405.4	34.3	58.1	286.0	24.1	111.9
	Production('000 t)	473.5	42.7	125.7	795.5	58.7	136.9	169.3	16.1	42.2	187.8	16.9	86.4
	Yield (kg ha^{-1})	942	1175	844	1298	1158	1234	418	470	726	657	700	772
Jigawa	Area ('000 ha)	101.3	131.3	182.6	128.9	98.9	15.1	110.8	116.5	94.4	35942	43.0	16.5
	Production ('000 t)	61.8	60.7	81.2	58.0	44.0	61.3	20.5	15.5	21.2	11.2	11.7	4.8
	Yield (kg ha^{-1})	610	463	445	450	445	405	185	133	225	313	273	293
Katsina	Area ('000 ha)	120.6	139.3	82.9	206.5	130.7	170.8	156.8	107.3	90.6	95.2	115.9	863.9
	Production ('000 t)	65.9	127.5	93.3	182.2	176.5	181.9	55.4	75.7	54.9	47.0	74.5	49.1
	Yield (kg ha^{-1})	546	915	1126	882	1351	1065	353	705	606	494	643	569

farm holdings are larger in the Sudan Savanna Zone with lower population densities, where arable farming is taken more seriously than in the more humid regions of the southern parts with higher population densities and smaller farm sizes (NARP 1995).

Small-scale agriculture is highly labor intensive because most of the farm operations are done manually. Animal traction is widely adopted and practised in the zone, especially in Jigawa and Katsina States. This practice reduces human labor input and alleviates drudgery. The bulk of farm labor is provided by family members. The people of this region are mainly Hausa and Fulani with Islam as their religion. Most of the farm operations are undertaken by men and children, as Muslim women are not allowed to work openly on the fields. They, however, participate in harvesting and processing of farm produce. The gandu system (which, in the past, guaranteed family labor) has broken down, and hired labor is now being used. Further, the use of traditional communal labor is no longer important, because more and more farmers are becoming commercially oriented. Farm labor is available because there are not many other industries that can absorb them, and even people from urban areas seek employment in farms (Norman et al. 1982).

Fertilizer application was, in the recent past, widely adopted to maintain soil fertility. However, the amount of fertilizer applied to upland fields is rarely adequate. An average farmer uses about 20–30 kg N ha^{-1} when it is available. This is believed to be grossly inadequate for most savanna upland soils. Fertilizer consumption is reported to be higher here than in other parts of the country. Fertilizer distribution is not properly managed, and this has resulted in scarcity and a rise in fertilizer prices, in spite of about 80% subsidy (Smith et al 1994).

Since 1995, fertilizer subsidy has been dropped, and this has also led to reduced quality of fertilizer used and a shift from crops that need high fertilizer levels, such as maize, towards crops that do not need high fertilizer levels, such as sorghum. Farmers are discovering more and more, the potential of improved early-maturing varieties, which help them to produce some grains despite lower rainfall and a shorter growing season. In addition, almost all farmers apply organic manure on their fields, but again availability is a constraint, the quantities being hardly enough to cover 20% of their farms (Ogungbile et al. 1995).

Livestock systems

Kano, Jigawa, and Katsina States contribute more than 50% of the total annual livestock production in the Sudan Savanna Zone (NARP 1995) as illustrated in Table 3.7.

Livestock production is an integral part of the farming system in the Sudan Savanna Zone. There is hardly any rural household without one form of animal or the other. Animals are owned and managed both by mixed farmers and agropastoralists. Both

Table 3.7. Livestock population ('000) density (heads km^{-2}, in parentheses) in Kano, Jigawa, and Katsina States of Nigeria (NARP 1995).

State	Cattle	Goat	Sheep	Pig	Donkey	Horse	Rabbit	Camel	Poultry
Kano	1553	5357	3681	-[1]	967	26	119	3	3456
	(23.0)	(63.0)	(59.0)		(3.0)	-	-	-	-
Jigawa	855	2447	1943	-	109	22	98	4	3152
	(20.0)	(54)	(44)	-	(2.0)	-	-	-	-
Katsina	688	2270	1854	-	214	24	166	5	3678
	(26.0)	(86.0)	(70.0)	-	(7.0)	(1.0)	(7.0)	(0.3)	-
Total	3096	10 074	7478	0	419	72	383	12	10 286
Percentage of national output	22	43	31	0	45	35	22	14	12

1. - = data not available.

crops and livestock are sources of employment to the household members. In addition, they provide food and income for farmers. Crop residues and byproducts are used as feed for livestock. The animals, in turn, provide draught power used for farm operations and transportation of inputs and produce. The mixed farmers keep 2–5 heads of cattle and 5–10 sheep, while the Fulani pastoralists keep 20–50 cattle and 20–50 sheep and goats. Women tend to keep more small ruminants such as sheep, goats, and poultry.

Fattening of bulls and rams for sale is common. Animal traction is practised in over 70% of the area. A large proportion of the cattle population is used for milk production, usually prepared and sold by the Fulani women. Feed and water availability constitute large problems for the livestock holders, especially during the dry season. This often causes communal clashes between the pastoralists and farmers.

Fishery

Although the fishery resources of the states have not been adequately exploited, the presence of fresh water bodies such as lakes, reservoirs, dams, and rivers indicates some potential for artisanal fish production. Major river systems such as Kano and Hadejia, and their tributaries and flood plains already support substantial fish production.

Markets

The major objective of the farmers in the Sudan Savanna Zone is to be self sufficient. Other objectives include producing some excess food and other cash crops in order to

obtain cash to purchase farm inputs and fulfil social obligations. Farmers in the Zone have the largest area under cultivation (cereal and grain legume crops) and the highest total output. Although the yields per hectare obtained from these crops are low, the farmers in this Zone always produce excess of these crops from large areas such that only about half of the production is consumed in the states. It has been observed that the marketable surplus of farmers from this zone is higher than from other zones of Nigeria (NARP 1995). As a result, a systematic domestic trade has developed between the states and other parts of the country, especially the southern states where many breweries and livestock feed mills (which depend on sorghum and maize) are located. Excess grain from the three states is also sold to neighboring countries, especially Niger and Benin Republic. The marketing process for small-scale farmers takes place in periodic rural markets or at the farm gate. The village retailers and middle men transport their produce to urban centers. Depending on the crop, prices differ within the year, and from year to year.

Characterization of the Selected States

The main characteristics of the three selected states (Kano, Jigawa, and Katsina), along with six others, are presented in Table 3.1. A description of different aspects of each of these three states follows.

Kano State

General description

Kano State lies between latitudes 10°33' and 12°37' North, and longitudes 7°43' and 9°25' East. It occupies a total land area of about 20 400 km^2 (Table 3.1). The state is divided into 34 LGAs with the capital, Kano city (Figure 4.1, see page 6C of color insert). For effective coverage by agricultural extension services, Kano State has been delineated into three agroecological zones: Zone I comprising 11 LGAs, located in the southern-most and wettest parts of the state with headquarters at Rano; Zone II also comprising 11 LGAs, in the northern-most and the driest parts of the state with headquarters at Dambatta. Zone III lies between Zones I and II and consists of 12 LGAs with headquarters in Gaya (Table 4.1).

Climate

Approximately, 90% of Kano State lies within the Sudan Savanna Zone, while 10% lies in the South, within the northern Guinea Savanna Zone. Rainfall throughout the state is unimodal, and ranges between 600 and 1000 mm per annum. The long-term (1906–85) mean annual rainfall for Kano State is 822 mm. It is clear that variation exists within the state with Zone I being the wettest and rains become less predictable as one moves from

Table 4.1. Main characteristics of the ecological zones of Kano State of Nigeria (KNARDA 1995)

Zone	Relative climate	Rainfall (mm)	No. of Local Government Areas	Headquarters of extension service	No of villages	No of farm households
I	Wet	909	11	Rano	269	402 412
II	Dry	710	11	Dambatta	385	418 348
III	Medium	709	12	Gaya	335	661 402
Total			34		989	1 482 162

Table 4.2. Mean annual rainfall (mm) for different zones in the three ecological zones, of Kano State, Nigeria, 1990–94.

Zone	1990	1991	1992	1993	1994	Mean
I	652	884	1089	856	1007	898
II	427	857	640	750	875	710
III	447	900	606	675	892	704
Mean	509	880	778	760	925	771

the southern to the northern borders in Zone II. In recent years, the rainfall pattern among the three zones has changed slightly (Table 4.2). Daily average temperatures are between 30 and 35°C, with maximum mean temperature of about (40°C) recorded in May. The lowest mean temperature of 13°C occurs between December and January (Owonubi and Abdulmumini 1994).

Soils

Soil types in Kano State are the same as those in the Sudan Savanna Zone as a whole. They consist of the ferrigenous, weakly developed Alfisols in the south, Regosols in the northern parts, and Ferrisols and hydromorphic soils in restricted parts of the state. In terms of soil fertility, the whole state is rated low in terms of nitrogen availability, medium-to-high for phosphorus, and most parts of the state rank medium-to-high for potassium (FMANR 1990). Fertility is being maintained by the use of inorganic fertilizers, farmyard manure, crop rotation, and mixed cropping practices.

Population

Kano State has an estimated population of about 5.6 million people (1991 census), with an average population density of about 276 persons km^{-2} (Table 3.1). There are about 1.48 million farming households (FHH). As for the country, at this scale level, the population density is the highest in the wetter part of the state. About 45% of the FHHs resides in Zone III, while 27% and 28% of FHHs are found in Zones I and II respectively (Table 4.1). Three LGAs were selected as representatives for Kano State—Bebeji, Albasu, and Bichi.

Crop production systems

The climate permits the cultivation of a variety of rainfed crops, mostly cereals and grain legumes. In addition, both large- and small-scale irrigation schemes exist. The Kano State National Agricultural and Rural Development Authority (KNARDA) is the

Table 4.3. Occurrence of crops in field (%) in 1995 in Kano State, Nigeria, for the different zones.

Zone	Millet	Sorghum	Maize	Groundnut	Cowpea	Rice	Others	Total
I	15	32	19	7	8	12	7	100
II	24	31	5	10	16	1	13	100
III	22	36	4	18	13	1	6	100

state institute responsible for both extension and adaptive research activities in the state. Detailed surveys are carried out by the Planning, Monitoring, and Evaluating Unit of KNARDA, supervised by the Agricultural Project Monitoring and Evaluation Unit (APMEU), and the reports of the surveys are usually reported in KNARDA annual reports.

The major crops grown in the state are sorghum, millet, groundnut, cowpea, and maize. In addition, the production of rice on the fertile fadama soils is quite common. Pepper, onion, and tomatoes are also grown. The range of crops is greater in the wetter southern parts of the state, especially in Zone I.

Sorghum is the most important cereal crop in the state in terms of area covered and production output, followed by millet (Tables 4.3 and 4.4). The production of maize, which used to be an important crop, especially in the southern part, has declined during the last 2 years due to the scarcity of organic and chemical fertilizers, and high prices of the latter. In Zone I, the cropped area of sorghum, rice, and groundnut exceeded that of millet. However, millet dominates other crops in the north, especially in Bichi and Dambata LGAs. In the same vein, virtually every household in Kano State includes sorghum and millet in their cropping program. Cowpea is the most widespread intercropped legume crop, and is more dominant than groundnut in the northern part of the state.

Sole cropping is not common, but crops growing singly on the fields include maize, sorghum, rice, long-season millet, and groundnut to some extent. Sole crops are more frequently found in the southern than in the northern part of Kano, because of increased possibility of double cropping or relay cropping in the southern part.

Intercropping is dominant throughout the state. There is, however, always one crop dominant in any mixed-crop fields. In general, two-crop mixtures are the most common. Sorghum and millet are the major cereals found mixed with legume crops such as groundnut and cowpea. Millet-based crop-mixtures are not important in Zone I, where sorghum is dominant. The reverse is true in Zones II and III (Table 4.4). In all these mixed cropping systems, planting crops in alternate rows is preferred to planting in alternate stands within rows.

Table 4.4. Land occupancy (%) by major cropping systems in Kano State, Nigeria, in 1995.

Zone	S	SMI	SMz	SG	SC	SR	SMIG	SMIC	SGC	MI	MIG	MIC	MIGC	G	R	Mz	O
I	7.7	7.1	11.8	0.9	5.8	5.3	1.3	10.8	1.9	0.9	1.8	5.1	1.0	2.0	7.9	9.6	8.0
II	7.0	11.5	0.9	2.5	12.4	2.0	4.1	13.2	3.3	5.8	5.5	10.2	4.1	4.1	3.6	4.5	5.8
III	7.8	7.8	1.2	7.6	12.8	2.5	5.1	11.4	7.6	3.5	6.8	7.0	4.5	1.8	3.3	1.8	7.8

1. S = sorghum, MI = millet, Mz = maize, SG = sorghum/groundnut, SC = sorghum/cowpea, SR = sorghum/rice, SMIG = sorghum/millet/groundnut, SMIC = sorghum/millet/cowpea, SGC = sorghum/groundnut/cowpea, MI = millet, MIG = millet/groundnut, MIC = millet/cowpea, MIGC = millet/groundnut/cowpea, G = groundnut; R = rice, Mz = maize, O = others.

Cultural practices

Land preparation consists of bush clearing and manure application. In Zones II and III, animal traction with oxen is generally practised to prepare the land. Ridging is generally not carried out in the southern zones. Farmers who practice ridging do so after planting with hand hoes. All farmers weed their fields with hand hoes, because most oxen owners do not have the required animal-drawn equipment.

Virtually all labor input on the field is by men and children, as women are not permitted to work on the field. Women help in picking groundnut brought from the field, and in threshing and winnowing the cereals. In general, farmers still grow more of the traditional crop varieties than the improved ones (Table 4.5). When they adopt improved varieties, it is mainly because of their early maturity. Farmers still prefer the traditional sorghum cultivars in any year with favorable weather, because they believe that their varieties are higher yielding than the improved varieties if the rainy season lasts long enough for the cultivars to mature. Agrochemicals are hardly used because of their high cost and because they are scarce (Table 4.6).

Table 4.5. Major crop varieties in different zones of Kano State, Nigeria.

Crop	Zone I	Zone II	Zone III
Sorghum	Farafara	Zango (nearly extinct)	Farafara
	Kaura	Farafara	Kaura
	Mori	Kaura	Yala
	Yarwasha[1]	YarTsanyawa[1]	
	Gaya early[1]	Yar Gexawa (Buha Maza)	
	Samsorg 15[1]		
Millet	Ex-Bornu[1]	Zango	Zango
		WuyanBijimi	Lawur[1]
		Dan Akaranja	
Groundnut	RRB[1]	RRB[1]	Kwalci
	RMP12[1]	Ex-Dakar[1]	Yar Ghana[1]
Cowpea	Kananado[1]	Kananado	Kananado
	Danwuri		Kembas
	Dan Illa		
	ITA60[1]		

1. Improved variety.

Table 4.6. Input use (% of farmers) per ecological zone in Kano State, Nigeria (KNARDA 1995).

Zone	Inorganic fertilizer	Organic fertilizer	Agrochemical	Improved seed
I	51	36	5	8
II	34	38	4	22
III	36	51	5	8
Mean	41	42	5	13

Livestock production systems

Apart from crops, Kano State is also important for the production of livestock. There are an estimated 1.5 million cattle, 3.7 million sheep, 5.4 million goats, and 11 million poultry of different breeds (KNARDA 1994) (Table 3.7).

All households keep livestock of one or more species, except camels and pigs (Table 4.7). Breeds of cattle kept are predominantly Bunaji (white Fulani) and a few Rahaji (Red Bororo). The sheep breed is predominantly Yankasa and very few Balami. The goats are mainly Red Sokoto and a few white breeds. Donkeys are only kept by the Hausa. Women own more of the small ruminants and poultry, while men own more cattle, donkeys, and horses.

Marketing

Prices of crop products differ from one year to the other (Figure 4.2, see page 7C of color insert). In the course of the year, prices are generally the lowest at harvest time, and increase thereafter, with peak towards the end of the growing season (Figure 4.3, see page 8C of color insert).

Selection of representative LGAs

On the basis of the data and information given, and based on discussions and consultations with key informants, the LGAs of Bebeji, Albasu, and Bichi were selected to represent ADP production Zones I, II, and III of Kano State, respectively. Their locations are indicated in Figure 4.1.

Table 4.7. Indicative numbers of livestock per household in selected Local Government Areas (LGAs) (KNARDA 1995).

Location	Cattle	Sheep	Goat	Donkey	Horse	Rabbit	Chicken	Duck	Water duck	Guinea fowl	Turkey	Pigeon
Kaleko	2–100	5–100	5–100	1–2	0	1–10	5–50	10–50	6–10	20–1000	2–6	2–200
Kutama	2–40	5–20	10–20	1–3	2	6–10	2–50	3–10	1–5	60–100	0	150–1000
Tagwaye	20–70	10–20	10–20	1–2	0	3–5	5–30	1–5	1–3	2–30	0	2–50
Karefa	2–50	5–20	5–20	1–2	3	5–20	10–100	1–15	1–4	1–30	0	12–25
Karfi	2–100	2–50	2–50	1	0	1–10	20–40	1–30	10–20	1–30	0	2–100
Runkure	1–100	3–100	3–100	1–4	1	1–100	5–20	1–30	1–5	1–20	1–4	2–60
Madobi	10–250	5–60	5–500	1–5	1–2	1–100	1–200	1–30	1–100	1–200	1–20	2–2000
Kumbotso	10–40	5–20	5–30	1–3	1–10	2–20	20–100	20–100	2–10	2–30	2–10	4–100

Jigawa State

General description

Jigawa State is geographically located between latitudes 11°–12° North and longitudes 8°–10°5' East. Jigawa State was created out of the former Kano State in 1989. It covers a land area of about 20 000 km^2. Jigawa is administratively divided into 21 LGAs with Dutse as the state capital (Figure 4.4, see page 9C of color insert). The state is divided into four ecological zones, with the zonal headquarters of each of these at Birnin Kudu, Hadejia, Gumel, and Kazaure. Zones I, II, and IV comprise five LGAs each, and Zone III has six. Birnin Kudu is the wettest, Gumel and Hadejia zones are the driest and also prone to drought, since annual rainfall in some LGAs in these zones sometimes falls below 500 mm (Table 4.8)

Climate

Ecologically, the state is situated within the Sudano-Sahelian Zone, with about 400–850 mm of annual rainfall (Table 4.9). The rainy season is between late May to September, with the peak rainfall in August. There is a dry season between October and May. Temperatures are stable and warm, except between December and January, when the harmattan winds render temperatures variable between night and day. Climatic and biotic factors tend to make the northern parts of the state drier, as natural vegetation changes from the Sudan type to the Sahel Savanna type.

Table 4.8. Main characteristics of the ecological zones of Jigawa State, Nigeria (JARDA 1995).

Zone	No of Local Government Areas	Headquarters	No of villages	Rainfall (mm)	No of households
I	5	Birnin Kudu	NA[1]	799	134 000
II	5	Gumel	NA	638	75 000
III	6	Hadejia	NA	605	84 000
IV	5	Kazaure	NA	710	77 000
Total	21				370 000

1. NA = Not available

Table 4.9. Average annual rainfall (mm) in the various ecological zones in Jigawa State, Nigeria.

Zone	1990	1991	1992	1993	1994	Mean
I	588	933	850	437	1025	767
II	496	614	829	518	739	639
III	436	570	552	563	863	597
IV	454	648	597	691	977	673

Soils

The soils found in Jigawa are typical of the Sudan Savanna zone. Entisols and Inceptisols in the drier northern part of the state, Alfisols across the state, and Hygromorphic soils are found in pockets across the state, but are more prominent in Zones II and III. The soils in Kantoga (in Zone I) are sandy loam, and those in Zones II and III are loamy clay and sandy respectively. The fertility status of soils in Zone III is generally low and moderately high in Zone I and lowland valleys of Zone II. Wind erosion is common in Zones II and III where soils are sandy and there are fewer trees. Before the beginning of the planting season each year, between April and May, farmers transport farmyard manure to fields, and incorporate it into the soil at the time of land preparation. Ridges are generally made by animal traction or by hand hoe before planting in Zone I, but it is a common practice to plant without ridging in Zone III. Chemical fertilizers are also used, but rates applied are too low to support a good crop yield, mainly because of inadequate supply and high cost of fertilizers.

Population

Jigawa has a population of 2.8 million people, and a density of 125 persons per km^2. The major ethnic groups are mostly Hausa and Fulani. The Kanuris are also present. Table 4.8 shows the statistics of farm household by zones. There are about 370 000 households with the largest number in the southern part, i.e., 36% of the total compared with 20–22% in Zones II and IV.

Table 4.10. Occurrence of crops in field (%), in 1995 in Jigawa State, Nigeria.

Zone	Millet	Sorghum	Maize	Groundnut	Cowpea	Rice	Others
I	69	75	2	42	88	5	0.3
II	70	66	-	67	1	24	-
III	60	58	6	2	52	1	19

Table 4.11. Land occupied (% of total) by major cropping systems as a function of zones in Jigawa State, Nigeria, in 1995.

Zone	S[1]	SMl	SG	SMlG	Ml	MlG	O
I	17	19	8	20	16	18	2
II	8	29	13	15	30	5	-
III	13	39	-	-	19	2	27
Mean	12.7	29	10.5	17.5	23	8.3	9.3

1. S = sorghum, M1 = millet, G = groundnut, O = others.

Cropping systems

The major crops are sorghum, millet, groundnut, and cowpea in all parts of the state. Rice is, however, more important in the southern part of Zones I and II (Birni Kudu and Hadejia) in the north due to the presence of fadama soils and the flood plains. Sesame is not important in the south but is steadily becoming important in the north around Gumel and Hadejia or Zones II and III. Millet is more important in the northern part of Zones II and III than in those of the southern part. Groundnut is very important in Birni Kudu, Jahun, and Dalari in Kaugama LGAs of Zones I and II, but is insignificant around Hadejia where the heavy clay fadama soils limit its cultivation (Table 4.10). Millet and sorghum are the most important crops in terms of production and yield (Figure 4.5, see page 10C of color insert).

Sole cropping is limited to rice in the lowland areas of Birni Kudu and Hadejia. Mixed cropping is, however, the dominant cropping pattern throughout the state (Table 4.11). Millet/cowpea and millet/sorghum/cowpea planted in different row arrangements (2:1:1) is the dominant combination in Zone I (Birni Kudu), while millet/sesame/cowpea, millet/sesame/sorghum, or millet/groundnut/ sorghum (2:2:1) rows are common in Zone II (Table 4.11). Sorghum/cowpea, sorghum/millet/cowpea (2:2:1 row ratio), and sorghum/sesame/cowpea (2:2:1 ratio), with sorghum as the dominant crop are found in the southern part. Sesame becomes a prominent component of the system in the northern part. Groundnut is usually intercropped as groundnut/sorghum and groundnut/millet with or without sesame. In the southern part, sorghum is often planted in gicci with groundnut. Gicci is a system of planting one major crop as sole and includes a minor crop also across the row of the dominant crop. It is widely practised in the southern and middle LGAs, but is completely absent in the northern areas.

Farmers still grow traditional varieties, which, in general, mature late and expose farmers to risks when the growing season is short. With the increasingly erratic rainfall pattern and a decline in the amount of rainfall, farmers are now acquiring such early-

Table 4.12. Major crop varieties in different zones of Jigawa State, Nigeria

Crop	Zone I	Zone II	Zone III
Sorghum	Baka daniya	Garbi	Garbin
	Farafara	Guguza	Babba diya
	Jankaura	Yar daudu[1]	Kaura
		Yar Dumel[1]	Yar Labba[1]
		Yar washa[1]	Yar washa[1]
		Kaura	Makaho wayo
Millet	Zango		
	Lawur		
	Ex-Bornu[1]		
Groundnut	Ayaya	Ex-Dakar[1]	Gana
	Yar kabara[1]		
	Mai baro (RMP12)[1]		
Cowpea	Kananado	Kananado	Kananado
	Tokarabaka		Jampus
	Dan Illa		Aluko
	ITA60[1]		

1. Improved variety.

maturing sorghum varieties as yar-gumel and yar-washa in Kaugama and Gumel areas, Ex-Bornu millet and improved varieties of groundnut (Table 4.12). Kananado cowpea variety is widely grown, not only because it gives reasonable yields without any chemical control, but also because it produces good fodder for livestock feed. In the dry areas of Sudan Savanna Zone, the need for good quality livestock fodder during the dry season overrides the alternative for high cowpea yield without fodder. While farmers have potentially good and acceptable local groundnut varieties, the relatively high yield and shorter-duration cultivars (ICGV 86105, Fleur II, and UGA2) introduced by ICRISAT are generating much enthusiasm among farmers (Table 4.6).

Crop calendar

Transportation and application of organic manure to the fields start in April and May. Planting begins between late May and June in Birni Kudu, and it may not start until late June or early July in Zone II. Farmers in Gumel who took a chance of planting early in May 1996 lost virtually all their millet when no further rains were received long after the

first early rain in May. In the southern part of the state, millet is the first crop to be planted, followed by sorghum and groundnut, and cowpea later. However, most crops including millet, sorghum, and groundnut are planted about the same time once the rains have established. Cowpea is usually planted later. The availability of animal traction for land preparation makes it possible for farmers in the northern part of the state to complete planting their cereal crops within a short period of time.

Cultural practices

The use of animal traction for land preparation and transportation is widespread in Jigawa State. Those who cannot afford to use animal traction plant directly with hand hoes on old ridges or furrows. The practice of wide crop spacing is more common in Jigawa than in Kano and Katsina States. The spacing between crops gets wider in the drier part of the state, thereby giving a low plant density and reducing the risk of crop failure due to drought. In Dalari village of Hadejia zone, cereal crops are planted in alternate ridges, leaving one row without crops in order to allow more feeding space for crops, and to produce more tillers and bigger heads of sorghum or millet. Farms are better managed with less weedy fields in the drier northern areas than in the southern parts, because of less weed competition and availability of animal traction tools. Women are exempted from field work, and their work is restricted to harvesting and processing of farm produce.

Inputs

Animal manure is used in all parts of the state, but higher doses are applied in the northern LGAs where there are more animals than in the southern LGAs. The use of organic manure is associated with the problem of termite attack and other root diseases on crops by the farmers. The use of agrochemicals is irregular, and depend on price and availability (Figure 4.6, see page 11C of color insert).

Livestock productions systems

Jigawa State is one of the major livestock-producing areas in Nigeria. It has an estimated 855 000 cattle heads, 1 943 000 sheep, 2 447 000 goats, and poultry of different species of about 3.2 billion (NAPRI 1995). The breeds of cattle kept include Bunaji (white Fulani) and Rahaji (Bororo). Bunaji breed is the most important in the southern parts around Birni Kudu, Kwaram, Dutse, and Kiyawa LGAs, while Rahaji breed is popular in the extreme northern part of the state such as Hadejia and Gumel LGAs. Rahaji is widely used as a drought animal in Malam Maduri LGA and Bunaji is found in the central LGAs of Kafin-Hausa, Jahun, and Garki. Other breeds include Sokoto Gudali.

The most common breed of sheep is Yankasa, and that of goats is Kano brown and Sokoto red. In most communities, the Hausawa/Kanuri only keep oxen and other ruminants, while the Fulanis own more than 70–80% of the total number of livestock available (JARDA 1995). There are not enough number of veterinary clinics in the state—only nine out of the 21 LGAs have a veterinary clinic. Animals have access to a variety of feed during the rainy season. They are grazed in the community grazing land and in the few government grazing reserves. Frequent clashes occur between farmers and herders over grazing land rights and damage done to crops by animals. Crop residues are preserved as animal feeds in the dry season.

Marketing

Although sorghum and millet are produced mainly for family consumption, many farmers sell grain surplus to meet the family's cash needs. Almost all major crops are sold when the need for cash arises. Sometimes farmers sell more grains than they would have liked. Many crops are sold unprocessed because there is no time to process them in the traditional way, and because it is difficult to gain access to modern processing facilities such as rice mills. Small-scale farmers are also usually forced to sell their produce immediately after harvest when prices are lowest. Marketing becomes very difficult for farmers who cannot afford to hire vehicles to carry their produce to towns and cities. Most of the produce is therefore marketed through small traders who come to villages or at the local market. Groundnut and sesame are very important cash crops in Jigawa State. Many farmers carry their produce to the market on their heads or on donkeys. The major markets in Zones I, II, and III are Birnin Kudu, Malamadori, and Maigatari, respectively. Maigatari is a border market between Nigeria and Niger Republic. Figure 4.7 (see page 12C of color insert) shows the average prices of major crops and Figure 4.8 (see page 13C of color insert) describes the price trend.

Selection of representative LGAs

On the basis on the above description of the state, Birnin Kudu LGA was chosen to represent the wettest part of Jigawa State, while Kaugama and Gume represent the drier Zones II and III .

Katsina State

General description

Katsina State was carved out of the former Kaduna State in 1987. It occupies a total land area of about 25 938 km^2, out of which 1.64 million ha are arable. It is located between

Table 4.13. Main characteristics of the ecological zones of Katsina State, Nigeria.

Zone	No of Local Government Areas	Headquarters	No of villages	Rainfall (mm)	No of households
I	11	Ajiwa	127	461	393 789
II	7	Malumfashi	78	1050	277 317
III	8	Dutsin-Ma	97	879	318 319
Total	26		302		989 425

latitudes 11°07' and 13°22' North and longitudes 6°52' and 9°22' East. Katsina State is divided into 26 LGAs (Figure 4.9, see page 14C of color insert).

For the extension services, the state is divided into three ecological zones: Zone I with its headquarters in Ajiwa in the northern part bordering the Sahel, and comprises 11 LGAs; Zone II with seven LGAs has its headquarters in Funtua, and lies in the south between the northern Guinea and southern Sudan Savanna Zone.; and Zone III is in the center consisting of eight LGAs with Dutsin-Ma as the zonal headquarters (Table 4.13).

Climate

Katsina State covers three agroecological zones, i.e., the Sahel in the extreme north up to Katsina city, the Sudan Savanna Zone, and the northern Guinea Savanna Zone in the south. The rainfall pattern is unimodal with the peak in August. Annual rainfall ranges between 350 and 500 mm in the Sahel, 600 and 850 mm in the Sudan Savanna, and between 900 and 1000 mm in the North Guinea Savanna (Table 4.14). Annual temperatures range between 29°C and 39°C. The lowest mean temperatures occur between December and January, with the cold dusty harmattan winds.

Table 4.14. Annual rainfall (mm) for different zones in Katsina State, Nigeria, during 1990–94.

Zone	1990	1991	1992	1993	1994	Mean
I	520	327	337	214	905	461
II	1180	1054	1086	728	1204	1050
III	734	846	928	NA	1007	879
Mean	811	742	784	471	1039	769

1. NA = Not available

Soils

Soil types of Katsina State comprise Entisols and Inceptisols, which are young and immature soils, well-drained and derived from recent aeolian deposits. Weathering and leaching are slight, and are found in the more arid areas at the northern fringes of the state. The second soil type common across the state is the Alfisols. They are formed of the parent materials rich in quartz, cystalline rocks of basement complex, and on sedimentary deposits (Enwezor et al. 1990). A common feature of these soils is low organic matter content, cation exchange capacity (CEC), and low nutrient content, especially N and P. Hydromorphic soils are found in pockets in all the zones in the state. The soils have fluctuating water tables and occur in small valley bottoms and flood plains.

Farmers in the state recognize these three types of soil and defined them as:

- Sandy to sandy loam—Jigawa
- Sandy clay loam to clay soils—Damba, Shabua, or Fadama
- Gravelly soils—Tsakuwa or Fako

Farmers maintain soil fertility through application of inorganic fertilizers and animal manure. The quantities are, however, insufficient to meet crop requirements. Land degradation through erosion, overgrazing, and deforestation is common in most parts of Sahel and Sudan Savanna Zone.

Population

Katsina State has an estimated population of about 3.9 million people (1991 census), with 51% men and 49% women. Population density is about 217 persons km^{-2}. The people of the state comprise Hausa and Fulani ethnic groups with Islam as the major religion. Magusawa people are present, some of whom are Christians in some parts.

Crop production systems

Major crops grown in Katsina State include sorghum, millet, maize, rice, groundnut, cowpea, cotton, and soybean. However, the relative importance of these crops varies according to location. For example, sorghum, maize, rice, cotton, millet, cowpea, and pepper are the most important in the more humid, southern parts of the state (Table 4.15). Maize has declined from its second rank position behind sorghum to about the fifth in recent years due to scarcity and high cost of inorganic fertilizers. As one moves northwards into the middle belt of the Sudan Savanna Zone (Zone III), millet, sorghum, groundnut, cotton, and cowpea become dominant. Millet, followed by sorghum, cowpea, and groundnut are the most important crops in the northern part (Zone I).

Table 4.15. Occurrence of crops in field (% of total) by ecological zone in Katsina State, Nigeria 1995.

Zone	Millet	Sorghum	Maize	Groundnut	Cowpea	Rice	Others
I	59	27	1	60	52	1	0
II	6	43	76	2	12	32	36
III	36	29	24	38	36	67	64

Tomato is an important cash crop in Barhim village of Batagarawa LGA. Sorghum is the most important crop in terms of total production and yield, followed by millet in Katsina State (Figure 4.10, see page 15C of color insert).

Sole-cropped fields of sorghum, maize, rice, cotton, groundnut, and pepper are common in Malumfashi and Kankia LGAs, but they are found less frequently as one moves from the southern to northern parts. In general, two-crop mixtures planted in alternate rows are very common (Table 4.16). Fields located near the homestead have a higher degree of intercropping. The gicci system of planting is common in the South Sudan LGAs whereas it is not noticeable in the northern part.

The varieties of crops grown are mostly local cultivars (Table 4.17). The range of local cultivars of each crop is rather large and often difficult to distinguish. For example, the same local crop cultivar may be called by different names depending on the locality. Crops with preponderance of local names include sorghum (Farafara, Mori, Dan Ilela, Kaura, Dan-Hamza, etc.), millet (Zango, Baragadi, Dan-Digali, Dan-Dusai, etc.), and cowpea (Kamanado, Dan-Illan, Dan-Mahi, etc.). Some of the cultivars with local names could have been adaptations of some of the improved varieties (Ogungbile et al. 1995) over the years through ADP extension services. Outcrossing and lack of continuous supply of certified seeds of the original varieties have led to mixtures and loss of varietal identities. Even where and when new varieties have been adopted by farmers, there is no way of maintaining their purity in the absence of a reliable seed production program.

Table 4.16. Percentage distribution of crop mixtures in Katsina State, Nigeria (information from 1996 survey).

Zone	Sole (%)	2-crop (%)	3-crop (%)	3-crop (%)
I	6	47	37	10
II	44	52	4	0
III	15	54	28	3

Table 4.17. Major crop varieties in different zones of Katsina State, Nigeria.

Crop	Zone I	Zone II	Zone III
Sorghum	Farafara Kaura Jar Dawa	Kaura Farafara Mori Bagaji Rubus Samsorg 14	Farafara Jan Dawa (Yar Barhim) Yar Ruruka (Samsorg 14)[1]
Millet	Zango Ex-Bornu[1] Ex-Bornu[1]	Not significant	
Groundnut	Yar Tsugune Kalle (RM012)[1] Ex-Dakar[1] J5[1]	Kalle (RMP12[1]) Ex-Dakar[1]	Yar Tsugume Ex-Dakar[1] RMP12[1] Jar Jigila
Cowpea	Kananado Dan Illa Dan Arbain ITA60[1]	Kananado Dan Illa TVX[1]	Dan Illa Kananado

1. Improved variety.

The bulk of sorghum varieties grown are local, although some improved varieties such as SAMSORG 14 and other early-maturing varieties have been adopted. Improved Ex-Bornu millet is the most widely grown millet variety, followed by Zango. Several improved varieties of groundnut such as Ex-Dakar and RMP 12 are common. These varieties, however, mature late. Farmers expressed desire and enthusiasm for ICRISAT's early-maturing sorghum (ICSV111, ICSV 400) and groundnut (ICGV6015, Fleur 11, and UGA2) which were under on-farm evaluation in the villages, and performed better.

Cultural practices

Animal traction is accepted and practised almost all over Katsina State, but mostly in the southern parts (in contrast to Bebeji in Kano), followed by the northern part, and then in the transitional zone between them. Continuous cropping is common in the South Sudan area where they grow more cash crops, and are familiar with the use of inorganic fertilizers. There is some amount of fallow period from 1 to 2 years in the areas in the

middle (Zone III). There is practically no fallow land in the Batagarawa area of Katsina because of land shortage owing to its close proximity to the capital city of Katsina. Farmers practice crop rotation, which is part of the system of interplanting cereals and legumes in alternate rows. Legumes are grown in one year, and cereals the following year, on the same land. Relay cropping with millet followed by cowpea is practised, and helps maintain soil fertility.

Inputs

The scarcity of fertilizer has severely limited its use, and when available, priority is given to maize, cotton, rice, and sorghum in that order. Persistent shortage of fertilizers could result in a drastic decline in the production of these crops. Manure is used to maintain soil fertility, but rarely enough to cover about 20–25% (Zone II), 15% (Zone III), and 30–40% (Zone I) of the annually cultivated land. Farms further away from the homestead receive less manure than those nearby, owing to transportation problems.

Livestock production system

Livestock production is an integral part of farming systems in Katsina State as both crop and animals are sources of food and cash income for farmers. There is hardly any household without livestock. Livestock population comprises 1.2 million cattle, 2.6 million sheep, 4.1 million goats, 41 400 camels, 182 160 donkeys, 43 470 horses (Table 3.7), and 4.2 million poultry (KTARDA 1995).

Breeds of cattle include Bokoloji (Sokoto Gudali), Rahaji (red Bororo), Banaji (white Fulani), and Azouak. The sheep include Uda, Salami, and Yankassa; goats include Sahelian long legged and red Sokoto. The dominant livestock species in the northern Sudan Savanna Zone are goats followed by sheep, and cattle. Small ruminants such as sheep and goats are most common around Kankia and Dutsin-Ma LGAs in Zone III. The southern region around Malumfashi has the highest concentration of cattle in Katsina. Fattening of bullocks and rams for sale is very common. Other activities include livestock sales, milk processing, and marketing and sales of crop residues and cereal bran.

Livestock have access to a variety of feeds during the rainy season, but availability of feed is a problem during the dry season. Frequent clashes occur between cattle Fulani and pastoralists when cattle damage pastoralist's crops.

Marketing

Most of the coarse grains (sorghum, millet, and maize) except rice are produced for family consumption. Only a small surplus is available for sale. About 26, 28, and 51% of sorghum, millet, and maize, respectively, are sold or given away as gifts, the rest is consumed by the family. Groundnut, cotton, and rice are the main cash crops. While some grains are traded within the villages in the LGAs, and sold directly to traders, the bulk of the sales are made at weekly rural markets. The major rural markets in Zone II in the southern region include Malumfashi, Funtua, and Dayi. Musawa and Rimaye are the major markets in Zone III. Traders from large cities including those from the southern parts of Katsina patronize these markets. There is a lot of border trading with Niger in the border markets of Mai-Ardua, Ajiwa, and Maradi in Zone I in the northern part of Katsina. Figure 4.11 (see page 15C of color insert) describes the price trends for major crops during 1991–95, while Figure 4.12 (see page 16C of color insert) shows the average prices of these crops.

Selection of representative LGAs

Based on the data and results from the characterization of ADP zones, three LGAs, one in each zone were selected to represent the production systems in the three ADP zones in the state. The LGAs are Malumfashi in the wettest southern part, i.e., Zone II, Kankia in Zone III, and Batagarawa in Zone I in the driest part of Katsina.

Characterization of selected LGAs

General description of the selected LGAs and villages

In the preceding chapter, for each of the three states, three LGAs were selected as representatives. Table 5.1 presents selected characteristics. In each LGA, there are several villages, and on the basis of criteria such as rainfall distribution and soil fertility, one village was selected in each LGA. Their characteristics are presented in Table 5.2.

Bebeji LGA/Kofa village

Bebeji LGA is located in the southern part of Kano State, with about 52% of all the households being farmers. Bebeji is about 80 km from Kano, the state capital. Hausa and Fulani are the main ethnic groups, and Islam predominates.

Kofa village is accessible throughout the year by a good road. Kofa is located on a gently undulating plain.The soils are loamy with less than 10% hydromorphic fadama land. The village is about 12 km from Bebeji town, and about 84 kilometers from Kano. The population is predominantly Hausa with about 1350 taxable adults. Since Kofa has no market of its own, people patronize the daily and weekly markets in Kano and Kona Dangora, about 81 and 40 kilometers from Kofa, respectively.

In 1996, there was a substantial reduction in the amount of land cropped to maize, owing to scarcity of inorganic fertilizers. Animal traction is not important in this village, but animal manure is applied every 4 years in crop rotation. Most people plant their

Table 5.1. Characteristics of selected Local Government Areas (LGAs) in Kano, Jigawa, and Katsina States of Nigeria (ADP 1990–95).

State	LGA	No of villages	Land area (km^2)	Population	No of households	Density ($p\ km^{-2}$)
Kano	Bebeji	17	300	71 324	37 294	55
	Albasu	20	320	111 508	22 636	348
	Bichi	30	NA[1]	NA	59 664	NA
Jigawa	Birnin Kudu	NA	1 960	292 838	40 000	149
	Kaugama	20	8 400	183 672	10 000	22
	Gumel	NA	NA	121 279	14 000	NA
Katsina	Malum fashi	23	20 000	312 940	36 442	147
	Kankia	58	1 390	174 322	45 348	125
	Batagarawa	27	427 900	306 450	18 124	716

1. NA = Not available.

Table 5.2. Location and biophysical details of selected Local Government Areas (LGAs) and villages in Kano, Jigawa, and Katsina States of Nigeria.

State	Selected LGA	Village name	Agro-ecological zone	Coordinates		Soil type
				Latitude	Longitude	
Kano	Bebeji	Kofa	Southern Sudan	11°34'	8°17'	Loamy
	Alabazu	Panda	Southern Sudan	11°31'	8°04'	Loamy
	Bichi	Badume	Northern Sudan	12°12'	8°19'	Sandy
Jigawa	Birni Kudu	Kantoga	Southern Sudan	11°30'	9°23	Sandy loam
	Kaugama	Dalari	Northern Sudan	12°36'	9°48'	Sandy
	Gumel	Gijigami	Northern Sudan	12°34'	9°25'	Sandy
Katsina	Malumfashi	Gora	Southern Sudan	11°55'	7°43'	Loamy
	Kankia	Rimaye	Northern Sudan	12°19'	7°54'	Loamy
	Batagarawa	Barhim	Northern Sudan	12°58'	7°41'	Sandy

cereals without ridging, but directly on a piece of soil scooped from the previous season ridge into the furrow. This system is called Kishingiwa in the local Hausa language. When planting is done on the old ridge, this planting method is called Sangumi.

Albasu LGA/Panda village

Albasu LGA is located in the southern part of Kano State, and about 50% of the population are farmers. The rainy season starts from May to September, with an average annual rainfall of about 700 mm. Although the total rainfall during 1996 was adequate, the late onset of rains led to a reduction in the amount of rice grown. The distance from Kano to Albasu is about 102 km. Livestock are an important aspect of farming in Albasu. Fisheries are developed in the ponds/lakes behind earth dams in Farantama village, about 2 km from Panda village. It has about 350 ha covered by wood lot/belts.

Albasu has no industries. Marketing takes place through the four weekly rural markets. Infrastructure is well developed with a total of 30 kms of federal and 15 km of tarred road, and 200 km of laterite roads. There is also a Staff Training Centre owned by KNARDA, for extension services at Panda.

Panda village is located on a gentle undulating plain. It is located about 6 km from a major paved road. It has a population of about 1000 people, predominantly Hausa. Animal traction is widely used for cultivation of land. Manure is used to maintain soil fertility. Major constraints include shortage of fertilizers, attack of termites on groundnut, and lack of a village market.

Bichi LGA/Badume village

Bichi LGA is located in the northwestern part of Kano State, 44 km from Kano city. Its inhabitants (Hausa) are mostly farmers, petty traders, and cattle rearers. It lies in the mid-savanna region of the state, and has an area of about 150 ha covered by wood lot.

Bichi has three earth dams for water supply and fishery development and some irrigation, especially at Dadin Kanya, Aira, and Abukur. It has weekly markets, famous for agricultural and livestock products. It has two commercial banks. A total of 20 km of national road linking Kano, Katsina, and Niger Republic pass through the LGA. It has five points with potable tap water, 49 boreholes, and 70 open wells.

Badume village is located in the northern part of the Sudan Savanna Zone. The village is inhabited predominantly by the Hausa and a few Fulanis. It is about 40 km from Kano city. Rainfall was reported to have improved in this village in the last 6 years. A few farmers have access to tractor hiring services, and about 30% of the farming households own oxen and implements. While cotton production has declined in the area, there was an increase in the production of tomatoes and groundnut. Major constraints include high costs of farm inputs and limited access to fadama land and credit.

Birnin Kudu LGA/Kantoga village

Birnin Kudu LGA is located in the southern parts of Jigawa State, and falls within the wettest part of the state.

Kantoga is about 15 km from Birnin Kudu. It has electricity, and can be reached by a paved road. The soil type is gently undulating sand dunes over Chad sediments and basements complex of about 2% slope. The range of soils combines the pale brown to yellow Alfic Ustipsamments. Manure is used to maintain soil fertility. The 1996 cropping season was assessed to be good in terms of rainfall amount and distribution.

Kaugama LGA/Dalari village

Kaugama LGA is located in the northern dry part of Jigawa State. It was created in 1991. Dalari village is located in Kaugama LGA, about 5 km off the paved road. The soil is mainly sandy, with a small fraction of loam. Fadama soils are absent, hence no dry-

season farming is done. Farmers in this village practice good crop husbandry by adopting improved technologies such as ridging across the slope, improved crop varieties, and the use of inorganic fertilizers and good farm management practices. Due to the late rainfall in 1996, the land area sown to millet was reduced, compared with other years, but more sorghum was planted. There is no market in the village. About 50% of the land was acquired through purchase, 40% through inheritance, and 10% through lease.

Gumel LGA/Gijigami village

Gumel LGA in the upper north of Jigawa State is inhabited by Hausas, Kanuri, and Fulani. Cross-border migration between people of Gumel and the neighboring Niger Republic is common. The extent of migration is higher during the dry season, when cattle rearers move southwards in search of pasture and water for their animals. People also go to neighboring states for off-season jobs.

Gijigami is located on a paved road, 12 km from Gumel town. The soil is predominantly sandy. Fadama soils are absent, and so there is no dry-season agriculture. In 1996, the dry spell experienced after the initial start of the rains adversely affected the production of millet. About 80% of the land was acquired through inheritance, 15% through lease, and 2% through purchase.

Malumfashi LGA/Gora village

Malumfashi LGA falls within Zone II in the wetter southern parts of Katsina State. It is a transition zone between the northern Guinean Savanna and the Sudan Savanna Zones.

Gora is located about 18 km from the major town of Malumfashi. It has about 300 households. The major ethnic groups consist of Hausa (60%), Fulani (25%), and Mazaguawa (15%). It is located in the undulating plains with scattered hills, rocks, and iron pan. The soils are mainly loamy with some stony sands. Soil fertility is maintained using animal manure. Cultivation is mostly done using workbulls, and 20% is manual. Crops are generally planted on ridges.

Kankiya LGA/Rimaye village

Kankia LGA is located in the middle of Katsina State. Rimaye is on a paved road, and has about 1010 households.

The soil is mainly loamy with some gravelly patches. The rainfall was judged to be adequate for 1996 even though in the beginning it was erratic. Farmers observed an early-season dry spell of about 16 days after the first rain, which occured on 3 June. Soil

fertility is maintained by using farmyard manure sufficient for only 25% of the plots. There is a weekly market in the village.

Batagarawa LGA/Barhim village

Batagarawa LGA was created out of Kankia LGA in 1991. Barhim is about 6 km from the center of Katsina town. In 1996, only 25% of the millet planted could be harvested, because of drought. The rains which stopped for about 43 days favored sorghum production when it resumed.

Biophysical aspects

Most soils in the villages are sandy, sandy loam, or loamy (Table 5.2). As described earlier (Tables 4.12, 4.13, and 4.14), rainfall varies from year to year. No rainfall data are available for the individual selected LGAs. Bebeji, Malumfashi, and Birnin Kudu LGAs receive the highest rainfall, while the least amount is observed in Batagarawa, Gumel, and Kaugama LGAs.

Crop production systems

Major crops

Ranking of the main crops in the villages depends on such criteria as cropped land, food preference, or cash income (Table 5.3). For instance, in Kofa, the main crops grown in order of importance in terms of cropped land include sorghum, groundnut, rice, millet, and pepper. In terms of food preference, millet comes second, while in terms of cash income, groundnut comes first.

Assuming an equal relative importance of the villages and of the three criteria, sorghum is the most important crop in all villages, followed by millet and groundnut. The reported temporal change of sorghum being replaced by maize (Smith et al. 1994) does not seem to be true in the Sudan Savanna Zone of Nigeria. Malumfashi LGA used to be a major maize-growing area, but maize production has declined drastically because of scarcity and high prices of fertilizers. Table 5.4 confirms the importance of these crops in terms of frequency of occurrence on farmers' fields.

Cropping pattern

Most farmers grow their crops in mixture. Over 80% of the total land cultivated in the selected LGAs (Kano and Jigawa) was devoted to crop mixtures. The most important crop

Table 5.3. The order of importance of major crops in selected villages in Kano, Jigawa, and Katsina States of Nigeria.

			Area occupied by			Food crop			Cash crop		
State	Local Government Area	Village	I	II	III	I	II	III	I	II	III
Kano	Bebeji	Kofa	S[1]	G	R	S	Ml	R	G	PP	ON
	Albasu	Panda	S	Ml	G	S	Ml	R	G	R	C
	Bichi	Badume	S	Ml	G	S	Ml	Mz	TM	PP	C
Jigawa	Birnin Kudu	Kantoga	S	Ml	R	S	Ml	R	G	SS	C
	Kangama	Dalari	Ml	S	G	Ml	S	C	G	SS	C
	Gumel	Gijigama	Ml	S	C	Ml	S	C	SS	C	G
Katsina	Malumfashi	Dayi/Gora	S	CT	G	S	Ml	Mz	CT	G	C
	Kankia	Rimaye	S	Ml	C	S	Ml	Mz	CT	G	C
	Batagarawa	Barhim	Ml	S	G	Ml	S	C	TM	G	C

S = sorghum, G = groundnut, R = rice, Ml = millet, PP = pepper, ON = onion, C = cowpea, MZ = maize, TM = tomato, SS = sesame, CT = cotton.
(Source: Survey 1996)

Table 5.4. Occurrence of crops in selected Local Government Areas (LGAs) (% of total farmers) in Kano, Jigawa, and Katsina States of Nigeria, 1995.

LGA	MI[1]	S	Mz	G	C	R	O
Kano							
Bebeji	14	44	2	2	-[2]	-	5
Bichi	10	20	7	11	26	-	24
Albasu	18	28	-	37	17	-	-
Mean	**14.0**	**30.7**	**4.5**	**16.7**	**14.3**	-	**14.5**
Jigawa							
Birni Kudu	69	70	4	40	83	5	3
Kaugama	66	61	3	30	49	4	13
Gume	75	76	2	14	70	1	18
Mean	**70**	**69**	**3**	**28**	**67.3**	**3.3**	**11.3**
Katsina							
Malumfashi	6	43	76	2	12	32	36
Kankia	36	29	24	38	36	67	64
Batagarawa	59	27	1	60	52	52	0
Mean	**33.7**	**33**	**33.7**	**33.3**	**33.3**	**33.3**	**50**

1. MI = millet, S = sorghum, Mz = maize, G = groundnut, C = cowpea, R = rice, O = others.

2. - = Data not available.

mixtures are sorghum/millet, sorghum/cowpea, and millet/cowpea. Three-crop mixtures are rare except in Albasu LGA, although no data are available for Katsina State (Table 5.5).

Crop varieties

Traditional (local) varieties (Yusuf 1996, Flower 1996) still form the bulk of the crops grown. Crop varieties found have been presented in Tables 4.5, 4.12, and 4.17. Although the usually late-maturing, low-yielding traditional sorghum cultivars such as Farafara and Zango sorghum varieties are still popular, the erratic rainfall situation has forced many farmers, especially in the drier areas (Bichi), to adopt improved early-maturing cultivars. The late-maturing, low seed-yielding cultivar of cowpea (Kananado) is the most popular in the Sudan Savanna Zone, because of its ability to yield abundant fodder in addition to seed. Serious insect pest problems have limited the adoption of improved high seed-producing cowpeas.

In Panda, several improved varieties of sorghum, groundnut, and cowpea have been adopted. Mixed cropping is the predominant cropping pattern, but the crops are

Table 5.5. Land occupancy (% of farmers) by major cropping systems in selected Local Government Areas (LGAs), in Kano and Jigawa[1] States of Nigeria, 1995.

State	LGA	S[2]	SMl	SMz	SG	SC	SR	SMlG	SMlC	SGC	Ml	MlG	MlC	MlGC	G	R	MzR	O
Kano	Bebeji	12	14	3	5	4	20	-	-	-	8	-	2	-	-	10	10	12
	Bichi	11	13	-	4	8	-	9	7	2	5	11	10	-	8	4	5	3
	Albasu	19	-[3]	-	-	20	11	-	8	-	-	5	13	18	2	1	2	1
	Mean	**14**	**9**	**1**	**3**	**10.7**	**10.3**	**3**	**5**	**0.6**	**4.3**	**5.3**	**8.3**	**6**	**3.3**	**5**	**5.7**	**5.3**
Jigawa	Birninkudu	23	12	-	11	-	-	29	-	-	13	5	-	-	-	-	-	7
	Kaugama	-	69	-	-	-	-	-	-	-	15	-	-	-	10	-	-	6
	Gumel	12	16	-	13	-	-	30	-	-	8	4	5	-	-	-	-	12
	Mean	**11.6**	**32.3**	-	**8**	-	-	**19.6**	-	-	**13**	**3**	**1.6**	-	**3.3**	-	-	**8.3**

1. Data for Katsina State are not available.
2. S = sorghum, Ml = millet, Mz = maize, G = groundnut, C = cowpea, R = rice, O = others
3. - = Data not available

Table 5.6. Methods of field preparation in nine villages (% of farmers) in Kano, Jigawa, and Katsina States of Nigeria.

State/village	Ridging		No pre-sow ridging	
	Oxen	Manual	'Kishingiwa'[1]	'Sangumi'[2]
Kano				
Kofa	0	0	Most[3]	Few
Panda	80	Few	Few	0
Badume	40	Rare	60	Few
Jigawa				
Kantagora	70	Few	20	Few
Dalari	80	0	0	20
Gijigami	50	0	0	50
Katsina				
Gora	80	20	0	0
Rimaye	40	Few	Most	Most
Barhim	100	0	0	0

1. Planting is done directly on the soil scooped from the previous season's ridge into the furrow.
2. Planting is done on the old ridge.
3. Most = more than 90%, Few = 5–20%, Rare = less than 5%.

commonly grown in alternate rows. Table 5.5 lists the details of the most important cropping systems.

Cultural practices

Farmyard manure is carried to the field before the rainy season, and spread shortly before ridging. Ridging is carried out manually or by ox-drawn implements. It can be done before or after planting as a weed control measure. Additional 2 hoe-weedings at 2–3 week intervals are usually adequate for weed control. Table 5.6 shows the different methods of land preparation in the villages.

Socioeconomic aspects

Inheritance is the most important mode of land acquisition in most of the LGAs, except for Birnin Kudu and Kaugama LGAs in Jigawa State, and Batagarawa LGA in Katsina State where people purchase land (Table 5.7).

The size of the population is very different in the nine selected villages, using an assumed average of 13 persons per household. In the Sudan Savanna Zone, the ethnic groups are predominantly Hausa and Fulani, except in Gijigami.

Table 5.7. Method of land acquisition and major ethnic groups (%) in Kano, Jigwa and Katsina States of Nigeri a.

State	Local Government Area	Land acquisition			Ethnic group			
		Inheritance	Purchase	Rent	Hausa	Fulani	Kanuri	Mazaguawa
Kano	Bebeji	70	20	10	90	10	-	-
Albasu	80	15	5	100	-	-	-	
Bichi	85	10	5	100	-	-	-	
Jigawa	Birnin Kudu	25	60	15	90	10	-	-
Kaugama	40	50	10	80	10	10	-	
Gumel	80	15	5	10	20	70	-	
Katsina	Malumfashi	80	5	15	60	25	-	15
Kankia	70	20	10	85	10	-	5	
Batagarawa		40	60	0	100	-	-	-

1. - = Data not available

Characterization of the Selected Villages

The general characteristics of selected households in the nine selected villages vary in most parameters, except for the use of fallow (Table 6.1).

Resource endowment

Land use

There is high land use intensity at Kofa and Badume villages in Kano State. Farmers use all their land to grow crops, and there is virtually no grazing land available for livestock during the rainy season. Although Kofa is very close to the Hadejia-Jamare large-scale irrigation scheme area, no significant irrigated farming takes place there. There is, therefore, very little room for expansion. Badume, at the northeast of Kano city is only about 40 km from the capital city. It is within the Kano closed-settled zone (CSZ) described by Mortimore (1993b). Farming intensity on rainfed upland soils is very high here. Panda is farther away from any major city. Therefore, there is more land for farming. This is further confirmed by Turner (1997) who showed for Tumbau village, 230 km east of Kano, with more than 300 persons per km^2, that arable land (including fallow) increased from 77% (1950) to 89% (1971 and 1981). In the same time, grazing land reduced from 17 via 5 to 1%. Fallow has virtually been eliminated on the uplands (Yusuf 1996). The average farm size of respondents at Panda is higher than those at Kofa and Badume (Table 6.1). There is a high pressure on land.

The farm sizes are large, and to a certain extent, land fallow is practised lasting 2–3 years at Gijigami and Dalari villages in Jigawa State. There are communal grazing areas in the villages, and some of the respondents have woodlot plantations as recommended by the afforestation program in the area. The household density is also lower at Jigawa State.

Continuous cropping is very common in Gora and Barhim villages of Katsina State. Farming in Gora is highly intensified because it is within the former Funtua-enclaved Agricultural Development Project area, where the World Bank-assisted agricultural program started in Nigeria. Barhim, located about 6 km southwest of Katsina city, is under the direct influence of markets and business of the capital city. Farm expansion is difficult because urban development has encroached on arable farmland. Rimaye is located in a rural farming community far away from any major town, and there is space for larger farms for expansion of farmland and some fallow.

Farm holdings in Rimaye consist of several scattered fields which are about 1–4 km from homesteads. Farmers consider lands around homesteads poor, sandy, and exhausted, and therefore apply more manure. They consider distant fields to be more

Table 6.1. Characteristics of nine villages in Kano, Jigawa, and Katsina States, Nigeria.

	Kano			Jigawa			Katsina		
Village	Kofa	Panda	Badume	Kantoga	Dalari	Gijigami	Gora	Rimaye	Barhim
subzone	South	South	Middle	South	North	North	South	Middle	North
Population	1020	2260	1446	1700	1000	680	2000	900	900
Households selected	10	16	11	19	19	16	19	19	15
Household size	12	13	11	13	15	13	16	16	12
Working members/family	4	4	4	4	5	4	7	6	4
Farm size (ha)	4.0	4.6	3.7	3.3	8.5	4.7	3.8	5.5	6.2
No of fields	4	3	3	4	4	4	4	4	3
Household member (ha^{-1})	3.0	2.8	3.0	2.1	1.7	2.7	4.2	2.2	4.0
Working members (ha^{-1})	1.0	0.9	1.1	1.2	0.6	0.9	1.8	1.1	0.6
Fallow	None	None	None	None	Some	Some	None	Some	None
NPK (kg ha^{-1})	68	77	95	62	63	60	70	114	58
Manure (kg ha^{-1})	648	728	644	326	528	695	730	396	124

fertile and loamy. At Dalari and Gijigami, millet, groundnut, and vegetables are usually planted near the homestead, while sorghum is grown on distant fields.

Farm sizes increase as one moves from the south to the north of the Sudan Savanna Zone. This is probably because there is less pressure on land in the northern parts and the lighter soils are easier to work with the abundant use of ox-drawn implements. The average farm holdings are 4.7, 4.9, and 6.6 ha in the southern, central and northern zones, respectively (Table 6.1).

Although inheritance is the major mode of land acquisition, there is an increase in the rate of acquisition through purchase.

Labor

Both manual labor and animal traction are employed in plowing and making ridges. As shown in Table 6.1, about 36% of the household members take part in farm work. The practice of gandu where several household heads join together to farm and eat has nearly disappeared, and this has reduced the number of family members working on family farms. Except in Gijigami village where the majority of inhabitants are Kanuri by tribe, female adults of child-bearing age do not work on the field, but they process the harvested produce brought home from the field. The bulk of the farm labor is provided by the family, although most of the respondents reported no shortage of hired labor as long as there was money to pay for the labor.

The use of animal traction is most widely practised in three villages (Dalari, Gijigami, and Barhim), followed by Badume and Rimaye in the central belt and least practised at Kofa and Kantoga, in the south. The major problem of animal traction is that there are no implements for postplanting operations. Several prototype implements exist in IAR, at Samaru, which could be used for the operations, if only they can be produced in commercial quantities, at a reasonable price.

Livestock

In virtually all the villages, respondents expressed serious difficulties in obtaining credit from formal institutions for farm work. Apart from crop sales, the proceeds from livestock sales provide a major revenue required for farming activities and domestic obligations. Every household keeps one form of livestock or the other for the supply of animal power, manure, and cash (Table 6.2). There is usually a great demand for animal feeds, especially during the dry season. Farmers have to collect crop residues and store them to feed their livestock. Residues of such legume haulms as groundnut and cowpea are regarded to be of very high quality (e.g., Yusuf 1996; Okaiyeto 1984), with relatively high N contents [for groundnut N-minimum of straw is 1.2%, for bambar groundnut

Table 6.2. Mean number of animals per household in nine villages of Kano, Jigawa, and Katsina States of Nigeria.

State/Village	Cattle	Goat	Sheep	Chicken
Kano				
Kofa	3	5	4	13
Panda	4	7	5	16
Badume	4	4	6	15
Jigawa				
Kantoga	4	5	5	14
Dalari	5	6	4	12
Gijigami	4	4	3	14
Katsina				
Gora	3	3	6	10
Rimaye	3	4	5	12
Barhim	2	3	5	10

1.3%, and for cowpea 1.9% (van Duivenbooden 1992)]. Out of the cattle owned by the households, at least two bulls are reserved for animal traction. Donkeys are kept mainly for transportation.

Inorganic fertilizers/Manure

Both chemical fertilizer and organic manure are used to improve and maintain soil fertility. Chemical fertilizers used to be the main source of soil nutrients. The most popular fertilizer among farmers is the compound fertilizer (NPK). The amount of fertilizer applied to crops is rarely adequate to obtain a sustainable system (Jaiyeoba 1995, Yusuf 1996, Ogungbile et al. 1998). An average household obtains 3–5 bags of NPK, and applies it at a rate of 60–80 kg ha^{-1} (Table 6.3), mostly to cereal crops. This implies only a supply of about 25–30 kg N ha^{-1}.

However, in recent years, the high cost and scarcity of fertilizer due to poor distribution systems have forced farmers to shift their attention towards preparation and use of animal manure. Farmers accumulate manure in the compounds from the dropping of animals and poultry mixed with crop residues. Manure from small ruminants is reported to be of better quality than that from cattle (van Duivenbooden 1992). A good manure from small ruminants is processed within a year, while that from cattle will take 2 years. Manure is transported to the fields before the rains, on animal-drawn carts and donkeys. Animals that roam the fields during the dry season to graze the crop residues also leave some manure. Fulani pastoralists are sometimes invited to camp their animals in a particular field for a fee in exchange for the animal droppings.

Table 6.3. Fertilizer and manure quantities used by farmers in Kano, Jigawa, and Katsina States of Nigeria (PRA Survey 1996).

State/village	Inorganic fertilizer		Organic manure	
	kg per household	kg ha^{-1}	kg per household	kg ha^{-1}
Kano				
Kofa	178	68.1	1750	648.1
Panda	213	77.3	2366	728.4
Badume	158	95.0	1546	644.1
Mean	183	80.1	1887	673.5
Jigawa				
B/Kudu	233	62.4	1441	325.8
Dalari	383	63.0	2678	528.0
Gijigami	152	59.8	1424	694.6
Katsina				
Gora	139	70.6	1506	730.3
Rimaye	245	114.0	2023	396.0
Barhim	310	58.5	2379	424.0
Mean	231	81.03	1969.3	516.8

Because the quantity of manure produced is usually not sufficient to cover the whole farm in any given year (Onyewotu et al. 1998), it is rotated on the fields with each field receiving manure every 2–3 years. All the respondents were aware of the importance of legume crops in maintaining soil fertility. Hence, legumes are included in crop mixtures or rotation.

Agrochemicals

Very few of the farmers interviewed used any chemical to control insects and disease. Only a few farmers in Dalari used Fernasan D as seed dressing for sorghum and millet. Many farmers could not associate the high incidence of sorghum smut and downy mildew in millet to nondressing of their seeds with systemic fungicides. Cultural practices such as early planting, intercropping, and remoulding of ridges, and the use of such "natural" insecticides as neem are reported as means of controlling pests, diseases and parasitic weeds. At Dalari, a few farmers also applied Actellic dust on stored crops.

Crop production systems

The farming systems in all the villages are based on the production of crops and livestock. Farmers cultivate mainly four crops—sorghum, millet, groundnut, and cowpea. Maize, and probably rice, which used to be important in the villages in the southern subzone are not being grown much due to the high costs of fertilizers. Other subsidiary crops include sesame, vegetables, and pepper. These crops are grown in a variety of intercropping. The different patterns of cropping, and practices observed among the farmers are described later.

Major crops

Sorghum is the most important crop in terms of land area put to its cultivation, and as a major staple crop (Table 6.4), followed by millet. Sorghum is the most important staple food of the people in the southern zone, while millet is more important in the drier zone. Table 6.4 shows the land area occupied by various crops and crop combinations, while Table 6.5 shows the pattern of consumption of the major food crops. Groundnut and cowpea are the major cash crops, regardless of the location of the villages, while sesame is a subsidiary cash crop in both Gijigami and Dalari. Most of the sesame produced is sold in Niger Republic, and the proximity of these two villages to the border is an advantage. Farmers claimed that sesame was a replacement for groundnut, because of the risk of rosette disease, especially at Gijigami village.

Major crop enterprises

Table 6.5 also shows the major crop enterprises carried out on average farms. Sorghum was grown as sole crop, and most importantly in mixture with other cereal and legume crops such as millet, maize, groundnut, and cowpea. Sorghum was found in 50–70% of the total cropped fields in various combinations of other crops across the zone. Sole crop sorghum occupied about 5% and 11% of the total cropped land in Kofa and Badume villages in Kano state, respectively. Except at Kantoga, sole sorghum enterprise was very important in other villages in Jigawa and Katsina States, with the respondents devoting between 10% and 22% of the cropped land to sole sorghum.

Sole crop millet was very popular in Dalari and Gijigami villages of Jigawa State, occupying more than 20% of the cultivated land. Although groundnut was usually the dominant component in a crop mixture, it was seldom found as a sole crop enterprise. Groundnut was observed as a sole crop only at Dalari and Gijigami villages. Cowpea was rarely found as a sole crop. Sole cropping seems more prevalent in villages in the central and northern subzone of the Sudan Savanna. In Dalari village, respondents said

Table 6.4. Cropping systems in nine villages in Kano, Jigawa, and Katsina States of Nigeria in 1996.

	Kano			Jigawa			Katsina		
Type	Kofa	Panda	Badume	Birni Kudu	Dalari	Gijigami	Gora	Rimaye	Barhim
Sole									
Sorghum	8	8	9	7	6	2	8	10	7
Millet	0	3	3	0	5	10	0	10	3
Groundnut	0	0	0	0	4	0	0	0	0
Maize	2	1	12	-	-	-	5	-	-
Cowpea	1	-	-	-	5	9	6	-	3
Rice	9	3	-	2	-	-	9	-	-
Subtotal	20	15	24	9	20	21	28	20	13
2-crop mixture									
Sorghum/millet	14	5	9	7	6	7	11	-	7
Sorghum/ groundnut	9	14	17	9	5	-	12	15	10
Sorghum/ cowpea	12	12	16	11	9	13	14	15	9
Sorghum/ cotton	-	-	-	-	-	-	9	11	-
Sorghum/ sesame	-	-	-	2	2	7	-	-	-
Millet/ groundnut	10	4	4	8	7	-	7	11	16
Millet/cowpea	8	3	5	8	9	9	6	11	11
Millet/cotton	-	-	2	5	-	-	-	9	-
Groundnut/ cowpea	-	3	13	3	3	9	-	-	
Subtotal	53	41	66	53	41	45	56	72	53
3-crop mixture									
Sorghum/millet/ groundnut	11	9	10	8	-	6	-	-	7
Sorghum/millet/ cowpea	7	8	-	12	9	13	-	-	7
Millet/groundnut/ cowpea	-	10	-	8	3	-	-	-	-
Subtotal	18	27	10	28	12	19	0	0	14
Others	9	17	0	10	27	27	16	8	20
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. - = Data not available

Table 6.5. Percentage of major crops consumed by households in nine villages in Kano, Jigawa, and Katsina States of Nigeria.

State/village	Sorghum	Millet	Groundnut	Cowpea	Maize	Rice
Kano						
Kofa	74	73	61	9	46	10
Panda	64	80	12	20	77	6
Badume	79	78	9	13	44	-
Mean	72	77	8	14	56	5
Jigawa						
Birnin Kudu	75	76	14	5	-	-
Dalari	58	54	18	2	-	-
Gijigami	81	79	12	17	-	-
Mean	71	70	15	8	-	-
Katsina						
Gora	81	70	11	22	49	-
Rimaye	68	72	4	14	-	-
Barhim	74	75	4	20	-	-
Mean	74	72	6	19	49	-

1. - = Data not available

about 57% of their cropped land was sole cropped, followed by Gijigami with 39%. Sole cropping was least practised in Kofa and Panda villages in Kano.

The most important two-crop enterprises observed include sorghum/millet, sorghum/groundnut, sorghum/cowpea, millet/groundnut, and millet/cowpea. Two-crop mixture patterns were most widely practised in all the villages except at Dalari, where sole cropping predominated. The three-crop mixture enterprises are sorghum/millet/cowpea, and sorghum/groundnut/cowpea. Three-crop mixtures and other patterns were most common in the villages in the southern subzone with higher rainfall and more fertile loamy soils. Other important enterprises specific to some locations include sorghum/cotton, found in Gora and Rimaye villages in Katsina State.

Labor requirements by farm operations

Labor is an important input in the crop poduction systems (Table 6.6). Land clearing and ridging were aggregated under land preparation, while remoulding of ridges is counted along with weeding. Although the main purpose of remoulding was to prevent lodging of plants, it also served as a means of weed control.

Land preparation and weeding operations which involve tilling the soils consumed the largest proportion of the total labor required. The respondents may have

underestimated the labor record for harvesting, because the harvesting exercise was not concluded before the end of data collection. Labor requirements per hectare decreased as one moved from south to north, either among villages within the states, or locations along the zones.

Total labor requirements differed among the villages, and was highest in Kano State (Table 6.6). The differences in labor inputs in the sites were related to the variations in the physical properties of the soils, and determined by the level of the use of animal traction. The use of animal traction was most widely practised by the respondents in three villages—Dalari, Gijigami, and Barhim—in the north, followed by Badume and Rimaye in the central belt, and least practised in Kofa and Kantoga in the south. The major problem of animal traction was that there are no suitable implements for postplanting operations.

Table 6.6. Labor requirements (man-hours ha^{-1}) for various farm operations in selected villages of Kano, Jigawa, and Katsina States of Nigeria.

State	Land preparation	Planting application	Manuring	Fertilizer	Weeding	Moulding	Harvesting	Total
Kano								
Kofa	62	21	6	11	46	19	23	188
Panda	59	21	11	5	48	24	23	191
Badume	52	20	5	5	48	21	21	172
Mean	58	21	8	7	47	21	22	184
Jigawa								
Kantoga	35	12	4	5	33	11	17	117
Dalari	25	19	10	4	34	16	12	104
Gijigami	45	17	6	4	37	16	16	141
Mean	35	16	7	4	35	14	15	121
Katsina								
Gora	52	18	9	5	56	26	24	190
Rimaye	38	16	12	3	34	17	16	136
Barhim	35	10	7	3	26	14	17	112
Mean	42	15	9	4	40	19	19	146
Southern zone	52	18	8	7	46	20	22	173
Central zone	39	20	8	5	41	19	24	156
Northern zone	39	15	8	4	32	15	15	119

In Kano State, about 31% (in Kofa), 16% (in Panda) and 18% (in Badume) of household's total family labor was contributed by nonfamily hired labor. About 28%, 41%, and 19% of the total labor force were hired in Kantoga, Dalari, and Gijigami villages respectively in Jigawa State. The proportion of labor hired in Gora, Rimaye, and Barhim in Katsina State was 21%, 16%, and 21%, respectively.

Labor requirements vary considerably in the course of the year (Table 6.7). The agricultural calendar year starts in April with clearing, packing, burning of debris, and carrying of manure to the fields. The onset of rains, and subsequent sowing is between late May to early June in the southern part of Sudan, and between mid-June to early July in the northern parts (Owonubi and Abdulmumini 1984). During the 1996 cropping season, the rains came early in May, but had a sharp break in June. Thus, many farmers prepared their land and planted millet, sorghum, and groundnut. Normally, millet is the only crop planted in May when rainfall is uncertain, while sorghum and groundnut are delayed till June in the south and early July in the drier north. This could be the reason why May, July, and August constituted the busiest months, with June not as busy as was

Table 6.7. Total labor requirements (man hours) in Kano, Jigawa, and Katsina States of Nigeria, for the different months and farm operations.

State	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Kano								
Kofa	24	62	4	35	34	16	13	188
Panda	43	37	12	55	23	14	9	193
Badume	32	42	3	51	22	11	9	171
Mean	33	47	6	47	26	14	10	184
Jigawa								
Kantoga	5	19	30	27	19	9	8	117
Dalari	3	21	27	36	4	5	8	104
Gijigami	30	30	19	22	16	7	9	133
Mean	13	23	25	28	13	7	9	118
Katsina								
Gora	34	33	12	42	43	12	13	189
Rimaye	31	36	3	32	18	8	8	136
Barhim	23	14	15	29	14	8	9	112
Mean	29	28	10	35	25	9	10	146
Southern zone	27	38	24	40	30	13	11	173
Central zone	32	39	3	43	20	10	9	156
Northern zone	19	22	20	29	11	10	8	119
Mean	26	33	16	37	20	11	9	149

expected. There was a lot of time spent on planting and replanting cereal crops when the rains resumed in July after a drought spell.

Crop yields

Crop yields of sole crops were higher than those grown in mixtures (Table 6.8). The possible reasons for lower yields of individual crop components in mixtures include the lower proportion of individual crops in the mixture compared with those in sole crops, and competition with the other crops for water, light, and nutrients.The mean grain yield of about 1.5 t ha^{-1} for sole crop sorghum obtained from Kofa and Badume villages in the southern zone was higher than the average mean yield of 1.1 t ha^{-1} recorded in Dalari and Gijigami villages of Jigawa and the villages in Katsina State. Comparing the yields of sole crop sorghum, among states, the highest yield of 1.5 t ha^{-1} was obtained at Kano, followed by Jigawa and Katsina (Table 6.8). It should be noted that large proportion of land was committed to sole crop sorghum cultivation in Jigawa and Katsina States, spreading across all the subzones of the Sudan Savanna. A mean yield of 1.4 t ha^{-1}, was recorded in Badume, compared with 1.2 and 1.1 t ha^{-1} in the drier areas of Jigawa and Katsina States respectively. The difference per zone is very small (Table 6.9). These yields are thus much lower than those obtained onstation (1.8–3.6 t ha^{-1}), depending on the landrace (Flower 1996), or most probably owing to lack of inputs (fertilizer, labor, etc.).

With regard to crop mixtures, the yield of the component crops depended on the proportion of land allocated to the crops and the spacing arrangements. Comparing the states, crop yields were higher in Kano than either in Jigawa or Katsina, regardless of whether the crops were grown sole or in mixture. The reasons could be attributed to the fact that the whole of Kano State falls perfectly within areas that can be considered as wet Sudan, while both Jigawa and Katsina States belong to the drier parts in the northern boundaries, with Sudano-Sahelian characteristics. It was also observed that yields of component crops per hectare were lower in the northern zone than in the southern zone (Table 6.9). The reasons could be lower rainfall, poor soil fertility, and low plant population. The distance between plants was observed to be wider in the northern than in the southern parts, in order to minimize the effect of moisture stress.

Production cost and returns

Production cost

For the calculation of production costs, land was not valued as a fixed cost. Since the use of animal traction is widespread, a depreciation cost of 1200 Naira ha^{-1} was included for villages where the intensity of use of animal traction was high, and 1000 Naira ha^{-1} for villages in the southern subzone.

Table 6.8. Mean yield (t ha^{-1}) of sorghum and millet combined with other crops in Kano, Jigawa, and Katsina States of Nigeria.

	Kano			Jigawa						Katsina			
Crop[1]	S	Ml	G	C	S	Ml	G	C	SS	S	Ml	G	C
S	1.5	-	-	-	1.2	-	-	-	-	1.1	-	-	-
Ml	-	1.4	-	-	-	1.2	-	-	-	-	1.1	-	-
SMl	1.0	0.9	-	-	0.7	0.6	-	-	-	0.6	0.7	-	-
SG	0.9	-	0.5	-	0.5	-	0.5	-	-	0.7	-	0.4	-
SC	0.9	-	-	0.5	0.9	-	-	0.5	-	0.9	-	-	0.5
SSS	-	-	-	-	0.7	-	-	-	0.4	-	-	-	-
MlG	-	1.0	0.5	-	-	0.6	0.4	-	-	-	0.7	0.4	-
MlC	-	1.0	-	0.5	-	0.7	-	0.5	-	-	0.9	-	0.4
MlSC	-	-	-	-	-	0.7	-	-	0.4	-	-	-	-
SMlG	0.6	0.6	0.4	-	-	-	-	-	-	0.5	0.5	0.3	-
SMlC	0.7	0.5	-	0.4	0.4	0.4	-	0.2	-	0.3	0.5	-	0.2
SGC	0.8	-	0.4	0.5	0.5	-	0.3	0.2	-	0.7	-	0.6	0.5
MlGC	-	0.9	0.4	0.4	-	0.5	0.4	0.3	-	-	0.6	0.4	0.2

1. S = sorghum, Ml = millet, G = groundnut, C = cowpea, SS = sesame.

2. - = Data not available

Table 6.9. Mean yield (t ha^{-1}) of sorghum and millet combined with other crops, in the southern, central, and northern zones of Nigeria.

	Southern				Central				Northern			
Crop[1]	S	MI	G	C	S	MI	G	C	S	MI	G	C
S	1.3	-[2]	-	-	1.3	-	-	-	1.2	-	-	-
MI	-	1.4	-	-	-	1.2	-	-	-	-	-	-
SMI	0.9	0.8	-	-	0.9	0.9	-	-	0.6	-	-	-
SG	0.8	-	0.5	-	0.9	-	0.4	-	0.6	0.4	-	-
SC	0.8	-	-	0.5	1.0	-	-	0.5	0.9	-	0.5	-
SSS	-	-	-	-	-	-	-	-	0.7	-	-	0.4
MIG	-	1.9	0.4	-	-	0.9	0.5	-	-	0.4	-	-
MIC	-	0.9	-	0.5	-	1.0	-	0.4	-	-	0.5	-
MISS	-	-	-	-	-	-	-	-	-	-	-	0.4
SMIG	0.6	0.6	0.4	-	-	-	-	-	0.5	0.3	-	-
SMIC	0.6	0.5	-	03	-	-	-	-	0.3	-	0.2	-
SGC	0.7	-	0.4	0.4	0.7	-	0.6	0.5	-	-	-	-
MIGC	-	0.7	0.4	0.4	-	-	-	-	-	0.5	-	-

1. S = sorghum, MI = millet, G = groundnut, C = cowpea, SS = sesame.
2. - = Data not available.

Labor is a major factor for production, and hired labor costs constituted between 20 and 30% of total production costs, while total labor cost was over 70% of the production cost. The cost of family labor was included, since family labor had opportunity cost in nonfarm activities in the area.

Inorganic fertilizers became expensive in the last 3 years. Other inputs costs are, however, low. Seed costs were estimated as they did not involve direct cash, as most of the farmers used seeds saved from the previous years' harvest. Seed costs constituted between 11 and 20% of the total costs. Groundnut and cowpea seeds were more expensive than seeds of cereal crops. Villages such as Panda and Dalari, which had more groundnut combinations in the enterprise, spent more money on seed input.

Net farm income

Financial returns per hectare from crop mixtures were higher than those from sole crops. This partially explains why farmers grow crops in mixtures. While returns from 2-crop systems were more than those from sole crop enterprises, the advantage of a 3-crop system over the 2-crop system was not very obvious. Cereal-legume crop mixtures were usually more profitable than cereal-cereal mixtures (Tables 6.10, 6.11, and 6.12).

Net farm income by production system in the states

In Kano State, the higher gross margins were recorded for 3-crop systems in both Kofa and Panda (Table 6.10). Typical examples for 1996 were sorghum/groundnut/cowpea and millet/ groundnut/cowpea . There were no 3-crop systems in Bichi. Among the 2-crop systems, the highest gross margins were recorded for millet/cowpea mixture in Bebeji (16 858) and Albasu (18 771) while millet/groundnut mixture had the highest gross margin in Bichi (21 678). About the same gross margins were obtained for sole sorghum in two villages in Kano State (12 376) and (12 807). Millet/legume mixtures were more profitable in Albasu and Bichi, while in Bebeji, sorghum mixtures were more profitable.

In Jigawa State, the only 3-crop system in Birnin Kudu, which had a higher gross margin was millet/groundnut/cowpea (13 674), while in Kaugama and Gumel, there were no 3-crop systems. In all the three villages, the 2-crop systems were more profitable than the sole crop systems, except in Kaugama where sole millet (9707) was more profitable than sorghum/millet (9664). Millet/legume mixtures were more profitable in Birnin Kudu and Kaugama, while sorghum/legume mixtures were more profitable in Gumel, especially the sorghum/cowpea mixture (16 624).

In Katsina State, the millet/cowpea mixture was more profitable than other cropping systems in both Malumfashi and Batagarawa (20 110 and 14 525, respectively), while

Table 6.10. Gross margins for the different crop production systems in nine selected villages per hectare by village (Naira ha^{-1}), in Kano, Jigawa, and Katsina States of Nigeria.

	Kano			Jigawa			Katsina		
Crop[1]	Kofa	Panda	Badume	Kantoga	Dalari	Gijigami	Gora	Rimaye	Barhim
S	12 370	-	12 809	-	9 293	11 817	7 859	7 902	9 080
Ml	-	12 328	12 736	-	9 707	10 687	-	7 929	10 352
S/Ml	12 242	9 069	19 576	-	9 664	11 003	11 804	12 118	9 081
S/G	13 844	13 002	13 560	-	10 097	-	10 652	10 747	8 401
S/C	13 909	15 207	14 573	13 964	-	16 624	15 314	17 445	13 049
Ml/G	9 790	17 663	21 678	-	10 789	-	14 705	10 381	9 065
S/Ml/C	15 478	18 575	-	9 173	-	-	-	-	10 426
S/G/C	21 616	22 062	-	9 857	-	-	-	25 230	-
Ml/G/C	-	22 573	-	13 674	-	-	-	-	-

1. S = sorghum, Ml = millet, G = groundnut, C = cowpea.

2. - = Data not available.

Table 6.11. Farm enterprises, revenue, costs, and gross margins ('000 Naira ha^{-1})[1] in Kano, Jigawa, and Katsina States of Nigeria.

	Kano			Jigawa			Katsina		
Crop[2]	Total revenue	Total variable cost	Gross margin	Total revenue	Total variable cost	Gross margin	Total revenue	Total variable cost	Gross margin
S	18.0	5.4	12.6	14.4	3.8	10.5	13.2	4.9	8.3
Ml	18.2	5.0	13.2	15.6	4.7	10.8	14.3	4.7	9.6
G	-[3]	-	-	12.0	4.3	7.7	-	-	-
SMl	23.7	6.7	16.9	16.8	5.7	11.1	16.3	5.3	11.0
SG	20.8	7.0	13.7	16.0	5.1	10.9	16.4	6.9	9.5
SC	21.8	6.1	15.7	21.8	5.9	15.9	21.8	5.4	16.4
MlG	23.0	5.5	17.5	15.8	5.0	10.8	17.1	5.0	12.0
MlC	24.0	5.4	18.6	20.1	4.8	15.3	20.5	4.7	15.8
GC	23.0	6.9	16.1	16.7	5.5	11.2	-	-	-
SMlC	23.7	5.6	18.1	14.4	5.2	9.2	18.5	4.0	14.5
SGC	28.6	6.8	21.8	16.4	6.3	10.1	27.2	6.2	21.0
MlGC	28.5	5.9	22.6	21.1	5.5	15.6	16.4	5.2	11.2

1. 1 US $ = 80 Naira.
2. S = sorghum, Ml = millet, G = groundnut, C = cowpea.
3. - = Data not available.

Table 6.12. Farm enterprises, revenues, costs, and gross margins ('000 Naira ha^{-1})[1] in the southern, central, and northern zones of Nigeria.

	Southern zone			Central zone			Northern zone		
Crop[2]	Total revenue	Total variable cost	Gross margin	Total revenue	Total variable cost	Gross margin	Total revenue	Total variable cost	Gross margin
S[1]	15.6	5.5	10.1	15.6	5.2	10.3	14.4	3.9	10.5
MI	18.2	5.9	12.3	15.6	4.8	10.8	14.3	4.5	9.8
G	-	-	-	-	-	-	12.0	4.3	7.7
SMI	21.2	6.4	14.8	22.5	6.0	16.4	15.0	5.4	9.6
SG	19.6	7.5	12.1	18.8	6.7	12.1	15.2	5.6	9.6
SC	20.6	6.3	14.3	23.0	5.3	17.7	21.8	5.3	16.5
MIG	19.7	5.9	13.8	21.7	4.7	17.0	15.8	4.9	10.9
MIC	22.7	5.3	17.4	21.8	5.0	16.8	21.4	4.4	17.0
GC	21.0	5.8	15.2	19.8	8.9	11.0	-	-	-
SMIC	20.3	5.5	14.8	-	-	-	18.5	4.1	14.4
SGC	20.3	6.7	18.5	31.4	6.2	25.2	-	-	-
MIGC	25.9	5.7	20.2	-	-	-	20.9	5.2	15.7

1. 1 US $ = 80 Naira
2. S = sorghum, MI = millet, G = groundnut, C = cowpea.
3. - = Data not available

sorghum/groundnut/cowpea was more profitable in Kankia (25 230). Sole millet was more profitable than sole sorghum in both Kankia (7929 millet against 7902 sorghum) and Batagarawa (10 352 millet against 9080 sorghum), but sole millet did not occur in Malumfashi. The 2-crop systems were more common in all the villages. Three 3-crop systems existed only in Kankia (sorghum/groundnut/cowpea) and Batagarawa (sorghum/millet/cowpea).

If the nine villages are taken together as the average, the 2-crop systems were more profitable in most of the villages except in Bebeji and Albasu in Kano State. Millet/legume mixtures were more profitable in almost all the villages. A typical example of this was millet/cowpea mixture grown in all the villages.

Net farm income by state

In Kano State, 3-crop systems were more profitable than 2-crop systems and sole crops, except in the case of sorghum/millet/cowpea, which had a net farm income of 17 130, that is, lower than that recorded for millet/cowpea (17 600). Sole millet was more profitable than sole sorghum. Millet/legume mixtures were more profitable than sorghum/legume mixtures (Table 6.11).

In Jigawa State, 2-crop systems were more profitable than 3-crop systems and sole crops, except in the case of millet/groundnut/cowpea, which had the second highest net farm income (14 381). Also, millet/legume mixtures were more profitable than sorghum/legume mixtures. The lowest net farm income was recorded for sole groundnut.

In Katsina State, the highest net farm income was recorded for sorghum/groundnut/cowpea mixture, followed by sorghum/cowpea mixture, while the least was obtained from sorghum/groundnut mixture. Among the 3-crop systems, the lowest net farm income was recorded for millet/groundnut/cowpea mixture.

Across the three states, the highest average net farm income for 3-crop systems was recorded in Kano State. The highest average net farm income for the 2-crop systems was also recorded in Kano State, followed by Katsina.

Net farm income by zone

Gross margins. Sole millet was more profitable than sole sorghum in both southern and central zones, but less profitable in the northern zone. Three-crop systems were more profitable in the southern zone where a low gross margin was recorded. Among 2-crop systems in the southern zone, the millet/cowpea mixture had the highest gross margin (Table 6.12).

The only 3-crop system in the central zone (sorghum/groundnut/cowpea) had the highest gross margin compared with other cropping systems. In the northern zone, cereal/cowpea mixtures were more profitable than other cropping systems.

Characterization of Major Cropping Systems

Introduction and definitions

The prevailing cropping systems in the Sudan Savanna Zone are commodity based, and reflect the resource management systems related to the environmental conditions and the culture of the people. The major crops in the villages included:

- Cereals: sorghum, millet (early- and late-maturing millet), maize, and rice.
- Grain legumes and oil seeds: groundnut, cowpea, sesame, and Bambara groundnut.
- Fibres: cotton and roselle.
- Other crops: tomato, pepper, onion, and garlic (Table 5.3).

Various practices are used in the production of these crops. Cropping systems in the Sudan Savanna Zone include sole- and mixed-cropping, with most farmers growing their crops in mixture. Over 80% of the total land cultivated in the selected LGAs (Kano and Jigawa) was devoted to crop mixtures. The most important crop mixtures included sorghum/millet, sorghum/cowpea, and millet/cowpea. The cropping systems could therefore be broadly classified as sorghum-based and millet-based cropping systems. Others include cropping systems based on groundnut, rice, maize, and other crops (Table 7.1).

The following definitions are given for a better understanding of the cropping systems.

Sole cropping: Growing one type of crop species alone in pure stands. The crops usually grown singly are sorghum, maize, rice, and vegetables.

Double Cropping: Growing two crops in sequence in such a way that the second crop is sown or transplanted after the harvest of the first. This is practised in the wetter areas of the zone such as Kofa, Gora, and Birnin Kudu. It is common to plant cowpea or transplant vegetables and pepper after millet has been harvested. Early-maturing Gero 1, and improved groundnut varieties are suitable for double cropping.

Gicci: This is a system where a crop is sown almost as sole crop very early after substantial rains. A second crop, usually a cereal, is brought in later, planted at a right angle across the ridges of the former, usually with a very wide spacing of 2–3 m. This practice is widespread in villages in the wetter southern and central belt savanna zones. It is not popular in the drier northern parts that have sandy soils because of the risk of drought stress. The cereals in a gicci system, usually produce good grain yields.

Gididaye: This is the same as strip cropping. Two or more crops are grown in distinct strips of several rows. This is a very popular pattern of cropping throughout the zone, but is more prevalent in the northern parts. Groundnut/cereal and sorghum/millet mixtures are usually planted this way.

Table 7.1. Cropping systems with arable crops in the Sudan Savanna Zone of Nigeria, 1996.

Cropping systems	Base crop	Secondary crop	Tertiary crop	Special features	Area of cultivation
Sole crop	Sorghum, groundnut, maiwa millet, gero millet (rare)	-	-	-	Southern subzone — Kofa, Gora, Kantoga.
Sorghum/millet	Sorghum	Millet	-	Gicci, 3:1 Alternate1:1 alternate stands millet sown first.	Panda, Badume Gijigami, Kofa.
Sorghum/cowpea	Sorghum	Cowpea	-	Gicci, 3–5:1 alternate rows; 1–2:1 alternate stands, cowpea sown last	Albasu, Birnin Kudu, Bichi, Kankia Bebeji
Sorghum/groundnut	Groundnut	Sorghum	-	Gicci, 3–5:1 Alternate rows	Kangama, Bebeji, Albasu, Malumfashi
Sorghum/millet/ cowpea	Millet	Sorghum	Cowpea	2–3:1:1 Ml/S/C/ alternate rows 3:1 ml/S and cowpea in gicci	Prevalent in Central and northern subzones

Continued

Table 7.1. *Continued.*

Cropping systems	Base crop	Secondary crop	Tertiary crop	Special features	Area of cultivation
Sorghum/groundnut/ cowpea	Groundnut	Sorghum	Cowpea	3:1:1 alternate row: sorghum and cowpea as gicci crop	Popular in the southern subzones, Kano, and in the northern parts of Jigawa.
Millet /cowpea	Millet	Cowpea	-	Relay cropping in the southern zones 4:1 alternate rows 1:1 alternate stands. Gicci cowpea planted last	Practised as relay in the southern and most popular mixtures in the northern subzone
Millet/groundnut	Groundnut	Millet	-	3–4:1 ratio groundnut/millet	Predominant in northern Local Government Areas.

1. - = Data not available

Relay cropping: Growing two or more crops in sequence in such a way that the succeeding one is sown or transplanted before the harvest of the former. Usually cowpea is grown with millet in May, and is harvested in August.

Dry planting or *Sinne:* This is a system where a crop, especially millet, is grown, in anticipation of the onset of rains. This is practised in the drier parts of the zone, particularly in Gijigami village of Jigawa State.

Sorghum-based cropping systems

Sorghum is the most widely grown cereal crop in the Sudan Savanna Zone, and is a major staple of the people of the area. Sorghum-based cropping systems are especially prevalent in the wet southern parts of Sudan Savanna Zone (11° 30'–11° 55'N). Sorghum ranks first as the major cereal crop in terms of hectarage and tonnage (NARP 1995). It occupies about 35%, 34%, and 30% of the total land area where major upland crops are cultivated in Kano, Katsina, and Jigawa States respectively (ADP 1990–95). Sorghum is found in various crop combinations with other crops in over 70% of farmers' fields. Besides, every household (100%) annually grows sorghum in one combination or the other. Although sorghum is usually grown in mixture, some farmers grow it as a sole crop.

Sole sorghum

Sorghum was found as a sole crop in about 13% of the total cultivated area in Bichi, 8% of the land in Bebeji, and 9% in Albasu in 1995 (KNARDA 1995), whereas 24% of the land was devoted to sole sorghum in Bebeji, and 15% in Bichi in 1994 (KNARDA 1994). In Jigawa State, 28% of the land in Birnin Kudu, 13% in Kaugama, and 12% in Gumel had sole sorghum in 1994. In Katsina State, 25% of the land in Malumfashi, 13% in Kankia, and 7% in Batagarawa LGA was cultivated to the sole crop (KTARDA 1995). In the household survey, 20% of the households in Bebeji grew sole sorghum, 10% in Albasu, 45% in Birnin Kudu, 45% in Kangama, and 40% in Gumel. These results suggest that more people in the northern part of the Sudan Savanna Zone grow sorghum as a sole crop.

The time of the year in which the survey was conducted might have determined the farmers' responses, as most farmers have a tendency to include cowpea in virtually any field, towards the tail end of the growing season in September. It is therefore quite likely to find cowpea in a plot that is regarded as sole-crop sorghum for most part of the growing season. Sole-crop sorghum in one year can be followed by millet, as millet is considered by farmers to be less demanding with respect to nutrient requirements. Farmers rarely grow sole sorghum on a piece of land for two consecutive years. When

they do so, it is because the soil is be relatively fertile clayey, wet (*Dabaro*), and unsuitable for any low-growing or spreading crops such as groundnut and cowpea. Even under such conditions the variety of sorghum planted each year is different.

Sole-crop sorghum is usually the first crop after a fallow period or in the year when manure is applied into the field for the first time. Sorghum ranks next after maize in terms of its demand for nutrients. Faced with limited supply of inorganic nitrogen fertilizers, sorghum as a sole crop is given priority by farmers. Improved varieties are usually planted as sole crops, either because farmers think that they cannot adapt to intercropping, or because they are highly valued as commercial or industrial crops. One major characteristic of improved varieties found on the fields is early maturity. When early-maturing varieties are planted early in the rainy season in the south, the intention is to harvest early for food in August or September, the 'hunger period'. Most farmers who produce grains for sale in the market, plant late in order to avoid fungal attack and damage by birds. The growing period of improved varieties fits into the growing calendar of the farmers in the northern part of the zone because of the late onset of rains.

Farmers who plant sole crops are usually relatively wealthier than the others, and have access to more land and other inputs . No farmer grows only pure crops, and those who do so tend to be innovators, and are more likely to adopt or evaluate some of the improved agronomic packages for optimum output. Absentee farmers and contract growers are also likely to practise sole cropping. They tend to be commercially oriented and therefore more of the output is likely to be sold.

The key constraints to sole sorghum are *Striga* infestation and damage by birds. Farmers practising sole cropping run the risk of severe losses in case of crop failure.

Sorghum-millet intercrop

In 1994, about 6% of the land was devoted to sorghum/millet intercrop in Bebeji, 6% in Bichi and none in Albasu in Kano State while in Jigawa, 28% of land in Birnin Kudu, 32% in Kaugama, and 30% in Gumel was devoted to sorghum/millet intercrop (KNARDA 1995, JARDA 1995).

The pattern of arrangement and time of planting vary from place to place. In Albasu, sorghum with maiwa or late millet is the first enterprise in a 3–5 year rotation system. Sorghum is the dominant crop planted virtually as a sole crop on ridges or in rows. Maiwa millet is sown across the sorghum ridges about 3–4 m apart. The population of maiwa is kept low.

In Bichi, both crops are planted in rows with three rows of sorghum alternated with one row of millet (Figure 7.1). In Gijigami, the common pattern is one row of sorghum and one row of millet, while in Barhim, it is two rows of maiwa millet and two rows of sorghum. A relatively more fertile land will carry a high proportion of sorghum and a

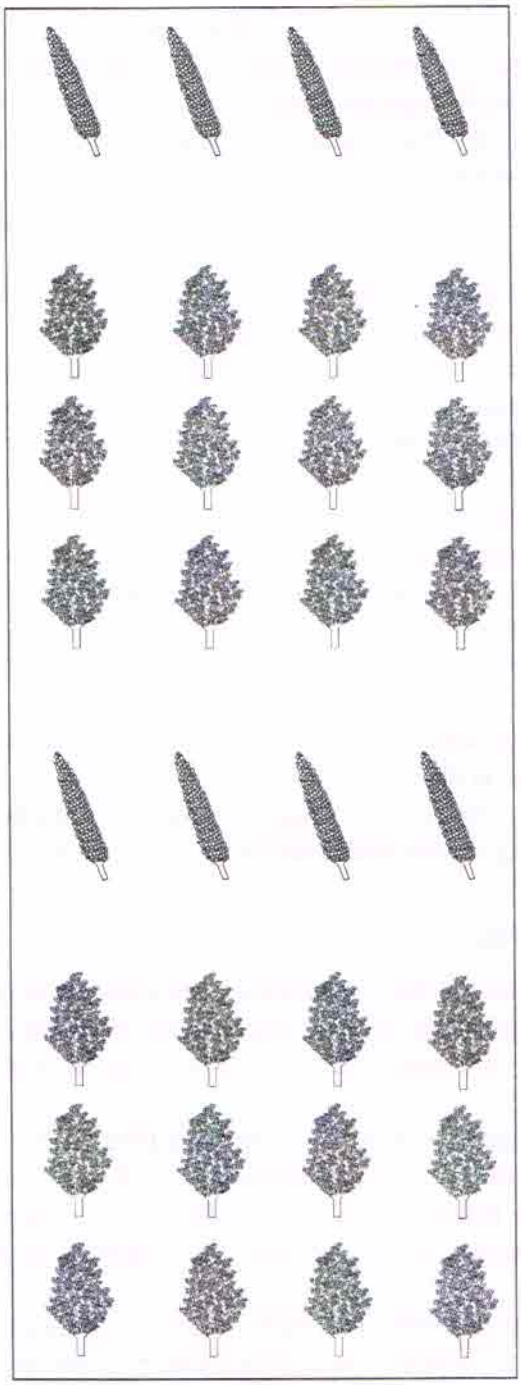
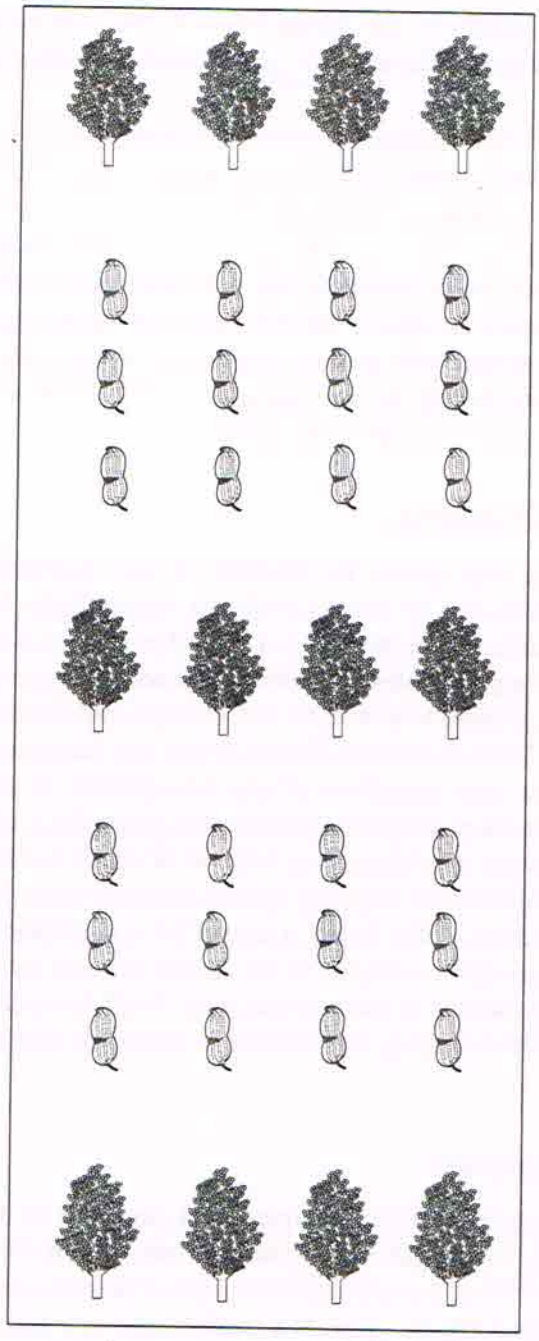


Figure 7.1. Planting pattern of sorghum-pearl millet intercrop.



Gicci system : strip cropping

Figure 7.2. Planting pattern of sorghum-groundnut intercrop.

less fertile land carries more millet. In the wetter parts, millet is planted first and sorghum a few days later, while in the drier areas, both millet and sorghum are planted at the same time.

At a first glance, this cereal/cereal intercrop might seem unsustainable in terms of soil fertility maintenance. The system is usually practised as the first crop in the first year of rotation or the year in which manure or inorganic fertilizer is generously applied, especially when sorghum is the dominant crop. The same system can be repeated on the same plot the second year, but millet would be the dominant crop, while sorghum occupies the minor component as in the drier north of Kaugama in Jigawa State. Farmers in Barhim do not practise this system with gero or early millet, as they believe that the growth of sorghum is disturbed during the harvesting of millet, which occurs much earlier. Instead, they combine sorghum with maiwa millet.

Sorghum-groundnut intercrop

Sorghum-groundnut intercrop was grown by 45–50% of the respondents in the household survey in Kano State, and by about 15–40% in Jigawa State. In 1994 and 1995, of the total land devoted to major crops in 6–11% in Kano State, and 7–12% in Jigawa was devoted to this cropping system. The most common arrangements are the gicci system found in Bebeji, Albasu, Malumfashi, and Rimaye, and the strip cropping (gigdaye) prevalent in Birnin Kudu, Kaugama, Gumel, Bichi, and Batagarawa.

Groundnut is the dominant crop regardless of any arrangement in all the fields monitored in the three states. In the gicci system, groundnut is planted as a sole crop, and sorghum is simply planted across the ridges at an interval of about 2–3 m. In Birnin Kudu, Bichi, and Barhim, under the strip cropping system, there are about three rows of groundnut to every row of sorghum, and in Dalari, a ratio of 5:1 is maintained in favor of groundnut (Figure 7.2). This system is adopted in the second or third year of rotation after a cereal-dominated crop mixture in the previous year. Fresh farmyard manure is generally not applied to the field carrying this mixture to minimize termite attack on groundnut.

Sorghum-cowpea intercrop

The sorghum-cowpea intercrop (Figure 7.3) occupies 4, 14, and 12% of the total land put to major crops in Bebeji, Bichi, and Albasu, respectively. About 40–50% of the respondents in Kano, and 25-45% of the respondents in Jigawa had this system in 1996. Cowpea is the most intercropped legume grain. It is hardly found as a sole crop mainly because of pests and diseases, which farmers believe, are more serious than when it is intercropped. The gicci system is practised in Bichi, Rimaye, and Bebeji, while the strip

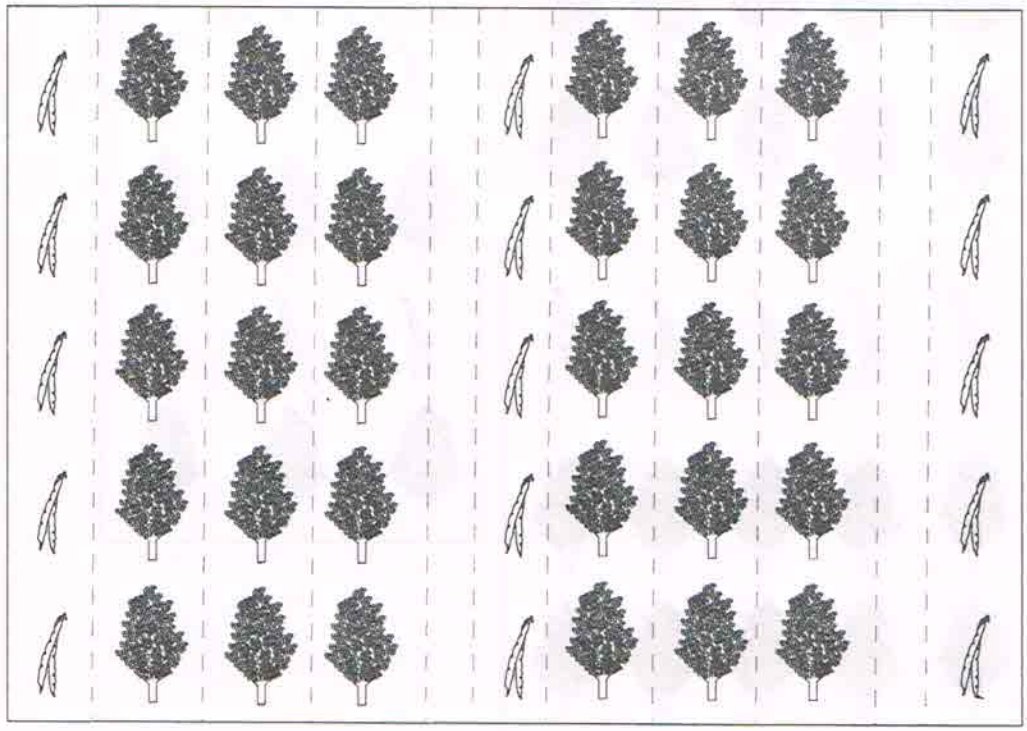


Figure 7.3. A sorghum-cowpea planting pattern.

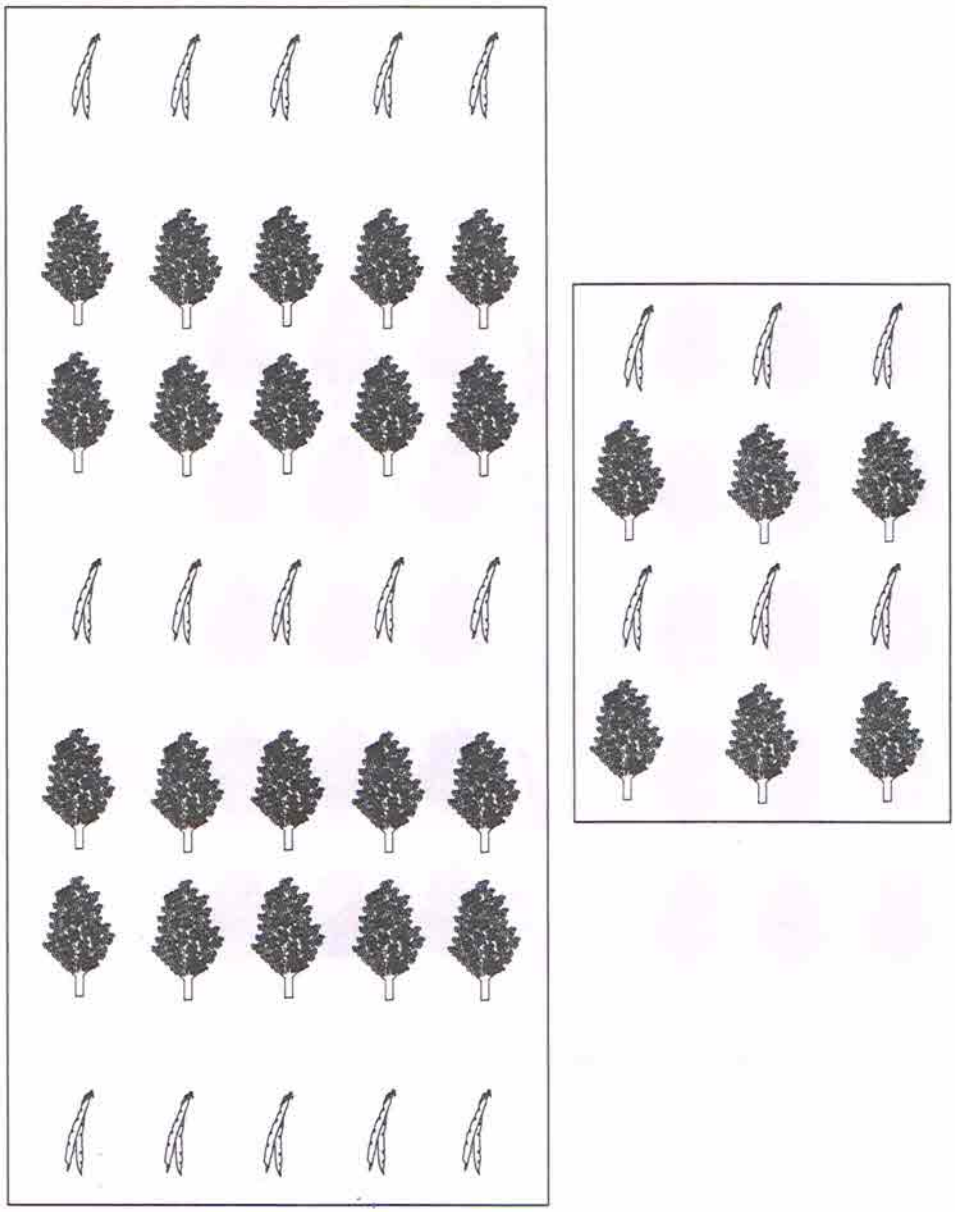


Figure 7.3 (contd.). Sorghum-cowpea planting patterns.

row cropping is found in Albasu, Birnin Kudu, and Kaugama. Sorghum and cowpea are intercropped in alternate stands within the same ridge or row. Whatever the arrangement, cowpea, unlike groundnut, is always the minor crop; cowpea is usually planted about 3 weeks after the planting of sorghum. The early-maturing cowpea varieties are planted between August and September. The cropping system is practised as a first year enterprise in the rotation where sorghum is the dominant crop, or during the third year of a rotation immediately after a crop such as groundnut has been harvested. No manure is applied when it is grown as a first crop in the rotation on a relatively fertile land, but inorganic fertilizers could be applied if available. In a a third year crop, both manure and inorganic fertilizers are applied.

Sorghum-sesame intercrop

Sesame is a legume crop commonly grown in the drier areas of Jigawa State. Although it can be grown as a sole crop, it is commonly grown in mixture with sorghum and millet. Sorghum-sesame crop is usually a first year crop in the rotation, especially if the soil is loamy. Sorghum is the dominant crop, with about 5:1 ratio in favor of sorghum.

Sorghum-millet-cowpea intercrop

In this mixture, millet is usually the dominant crop on the field. Millet and sorghum can be arranged in rows in a ratio of 3:1, and cowpea planted in the same rows with millet (Figure 7.4). Cowpea is left in place of millet after millet is harvested. Photoperiodic and late-maturing cowpea varieties are planted about 2–3 weeks after millet and sorghum have been planted. In the case of early-maturing cowpea varieties, planting is delayed until millet is about to be harvested, and it serves as a relay crop. The alternative arrangement is to plant cowpea as a gicci crop across millet rows, skipping sorghum stands. It is a very popular system. In Kano, 20, 17, and 25% of total land area for major crops are occupied by this crop mixture in Bebeji, Bichi, and Albasu LGAs respectively. In Jigawa, 25, 60, and 50% of arable land in Birnin Kudu, Kaugama, and Gumel respectively, are planted to this mixture. In 1996, about 20–35% of the respondents in Kano, and about 10–30% of the respondents in Jigawa practised this system.

Sorghum-groundnut-cowpea intercrop

This system can be planted with sorghum as a gicci crop, and an intercrop of groundnut and cowpea (Figure 7.5). Groundnut is the dominant crop, followed by cowpea and sorghum. This system is popular in the southern parts of the Sudan zone. The farmers around Kaugama LGA do not interplant cowpea with groundnut for fear that cowpea

will smother groundnut, and owing to the risk of moisture stress. They prefer to grow sorghum in rows. Another pattern is to plant groundnut and sorghum in rows in a ratio of 3:1, and interplant groundnut with cowpea. In Kano, 10–13% of the arable land area was devoted to this cropping system. In 1996 this increased to about 20–25%. In Birnin Kudu and Kaugama, even higher values (35–50%) were obtained.

Sorghum-millet-groundnut intercrop

The planting pattern is either having both sorghum and millet as gicci crops, and groundnut as the main crop, or groundnut and sorghum planted in rows with only millet as the gicci crop. The mixture is not particularly a popular one (Figure 7.6). Between 10 and 20% of respondents in Kano, and less than 5% in Jigawa practised this system. A range of 1–14%, 3–25%, and 11–21% of the land is devoted to this mixture in Kano State, and between 6–8% in Jigawa.

Millet-based cropping systems

Millet is the most important cereal crop in the drier areas of sub-Sahel and northern Sudan ecological zones where maize, and probably sorghum, cannot thrive. Millet ranks next to sorghum in terms of output and area planted to major crops in the Sudan Savanna. The Sudano-Sahelian Zone is predominated by millet-based cropping systems. The common crop mixtures include millet/cowpea, millet/groundnut, and millet/sesame. Both gero (early maturing) and maiwa (late maturing) millet varieties are included in this case.

Sole millet

Sole millet is planted as the first crop in a rotation in the drier areas of Jigawa and Katsina States, or as the second-year crop in a rotation following sorghum crop. Sorghum and millet rotation is very common in Gumel and Kaugama in Jigawa State. The reason given by the farmers is that sorghum demands more nutrients than millet. Nutrients are saved in the year millet is planted, and they are depleted the year sorghum is planted. Farmers claimed that millet roots decay faster and supply nutrients for the subsequent crop compared with sorghum roots and stubbles, which require more time to decay. Millet is the first crop to be planted with the first rains, and therefore, the first to be harvested in August/September. Maiwa (late millet) is harvested later. Whenever gero (early) millet is planted singly in the southern part of the zone where moisture is adequate, cowpea is planted as a relay crop or in double cropping. In Bichi and Albasu, between 5 and 16% of the land is devoted to sole millet, and in Jigawa, between 10 and

22% of the land is devoted to sole millet (KNARDA 1995). About 10% of the respondents in Albasu, and 20% in Bichi planted sole millet, and 30 and 35% of the respondents in Kaugama and Gumel respectively, grew millet as a sole crop.

Millet-groundnut intercrop

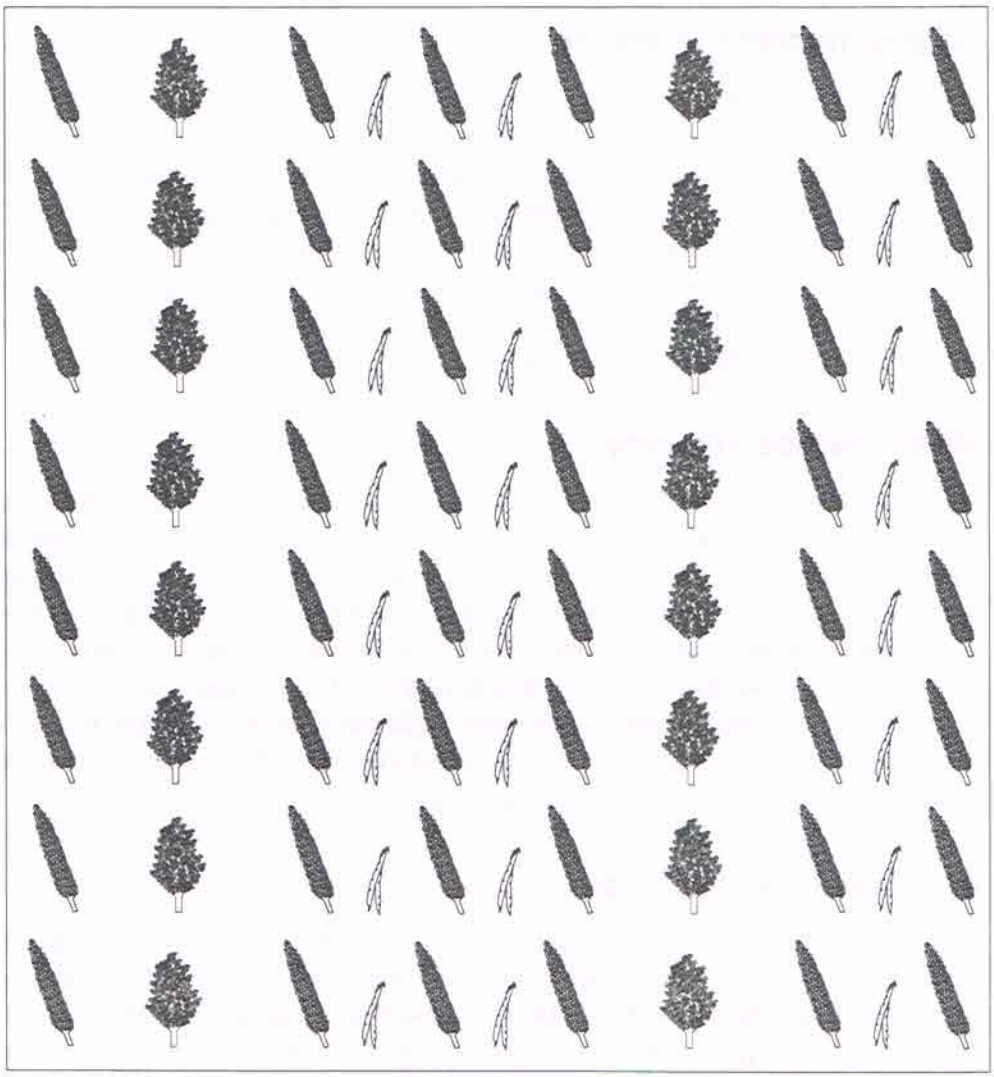
Groundnut is the dominant crop component in this mixture (Figure 7.7). Millet is planted as a gicci crop or in a 3:1 ratio in favor of groundnut. About 10% of the households in the survey in Bebeji and 10% in Albasu grew this mixture. About 30% of the households included millet-groundnut in their farming programs in Bichi. The enterprise is not popular in Kaugama and Gumel of Jigawa state because farmers in these areas believe that millet is an aggressive crop, which can overshadow and smother the groundnut crop. They preferred the sorghum-millet mixture. This intercrop is, however, popular in Barhim of Katsina State.

Millet-cowpea intercrop

This is one of the most popular crop mixtures in the Sudan Savanna Zone . Between 20 and 55% of the respondents had this mixture in their programs, and it was especially popular in the northern parts of the Sudan Savanna Zone . Cowpea is a crop that can be successfully grown in association with other crops. Millet is the first crop to be planted by the farmers at the beginning of the rainy season. Cowpea is usually interplanted with millet around July or August when millet is ready for harvest, and cowpea serves as a relay crop that occupies the whole field when millet has been removed. The mixture can be found in gicci in Bichi, or in strip rows in Dalari village of Kaugama, or in alternate stands on the same ridge in Birhim village in Katsina (Figure 7.8).

Millet-sesame intercrop

Millet-sesame is a second-year enterprise in a rotation following an enterprise involving sorghum the previous year. Millet is the dominant crop. This crop mixture is most common in Kaugama and Gumel LGAs of Jigawa State. Sesame is widely grown in the northern parts of Jigawa State, and competes with groundnut in the area. It is easier to grow and requires less attention than groundnut. Most of the sesame is sold across the border in the neighboring countries of Niger Republic. The fluctuating price of sesame from year to year makes it a risky enterprise. Between 15 and 20% of the farmers in Kaugama and Gumel LGAs included the mixture in their programs.



(i)

Figure 7.4. A sorghum-millet-cowpea intercrop planting pattern (see also next page).

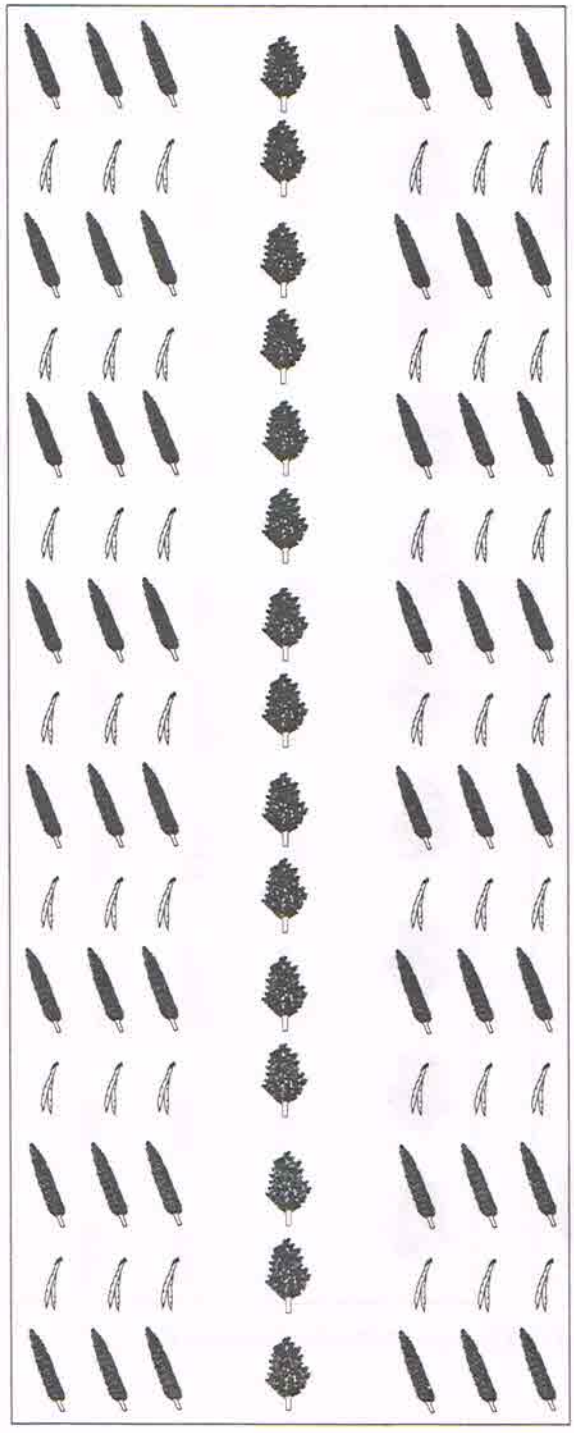


Figure 7.4 (contd.).
A sorghum-millet-cowpea intercrop planting pattern.

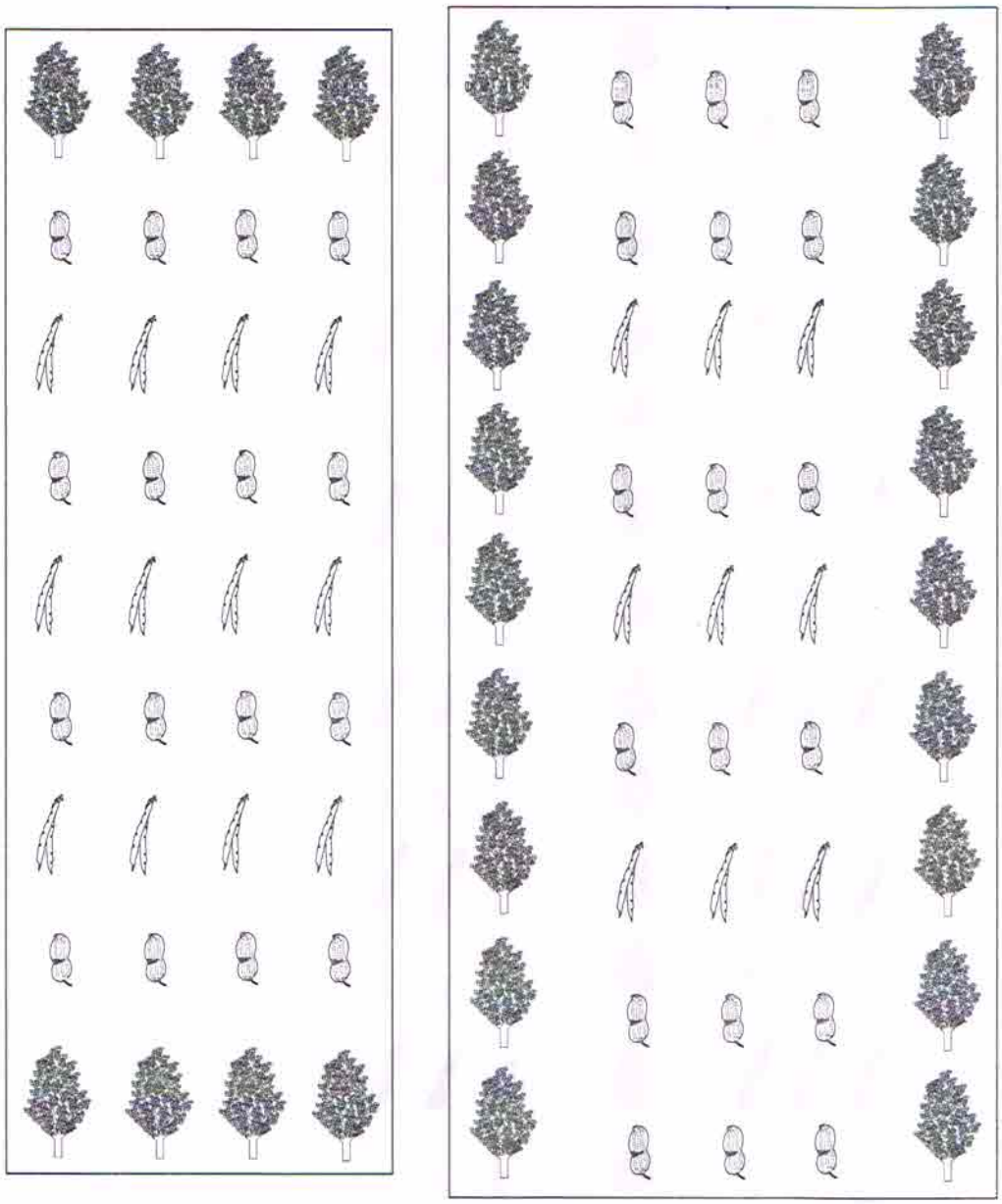


Figure 7.5 Two planting patterns of sorghum-groundnut-cowpea intercrop.

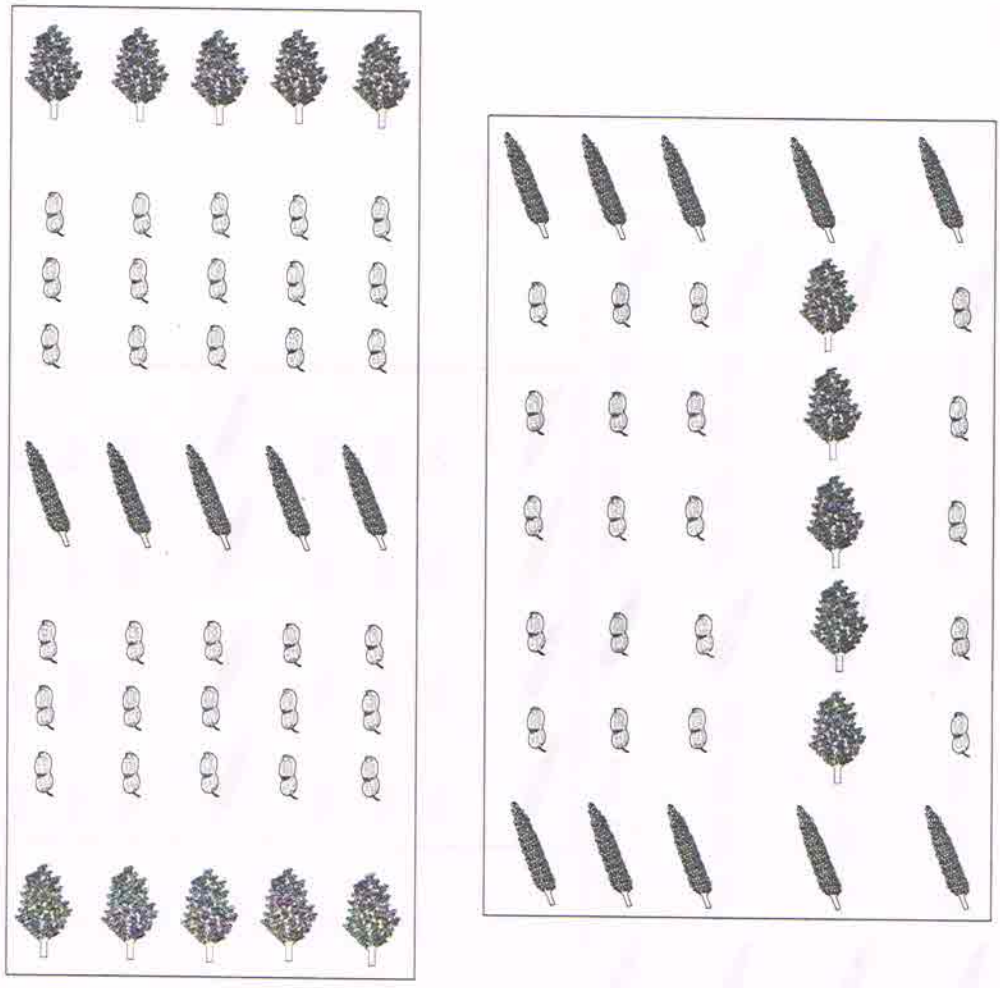


Figure 7.6. Two planting patterns of sorghum-millet-groundnut intercrop.

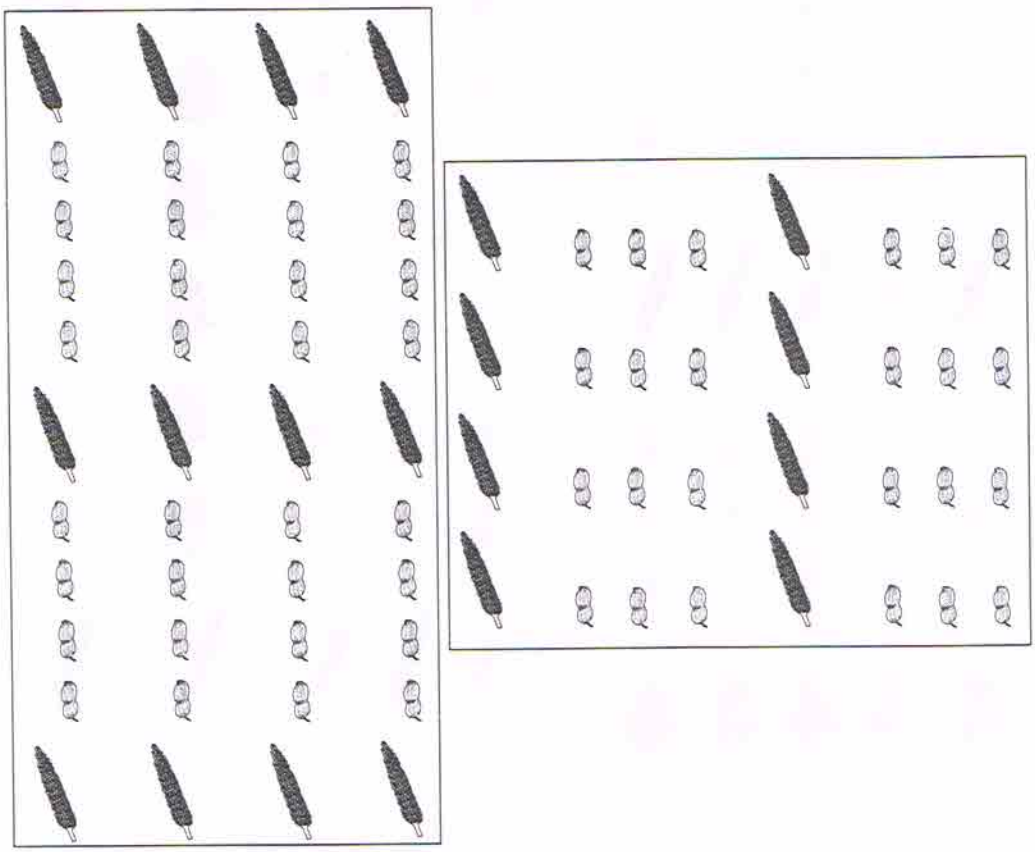
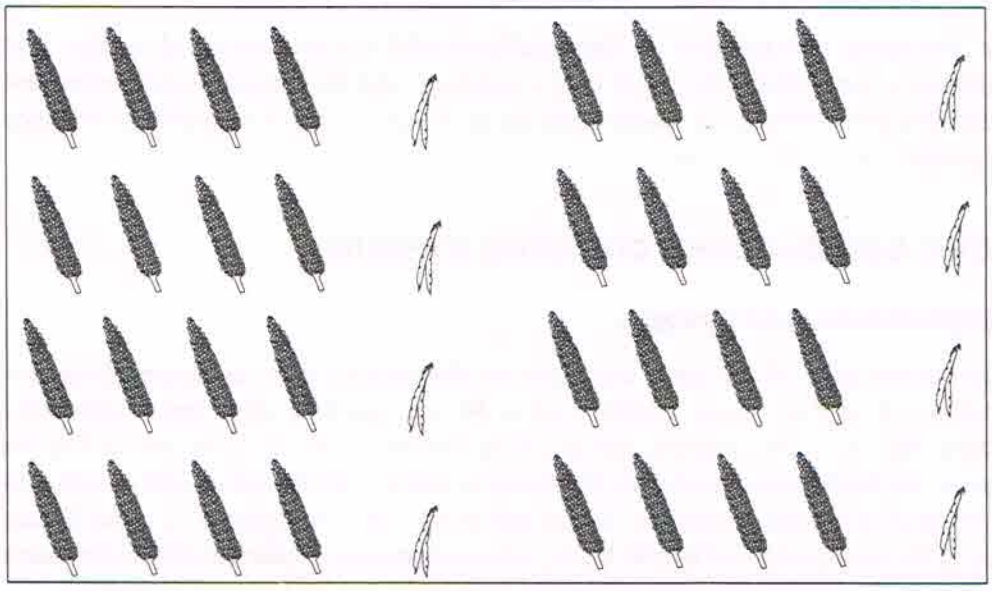
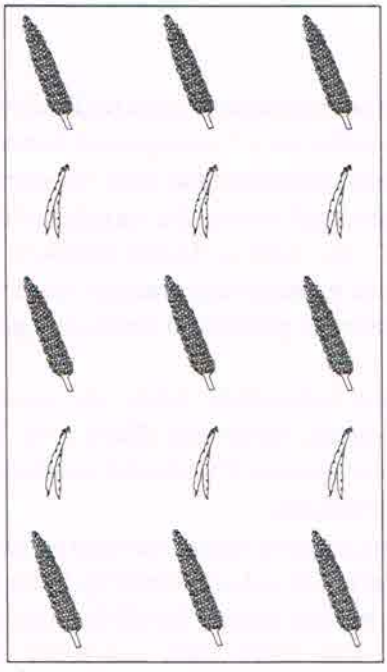


Figure 7.7. Two planting patterns of millet-groundnut intercrop.



Strip rows



Alternate stands

Figure 7.8 Two planting patterns of millet-cowpea intercrop.

Millet-sorghum-cowpea intercrop

This enterprise is equivalent to the sorghum-millet-cowpea discussed earlier. The difference is that millet is the major crop component, and the mixture is more prevalent in the drier parts of the zone. Early-maturing millet and sorghum varieties can enhance the productivity of the system.

Other cereal-based cropping systems

Maize-rice-based system

In the wetter parts of the zone, especially in Malumfashi LGA in Katsina State and Bebeji LGA in Kano State, maize used to be an important crop, and maize-based systems such as maize-sorghum, maize-cotton, and maize-rice were important. But the scarcity and high costs of inorganic fertilizers in recent years brought about a decline in the production of maize and rice. Maize had never been an important crop in Jigawa even in the wetter areas of Birnin Kudu, where conditions appear favorable for maize production. Rice is usually grown as a sole crop in the lowland areas (fadama).

Yield results of on-farm trials

Sorghum

There appeared to be no significant difference in the performance of improved cultivars across the zones. ICSV 111 appeared to be superior to the other two improved varieties across the villages (Table 7.2). All improved cultivars outyielded the local varieties at the village level. Significant differences could be observed among the varieties within and among villages. All the varieties performed very well at Dalari followed by Gijigami and Badume. These could be related to good management practices observed by the farmers. In the states, the three improved varieties performed better in Jigawa than in the other two states (Table 7.3).

On a zonal basis, yield improved as one moved northwards, where the weather appeared more favorable in terms of time of planting and harvesting (Table 7.4). The yields of farmers' varieties declined as one moved northwards. The overall yield could have been higher, but for the shortage of inorganic fertilizers.

In economic terms, over 90% of the participating farmers recovered their costs of production. Net returns per hectare were highest for ICSV 111, followed by those for ICSV 400 and ICSV 247. Jigawa State recorded the highest income for all the cultivars (net income Naira 7074, 7446, 6996 for ICSV 400, ICSV 247, and ICSV 111 respectively). The net income increased as we moved from the south to the north.

Table 7.2. Sorghum grain yield (t ha^{-1}) in nine villages in Kano, Jigawa, and Katsina States of Nigeria, 1996.

Village	ICSV 400	ICSV 747	ICSV 111	Local
Kano				
Kofa	1.08	0.88	0.92	1.04
Panda	1.07	0.83	1.13	0.57
Badume	1.34	1.37	1.61	1.01
Jigawa				
Kantoga	1.02	0.96	0.97	1.01
Dalari	1.78	1.55	1.49	0.55
Gijigami	1.40	1.81	1.77	1.03
Katsina				
Gora	1.04	0.986	1.22	1.00
Rimaye	1.07	1.39	1.41	-
Barhim	1.10	1.00	1.18	-
Mean	1.21	1.20	1.30	0.89
SE	±0.252	±0.344	±0.288	±0.224

1. - = Data not available

Table 7.3. Comparison of sorghum grain yields (t ha^{-1}) in Kano, Jigawa, and Katsina States of Nigeria, 1996.

State	ICSV 400	ICSV 747	CSV 111	Local
Kano	1.16	1.03	1.22	0.87
Jigawa	1.40	1.44	1.41	0.86
Katsina	1.07	1.13	1.27	1.00
Mean	1.21	1.20	1.30	0.91

Table 7.4. Comparison of sorghum grain yields (t ha^{-1}) in the southern, central, and northern zones of Nigeria, 1996.

Zone	ICSV 400	ICSV 247	ICSV 111	Local
South	1.05	0.91	1.06	0.91
Central	1.21	1.38	1.51	1.01
North	1.42	1.45	1.48	0.79
Mean	1.23	1.25	1.35	0.90

Millet

A mean yield of about 1.2 t ha^{-1} was recorded for GB 8735 as against 0.97 t ha^{-1} for the local varieties (Tables 7.5, 7.6, 7.7). No significant difference among the villages was observed except in Kantoga, where lower yields were recorded as a result of flood damage to plants. Yields of improved millet increased from the south to north, while no definite pattern could be observed in respect of local varieties.

In economic terms, higher net returns per ha or man hours were recorded for the improved cultivar (Naira 6274) as against Naira 2115 for the local varieties. The yield required to cover the cost was estimated at 735 kg ha^{-1} for the improved cultivars, and over 70% of the participating farmers obtained this yield. For the local variety, only 50% of the farmers obtained the required 732 kg ha^{-1}.

Groundnuts

Groundnut crop is regarded as precious, and the overall level of management of groundnut plots is very high. There was no significant difference among yields of different varieties, although differences were observed within and among villages (Table 7.8). The results should be interpreted with caution because seed supply was inadequate, and only one sample of some varieties could be grown in some villages. There was an acute shortage of UGA2 and a fairly generous supply of ICGV 86015.

From Table 7.8, the mean yields showed that ICGV 86015 performed better in all states except at Katsina, where UGA2 produced an average of 1 t ha^{-1}. All the improved varieties maintained stable yields across the states, but ICGV 86015 and UGA 2 performed better in the north (Table 7.9).

In economic terms, ICGV 86015 produced the highest net return of 13 360 per ha, followed by UGA2 with 12 160 per ha. The positive return per hour indicates that more labor could still be profitably used in groundnut production. ICGV 86015 gave the highest net return in both Kano and Jigawa states, while the highest return came fron UGA2 in Katsina. The yield required to cover costs was approximately 425 kg ha^{-1}. and all participants obtained yields above this target.

Farmers' assessment

In the case of groundnut, all the farmers were satisfied with the improved varieties, but none intended to drop the local varieties. They prefer cultivars with high pod yields, reasonable haulms yield, large seed size, early maturity, and tolerance to both drought and rosette. Farmers at Dalari, Panda, and Kantoga preferred ICGV 86015 because it was early maturing and high yielding. But for leaf spot diseases, Fleur 11 was favored by

Table 7.5. Mean grain yield (t ha^{-1}) of improved and local varieties of millet in nine villages in Kano, Jigawa, and Katsina States of Nigeria, 1996.

Village	GB 8735	Local
Kano		
Kofa	1.25	-
Panda	1.23	0.85
Badume	1.26	0.90
Jigawa		
Kantoga	0.93	0.76
Dalari	1.29	1.09
Gijigami	1.23	0.93
Katsina		
Gora	1.39	1.15
Rimaye	1.16	0.85
Barhim	-	0.65
Mean	1.22	0.89
SE	±0.145	±0.17

1. - = Not available.

Table 7.6. Comparison of yields (t ha^{-1}) of improved and local varieties of millet in Kano, Jigawa, and Katsina States of Nigeria, 1996.

State	GB 8735	Local
Kano	1.25	0.87
Jigawa	1.15	0.92
Katsina	1.27	0.88
Mean	1.22	0.89

Table 7.7. Comparison of yields (t ha^{-1}) of improved and local varieties of millet in the southern, central, and northern zones of Nigeria, 1996.

Zone	GB 8735	Local
Southern	1.20	0.92
Central	1.21	0.87
Northern	1.26	0.89
Mean	1.22	0.89

Table 7.8. Mean yields (t ha^{-1}) of different groundnut cultivars in nine villages in Kano, Jigawa, and Katsina States of Nigeria, 1996.

Village	ICGV 86015	Fleur 11	UGA 2	Local
Kano				
Kofa	1.16	0.98	0.97	1.10
Panda	1.11	0.96	0.96	0.96
Badume	1.19	0.99	1.00	1.00
Jigawa				
Kantoga	1.25	1.11	1.02	1.25
Dalari	1.13	1.05	1.11	0.92
Gijigami	1.13	0.90	1.13	1.12
Katsina				
Gora	0.99	0.93	0.93	1.91
Rimaye	0.98	0.91	1.16	1.00
Barhim	0.96	0.933	0.92	0.92
Mean	1.09	0.973	1.02	1.02
SE	±0.100	±0.069	±0.088	±0.114

Table 7.9. Comparison of different mean yields (t ha^{-1}) of different groundnut cultivars in Kano, Jigawa, and Katsina States of Nigeria, 1996.

State	ICGV 86015	Fleur 11	UGA 2	Local
Kano	1.15	0.97	0.98	1.02
Jigawa	1.14	1.02	1.09	1.09
Katsina	0.98	0.92	1.01	0.95
Mean	1.09	0.97	1.02	1.02

some farmers at Panda and Dalari, because it is likely to thrive better in the drier north. UGA2 was favored, not because of its pod yield, but because of its high haulm quality. It also better tolerated aphid infestation than did Fleur 11 or ICGV 86015.

Millet cultivar GB 8735 was popular among farmers, because of its extra earliness compared with any of the farmers' varieties without exception, therefore making double cropping feasible. Other attributes are bright color, large seeds, and uniformity at maturity. It outyielded most local varieties. Its taste, quality, and quantity were appreciated.

Constraints to Crop Production at Different Levels of Scale

Generalized constraints to agricultural production in the Sudan Savanna Zone at different levels are summarized in Table 8.1

State-level constraints

With regard to infrastructure, Nigeria has, over the past few decades, created a dense network of urban-urban road systems. With a total road network of about 2 km per 1000 persons, this is well above the sub-Saharan Africa's average of 1 km per 1000 persons. However, the rural feeder roads network of about 1 km per 1000 persons is considered very low (NARP 1995). Table 8.2 shows the recent statistics in respect of feeder roads in selected states of Nigeria. Good roads are found only between major towns. In rural areas one finds badly maintained laterite roads and footpaths. Poor road links between rural and urban markets result in high cost of transport, and poor families who cannot afford to transport their produce are forced to sell at the local or village markets at lower prices. Year-round access to four of the selected villages—Panda, Dalari, Gora, Barhim—is impossible because of bad roads.

Supply of electricity in rural areas is generally lacking, and this limits the scope of electrically powered agroprocessing. Because of the difficulty of operating modern mills, poor families tend to sell their produce unprocessed at low prices. Umura, Dalari, Gijigami, Gora, and Barhim villages have no electricity and consequently, no grain mills.

Increasing population and high rate of urbanization as a result of frequent creation of new states and local government authorities have led to land scarcity because of the rapid expansion of towns into former agricultural land. This is true in areas around urban centers such as Kano, Dutse, and Katsina town.

Rainfall pattern in the area studied is unimodal, and is characterized by a decline in rainfall, especially in the northern parts. The problem is not only that of inadequate rainfall, but also of its high variability and unreliability. Most parts of the states included in the study are prone to drought, thereby limiting the range of crop varieties that can be successfully cultivated.

Fertilizer subsidy by the government is one of the ways to encourage farmers to adopt new technologies, and to increase agricultural output. However, because of the poor distribution system, farmers do not get fertilizer at the subsidized prices. Credit and insurance services are inadequate and are not within the reach of the small-scale farmers, because of bureaucracy and high overhead costs of disbursing and/or insuring investments.

Table 8.1. Generalized constraints to agricultural production in Kano, Jigawa and Katsina states of Nigeria.

Identifier	State	Local Government Area	Village	Household	Production System
Infrastructure	Investment in paved roads only	Quantity and quality of laterite roads	Accessibility	Means of transport (donkeys and ox-carts)	Labor that could be used for other purposes
Population	Rapid population growth and urbanization	Land scarcity around cities	Land tenure: fragmentation of land due to inheritance; lack of grazing and fallow land	Land far from homestead; time requirements for walking, number of animals that can be kept, no space for extension	Fallow and manure availability required for soil fertility restoration, soil mining; overgrazing
Physical environment	Low soil fertility	Low soil fertility	Low soil fertility; lack of subsidized fertilizer	Lack of financial means to buy fertilizer	Low soil nutrient availability
	Low and erratic rainfall	Low and erratic rainfall	Lack of water supply (dry season)	Drinking water for human beings and animals	Drought
Inputs	Poor distribution system of subsidized fertilizer and other inputs	Service centres do not have the required inputs	Lack of inputs and credits	Lack of financial means to buy improved seeds, etc	Low yield potentials
Credit/ extension services	Poor credit extension and insurance services	Ineffective extension service	Absence of cooperations/ farmer's organizations	Limited access to extension knowledge	Lack of improved technology
		Degraded tractor-hiring services	Lack of traction power	Labor availability in June-July, inadequate farm tools	Weeds; higher labor requirements.
Marketing	Poor distribution system	Absence of agro-industry	Lack of processing and preservation facilities; absence of village markets	Possibilities to raise money	Reduced cash crop cultivation
Biological constraints	-[1]	-	-	-	Parasitic weeds, insects and diseases (e.g., downy mildew)

1. - = Not applicable

Table 8.2. Feeder road distribution and statistics in Kano, Jigawa, and Katsina States of Nigeria, 1994.

State	Length (km) feed road network	Percentage of national population to feeder road (km)	km/1000 km arable land	km/1000km distance from village	Mean
Bauchi	4900	4.5	1.16	75	3.33
Kano/Jigawa[1]	5760	5.3	1.47	132	1.89
Kaduna/Katsina[1]	4250	3.9	1.52	46	5.45

1. Prebifurcation figures.

Under the Training and Visit (T&V) unified agricultural extension system now operating in Nigeria, the World Bank-assisted Agricultural Development Projects (ADPs), operating under the state Ministries of Agriculture and Natural Resources (MANR) are responsible for the delivery of agricultural extension services, and conduct of adaptive trials in the state. The effectiveness of extension services is hampered by inadequate supervision and poor mobility of the extension agents.

The study area is endowed with rivers, streams, and water dams in the southern parts. However, the upstream dam development and inadequate release have reduced the stream flows and extent of flood area to the detriment of fadama farming during the dry season.

The states under study are bordered by Niger and Chad in the north. The border is porous and a lot of commodity smuggling goes on. In the absence of marketing restrictions and regulations with the neighboring countries, this poses the problem of monitoring the production surpluses and deficits. It has also led to illegal exportation of fertilizers and other farm inputs to neighboring countries.

Local Government Area level

The access roads connecting the towns and villages within the LGAs are bad. The rural roads constructed by the Agricultural Development Projects (ADPs) and the defunct Directorate for Food, Roads, and Rural Infrastructure (DFRRI), and handed over to the LGAs for maintenance, are poorly maintained.

Maintenance of grazing reserves and provision of water points for animals are among the responsibilities of the LGAs in which these facilities are located. The grazing reserves are, however, hardly maintained. Animals therefore roam the fields and damage crops, causing frequent conflicts between the pastoralists and crop farmers.

The LGAs are closer to the grassroot farming communities than any of the state and federal institutions responsible for agricultural development. Every LGA, therefore, has a Department of Agricultural and Veterinary Services. Although the LGAs have extension staff distributed throughout the development areas and villages, the staff is poorly trained and badly equipped. They do not take advantage of the extension service training provided through Monthly Technology Training Meeting (MTRM) and other fortnightly trainings.

Although the LGAs used to provide adequate tractor hiring services to the farmers, they can no longer do so because of high costs and scarcity of spare parts. Farm service centres in the LGA no longer stock relevant farm inputs required by the farmers. There are very few agro-allied industries which can process farm produce and provide employment to the people.

Village-level constraints

It is difficult to reach some of the villages throughout the year, especially during the rainy season. Four of the villages included in the study area—Panda, Dalari, Gora, and Barhim—belong to this category. Poor bridges, swamps, and flooded roads are the common problems.

There are no markets in some villages such as Kofa, Gora, Dalari, and Panda where farm produce and purchase inputs could be sold. Farmers have to travel to other markets, sometimes outside their LGAs, for market transactions. Middlemen, however, frequently visit these villages.

Inheritance is still the main source of land acquisition in most of the villages. This land tenure system insists on sharing land among the heirs of a deceased, and leads to fragmentation of land holdings, and makes the holdings smaller.

There is inadequate water supply for human beings and animals, especially during the dry season. The number of wells in the villages is inadequate.

Some problems such as lack of farm inputs and credit stem from the fact that there are no viable registered cooperatives and organizations. Most of the groups observed in the villages were peer or womens groups, organized principally to provide communal labor or for social activities. Some villages lack corn mills, grinders, and threshing machines.

Extension workers, in general, do not reside in villages in which they are posted. They prefer to live in nearby towns or larger villages, from where they visit the village of assignment only when transportation is available.

Household-level constraints

Farm holdings consist of several scattered fields which are about 1–4 km from homesteads. Time is lost traveling to the different small fields. A household has, on average, 3–4 fields.

The bulk of the farm labor is provided by the family. However, the number of labor from each family is not sufficient to cope with the high demand during June-July, when there are several cultivation activities in progress. Also, because of the apparent breakdown of the gandu system, there has been a decline in the contribution of family members to the total labor requirement of the farm. Only about 36% of the household members take part in farm work.

Land preparation and planting operations need to be carried out within a short time, given the limited amount and period of rainfall. Manual cultivation causes delay and prevents timely planting, with subsequent yield reduction. The tractor-hiring services do not function any longer. Although animal traction is widely practised in the zone, there is a need for implements for postplanting operations.

Animal manure is becoming increasingly important in maintaining soil fertility. Farmers complained of the difficulty involved in collecting crop residues from the field to feed the animals in the compound, before the village livestock are released to graze the fields after harvest. Transporting crops and residues to the compound, and manure to the fields, is easier and faster if farmers own donkeys and ox-carts.

In spite of the presence of many formal credit institutions such as the Nigerian Agricultural and Cooperative Bank (NACB), commercial banks, community and peoples' banks, the number of beneficiaries of agricultural credit is still very low. Lack of credit facilities seriously affects farmers' ability to purchase the improved inputs needed to improve their outputs.

Adoption of improved technologies is seriously hampered by inadequate supply and high costs of such farm inputs as fertilizers, agrochemicals, improved seeds, and improved breeds of livestock.

Farmers sell their farm produce at low prices shortly after harvest, usually to pay debts or to meet their family's financial obligations. Such grain legume crops as groundnut and cowpea are sold soon after harvest because of the risk of damage by insects if they are stored longer. The same farmers who sell earlier, may in fact buy the produce later in the season, when the prices are higher! If farmers could delay selling their grains until later in the year when prices are higher, they could make more profit and income from their labor.

Early adopters of successful innovations usually lose some of their harvest to theft by neighbors who use any means to possess the new cultivars. Crops planted too early or that stay longer in the fields are likely to suffer from damage caused by roaming livestock.

Production system level constraints

Drought stress is a crucial limitation to crop production in the Sudan Savanna Zone. Rainfall in the area is unimodal, and is characterized by a decline in amount, especially in the northern parts of the zone (Owonubi and Abdulmumini 1984). The problem is not only that of inadequate rainfall, but also of its high variability and unreliability. This results in frequent crop failures, and limits the range of crop varieties that can be successfully cultivated.

Characteristically, the soils of the Sudan Savanna Zone are inherently low in organic matter, nitrogen, and phosphorus (Jaiyeoba 1995). Potassium deficiency is gradually becoming important in most arable lands that are being subjected to intensive and continuous cropping (Ogunlela and Yusuf 1988). Micronutrient deficiencies are also becoming widespread as a result of continuous cropping. Reduced fallow periods have aggravated soil physical and chemical degradation (Yusuf 1996). An alternative could be, for instance, improved fallows, such as those being tested in the same agroecological zone in Ghana (Fugger and Vlek 1998).

Farmers in the zone still use mainly traditional/local crop varieties of sorghum and millet. These varieties respond very poorly to inputs and improved management. They also mature very late, and are therefore prone to terminal drought (Goldsworthy 1970, Flower 1996). Singh and Thakare (1986) analyzed an experiment in Kano, and showed that there was no significant increase in yield per unit N applied (van Duivenbooden 1992, p.90). There is a general lack of improved cultivars that are drought tolerant and early maturing.

In the moist southern parts of the zone, weeds grow luxuriantly and compete with crops for light, nutrients, and water. Because of inappropriate tools for weed control, farmers are sometimes forced to abandon parts of their fields. Parasitic weeds, especially *Striga*, on cereal and legume crops cause a more serious problem in the drier parts of the Sudan Savanna than in the more moist south.

Table 8.3 indicates some of the pests and diseases observed on major crops on farmers' fields. It is very difficult to estimate the extent of crop losses caused by pests and diseases. However, their effect could be very severe, especially on groundnut and cowpea, due to the high cost of chemicals. The effect of downy mildew was very severe on millet during the 1996 cropping season. Goats and sheep are major problems on farms near the homestead, and those close to the roads.

Table 8.3. Main pests and diseases observed in the Sudan Savanna Zone.

Crop	Insects/birds	Diseases
Sorghum	Blister beetles Stem borers Birss White grub Midge Head bug Shoot flies Spittle bugs	Foliar diseases Loose smut Head smut Leaf blight Downy mildew Grain mold
Millet	Stem borer Birds Head miners Head beetles	Smut Downy mildew Grain mold
Groundnut	Aphids White grub Termites/ants	Early leaf spot Late leaf spot Rosette Scab Root rot
Cowpea	Aphids Leaf-eating beetles Bugs Pod sucking bugs Termites	Leaf spot Scab

Recommendations, Priorities, and Selection of Benchmark Sites

Recommendations for development

State government level

Several factors that constrain the improvement of agricultural productivity are beyond the influence of researchers and extension workers. These problems include policies, environmental problems, infrastructure, natural resource allocation, and input distribution factors. They fall under the realm of either the federal or state government.

Poor access roads increase input costs, and lead to a delay in transportation of farm produce to the markets. It is therefore recommended that state governments should give more attention to roads that link major areas of agricultural production to urban centres. This will also help improve the supply of agricultural inputs, especially fertilizers, to the farmers. There is too much government control and involvement in the procurement, handling, and distribution of fertilizers. Despite the subsidy on fertilizers, these inputs do not reach farmers. The announced removal of the fertilizer subsidy, has not yielded positive results because the government still has a hand in the distribution. An effective and sustainable system of distribution should involve the private sector.

Extension service delivery is the sole responsibility of the state ADPs under the Unified Training and Visit (UT&V) system of extension, now in operation in Nigeria. Some of the ADPs could not discharge their duties properly because of inadequate funding and because the extension workers were not mobile owing to lack of vehicles. The state governments should therefore increase their funding to extension services in order to be able to sustain the system when the World Bank assistance runs out. In the same vein, research and extension are heavily dependent on assistance from donors such as the World Bank. A negligible percentage of investment in research and extension comes from national treasuries. If the system has to be sustained, the net contribution of the national government must improve.

Local Government Authority (LGA)

At present, LGA staff play virtually no important role in the UT&V system of extension. They should be more involved in the extension activities of their areas. Staff should also be trained to improve their skills. This will resolve the problem of extension staff not willing to live in the villages where they have been posted.

The LGA staff should be responsible for the multiplication and distribution of improved seeds and planting materials suitable to their areas.They should also

coordinate research and development activities of different organizations including the nongovernmental organizations operating in their areas. This will avoid duplication, and give them an opportunity to be involved in on-farm trials in their area of jurisdiction.

A cooperative society is an organization in which individuals voluntarily come together to solve common social and economic problems.. LGA staff should form farmers' groups and assist in registering them into viable cooperative societies in order to enable members to have access to credit and other economies of scale. There are very few cooperative societies in the area of study

Lack of appropriate processing facilities limits expansion of crop production, and reduces farmers' profits. Many agricultural products are sold unprocessed, thereby limiting the profits accruing to the farmers. LGAs should invest in agro-allied industries in order to process farm produce and add value to the products, thus increasing farmers' income and employment. Through cooperatives, agroservice centres should be established to make the purchase of inputs and sales of produce more convenient and profitable.

Grazing reserves under the jurisdiction of LGAs should be well maintained and put to use in order to minimize the frequent clashes between pastoralists and sedentary farmers.

Village level

Lack of potable water is a serious problem in rural areas. Although tube wells have been installed in some central villages, many of them no longer produce water. Hand-dug wells are quite common, but they often dry up during the dry season. In the drier parts of Jigawa and Katsina States, many people including very poor families, especially in Dalari and Barhim villages, are forced to buy water for household use. Village heads should ensure that wells are sunk, preferably through communal efforts.

Village heads are the custodians of land tenure laws. Communal grazing areas should be established in order to prevent the frequent conflicts between farmers and cattle rearers.

The potential of women in agricultural development has not been adequately exploited because of the purdah system, which isolates women. Researchers and extension workers should include female workers in their teams in order to facilitate access to women in their homes.

Household level

The use of agricultural inputs is very low. Farmers across the states have not adopted many of the available improved technologies except chemical fertilizers. Farmers

should be encouraged to adopt other yield-increasing practices such as improved seeds, seed dressing, spacing, pest- and disease-control measures, and the use of herbicides for highly profitable crops such as maize, cowpea, groundnut, and vegetables. Such soil conservation methods as ridging, strip cropping, and crop rotation should also be emphasized by the extension services.

Farmers should take advantage of new cultivars developed for their ecological environment, and diversify their options and enterprises, thus minimizing risks and enhancing their income generation base. The new cultivars include early-maturing cultivars of sorghum, maize, and other crops such as soybean and pigeonpea, found suitable to the area.

Within the household, men and women perform different tasks and have different opportunities. In general, the involvement of women in agricultural activities in the study area can be described as low. The role of women should be further studied.

Access to formal credit is very rare among rural households. Farmers require credit in order to be able to adopt improved practices. Most of the existing formal credit institutions appear to be inappropriate for the small holders because of poor loan facilities, and there is a need to find alternative credit systems.

Recommendations for research

Crop improvement research should not only aim at increasing yields, but also at improving resistance to diseases and pests, tolerance to environmental stress (drought, high temperature, etc.), adaptation to local farming systems, earliness and improvement in processing and storage. Some progress has been made in the area of sorghum breeding. For example, the two open-pollinated varieties (ICSV111 and ICSV400) that were released in 1996 are not only early maturing, but are also resistant to leaf diseases such as anthracnose. The two hybrids—ICSH 89002 NG and ICSH 89009 NG—that were released are early maturing and high yielding. For groundnut, on-farm trial results have shown that ICGV 86105 and Fleur 11 are high yielding in most parts of Sudan Savanna Zone. However, additional effort is required to incorporate rosette resistance into these varieties.

Crop cultivars selected should be targeted to areas within the zone where they are most adapted, and have ecological and economic comparative advantages. In general, early-maturing cereal and legume crop varieties would be more suited to the drier northern Sudan Savanna Zone (latitudes 9°–11°) where they are capable of escaping the risk of terminal drought stress. If they are, however, planted in the wetter part of the zone, planting should be delayed until late June or early July. Otherwise, provision should be made for artificial drying of the commodities.

The dormancy period of the improved groundnut varieties should be improved in order to avoid the losses due to germination of the nuts before harvesting.

Lack of seed materials that can adapt to different production systems and changing weather conditions is a problem. In a situation of unpredictable rainfall distribution and weather conditions, farmers should have access to varieties with different qualities that would enable them to make planting adjustments as the season progresses. Seed companies should be encouraged to stock reasonable quantities of seed varieties that can adapt to changing weather conditions and environment.

Farmers should be exposed to a wide range of technologies, enterprise options, and diversifications in order to minimize risks and enhance their income generation base. For instance, pearl millet (GB 8735), which was developed in Niger and has been released elsewhere, performed very well under Nigerian conditions, and is well accepted by the farmers. Based on the fact that soybean and maize crops have been performing very well in the southern parts of Katsina State, the cultivation of these two crops should be promoted in Birnin Kudu zone of Jigawa State, and in Zone I of Kano State with similar ecological conditions. Introduction of pigeonpea would include a useful legume crop to the cereal-dominated farming system of the zone.

Animal traction technology is widely adopted and practised in the study area, but it is least practised in the southern parts of Kano State. Experience from Kano and Jigawa States with similar environments should be exploited to promote animal traction in the southern LGAs of Kano State.

Harvesting and postharvest technology

Apart from management of resources during the production stage, there is the problem of loss of produce during and after harvesting, drying, threshing, and transportation. To solve this problem, there is a need to develop crop varieties that mature uniformly and are not prone to field losses, and to develop harvesting equipment and methods that minimize losses. This is especially true of groundnut harvesting, where a considerable number of nuts remain unharvested in the soil.

A majority of farmers sell the crops unprocessed owing to lack of time to process them in the traditional way, and because of lack of access to modern processing facilities. Inability to process crops and enhance their value poses a problem. The revenue that should have remained with the farmers is channeled to the middle men and traders who do the processing. It is therefore necessary to develop improved processing methods that can save time, reduce drudgery, and losses.

Soil fertility maintenance

Declining soil fertility is of great concern to farmers. The high cost and scarcity of inorganic fertilizers are a serious threat to the production of cereal crops, which require a high level of nitrogen. Research efforts should be directed at improving soil physical, chemical, and biological properties, which often decline because of continuous cropping. Other measures such as planned rotation, intercropping with legumes, the use of cover crops, fallow, composting, and agroforestry cropping systems should be explored.

Selection of benchmark sites

Criteria

A benchmark site consists of research domains large enough for biophysical and socioeconomic research at the most sustainable systems research. An important step towards defining benchmark sites is the identification of research domains, which constitute the focal point for strategic and diagnostic research. In this study, the first criterion towards choosing a benchmark site is that the location be within the Sudan Savanna Zone of Nigeria, with a growing period of 100–150 days, and an annual rainfall of 500–1000 mm.

Although nine villages were surveyed in three states, only four benchmark sites were recommended for Kano State, for logistic reasons. Kano State was chosen because its entire boundaries fall within the defined Sudan Savanna agroecological zone, and it is the host state for the ICRISAT research station in Nigeria. The villages proposed as benchmark sites include Kofa (Bebeji LGA), Gargai (Bebeji LGA), Badume (Bichi LGA), and Dambatta (Dambatta LGA).

Sites

Kofa: Located in Bebeji LGA, Kofa benchmark site represents the wettest subzone of the Sudan Zone, with an annual rainfall of about 889 mm. It is about 25 km from Bagauda, the ICRISAT station in Nigeria, and about 80 km from Kano city. Because it is located about 6 kms off Kano - Zaria road, and without any village market, its accessibility to market is rated as poor. It is densely populated, with little room for farm expansion. Kofa is within a sorghum-growing region. Cultivation is mainly manual, and animal traction technology is practised. An on-farm researcher-farmer-managed cereal-legume rotation experiment is presently going on there. There is little prospect for off-farm work.

Gargai: Also in Bebeji LGA, Gargai is located about 6 km from the ICRISAT Bagauda station. It is, however, sparsely populated with room for farm expansion. It is accessible with good road, and is very close to Tiga, a relatively bigger town. There are good prospects for nonfarm employment in the ICRISAT research station and in the Nigerian Institute for Horticulture (NIHORT) nearby.

Gargai's proximity to the Tiga Dam allows farmers to practise dry-season irrigation. A majority of the cereal laborers working at the ICRISAT station come from Gargai, and are likely to practise what they do on the experimental fields on their own farms. Researcher-farmer-managed experiments are currently going on there. The use of animal traction is more popular at Gargai than at Kofa.

Badume: Badume, in Bichi LGA, lies between the dry north and the wet southern part of Kano State. The main road linking Kano through Katsina State, to Niger Republic passes through this village. Although it is expected to be within the millet-based cropping system, farmers here produce diversified crops including tomatoes and other vegetables. It has a very big weekly market patronized by traders from outside Kano. Groundnut production is very important, and trading is a major nonfarm occupation.

Dambatta: Dambatta belongs to the extreme north of Kano State forming boundaries with Jigawa State and Niger Republic. The annual rainfall is about 600 mm. Although this site was not included in the survey, it is a good representation of the drier subzone where the early-maturity crop materials could be tested and developed. This location is a true millet-based zone, and animal traction is widely practised. Cross-border trade influences on adoption of technologies could be observed.

Pilot sites

It is suggested that pilot sites be established in order to ensure widespread benefit and participation of all partners such as ADPs, NARS, IARCs, LGAs, NGOs, etc. Pilot sites should be spread throughout the target domains and states. There should be at least one pilot site in each of Jigawa and Katsina States, which were included in the characterization study. These sites will serve the purpose of testing, evaluating, adapting, and transferring promising technologies. Emphasis should be given to adaptive research and farmer participatory technology development at the pilot sites. Strategic research studies will be carried out only to take advantage of location-specific enterprises or expertise.

Conclusions

This study used a multiscale approach, with participatory research. This was the right combination to obtain the required data to chararacterize the production systems and select benchmark sites for future research.

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Acronyms and abbreviations

ADP	Agricultural Development Project
AEZ	Agroecological Zone
APMEU	Agricultural Project Monitoring and Evaluation Unit
CAYS	Crop Area and Yield Survey
GIS	Geographical Information System
IAR	Institute for Agricultural Research (Nigeria)
IARC	International Agricultural Research Center
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ISC	ICRISAT Sahelian Center (Niger)
JARDA	Jigawa Agricultural and Rural Development Authority
KNARDA	Kano National Agricultural and Rural Development Authority
KTARDA	Katsina Agricultural and Rural Development Authority
LGA	Local Government Areas
LGP	Length of Growing Period (days)
NARP	National Agricultural Research Project
NARS	National Agricultural Research Systems
NGO	Nongovernmental Organization
PRA	Participatory Rural Approach

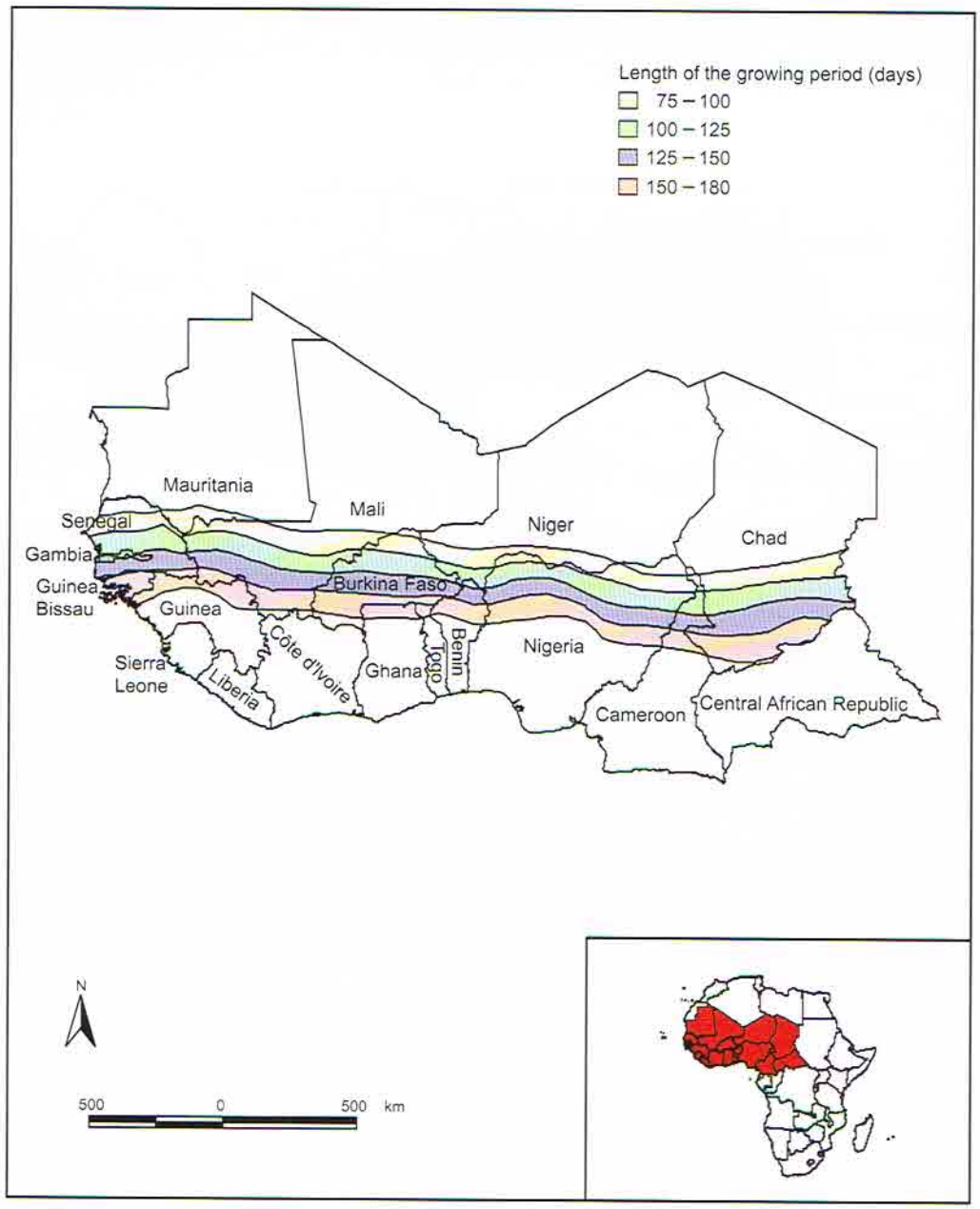

Figure 1.1. West and Central Africa with the semi-arid agroecological zones.

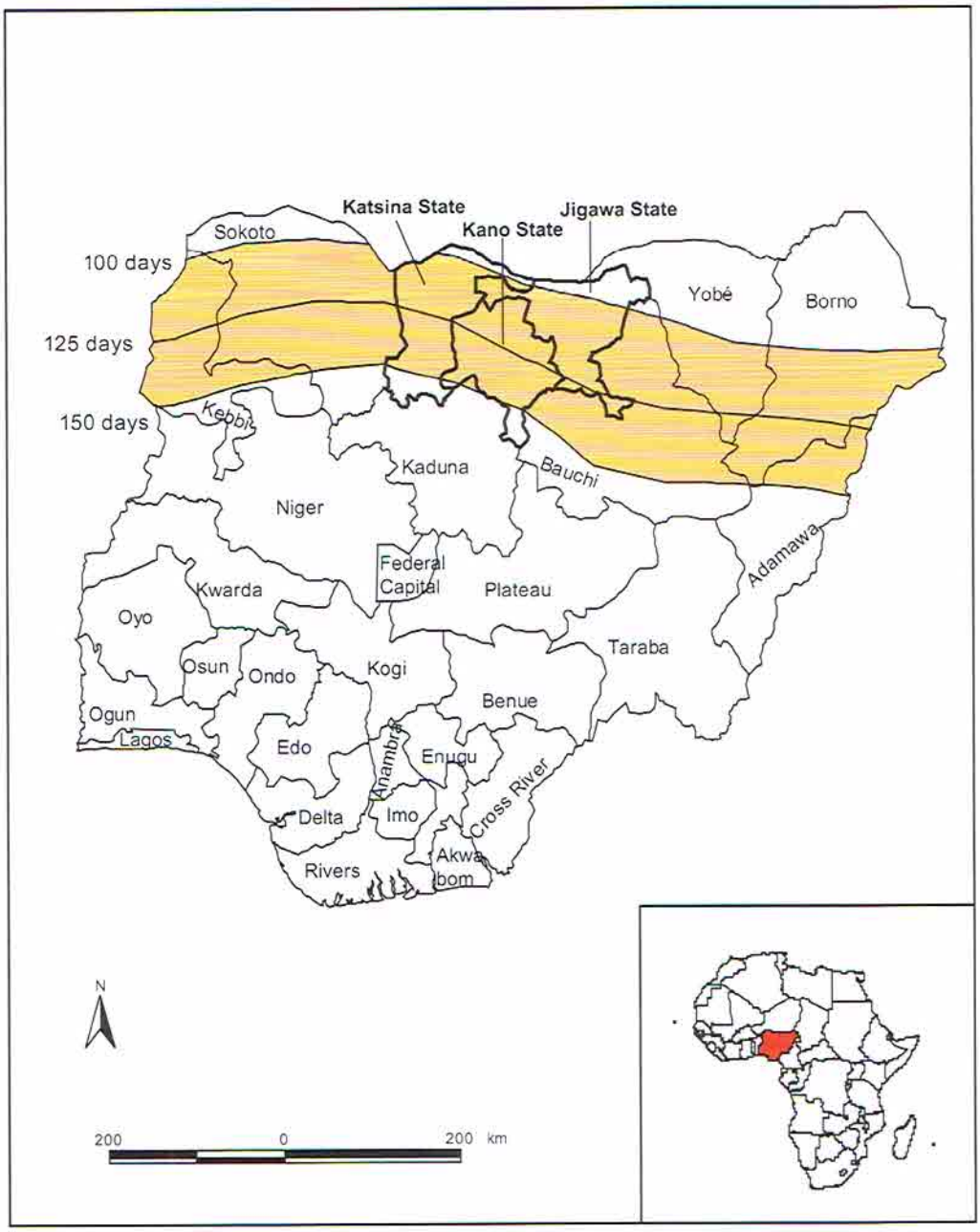

Figure 1.2. Nigeria's three states – Katsina, Kano, and Jigawa – and the Sudan Savanna Zone, with length of growing period between 100 and 150 days.

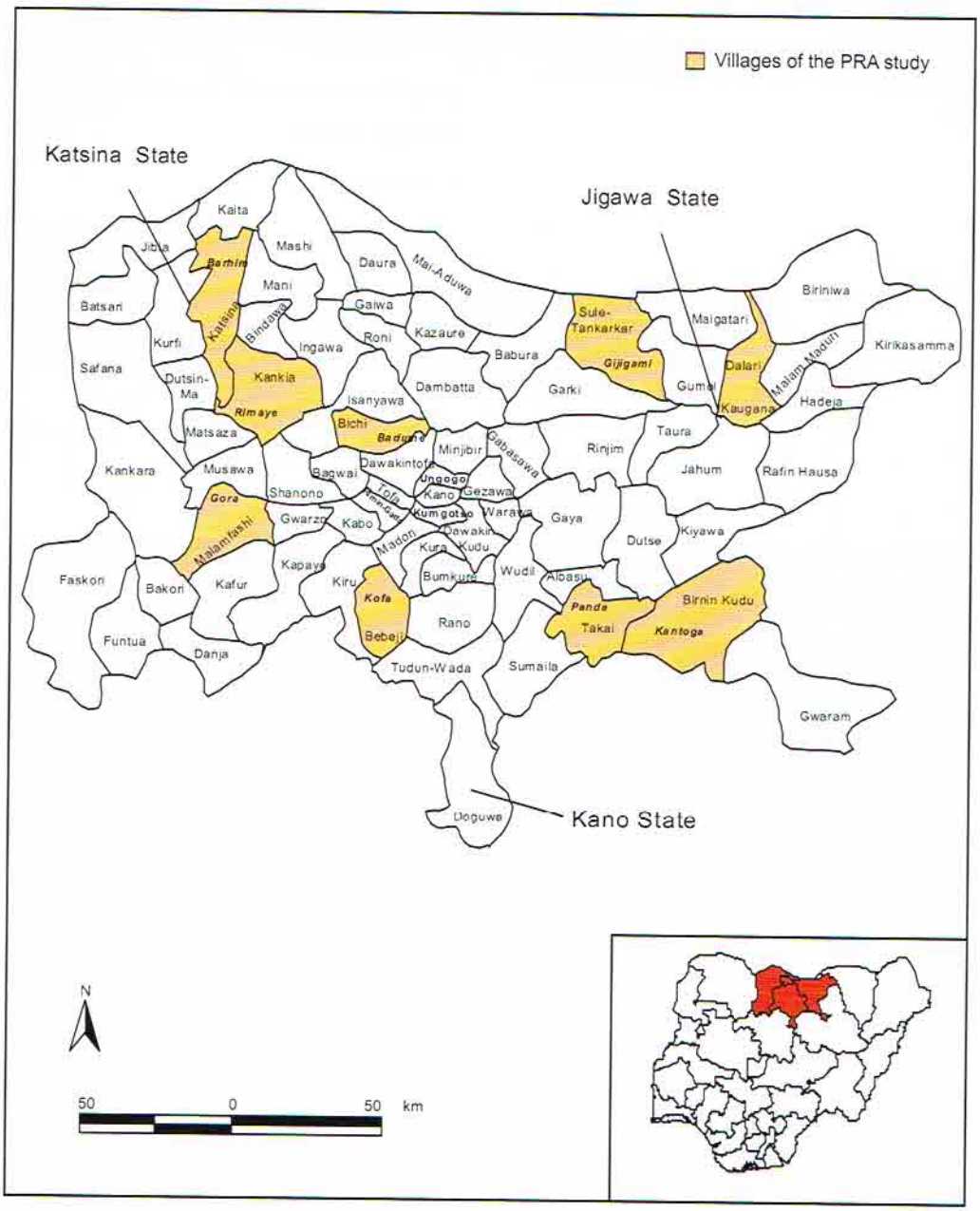

Figure 2.1. Villages of the Participatory Rural Appraisal (PRA) study along the north-south transect in Katsina, Kano, and Jigawa States of Nigeria.

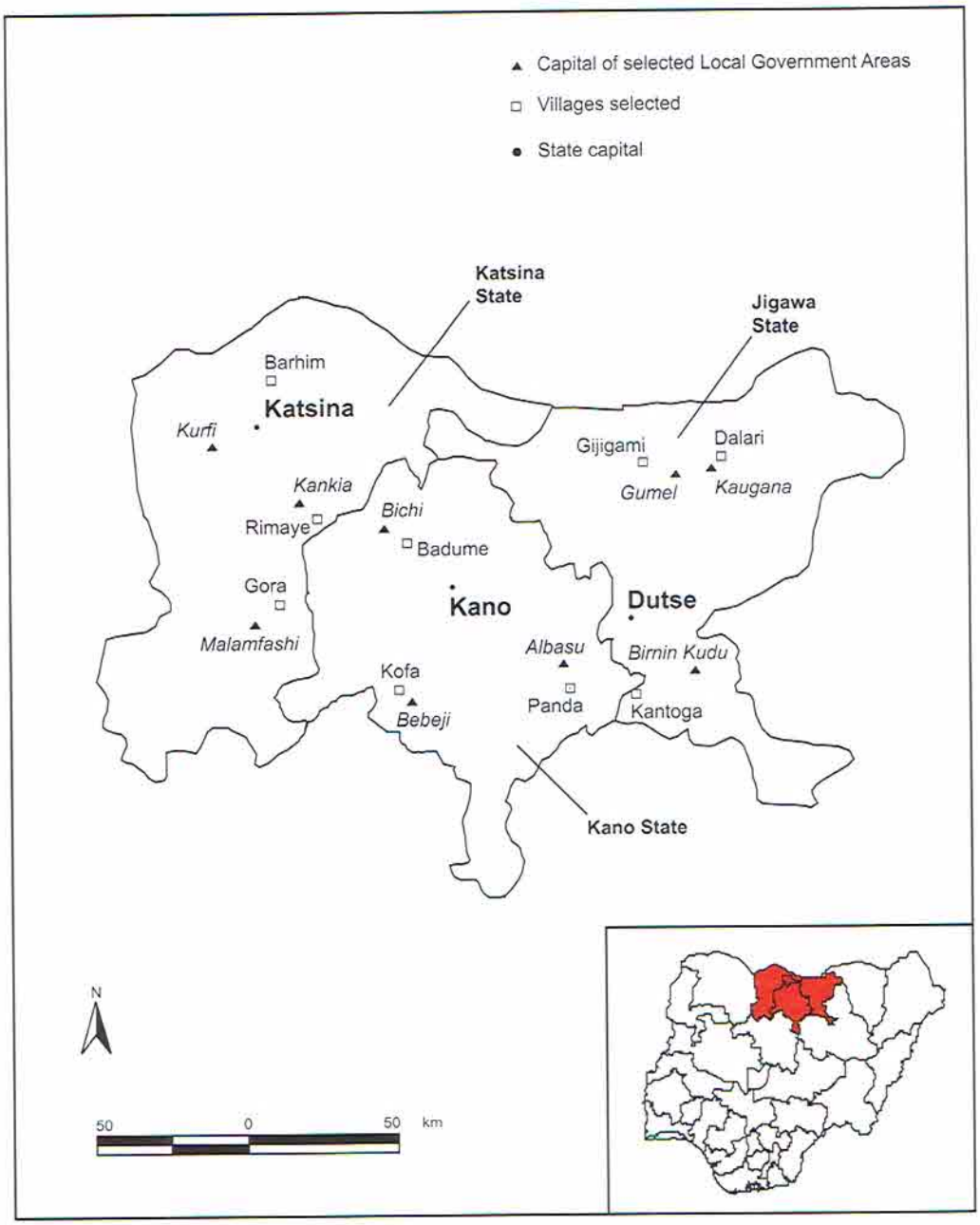

Figure 2.2. Location of on-farm sites in Katsina, Kano, and Jigawa States of Nigeria, 1996.

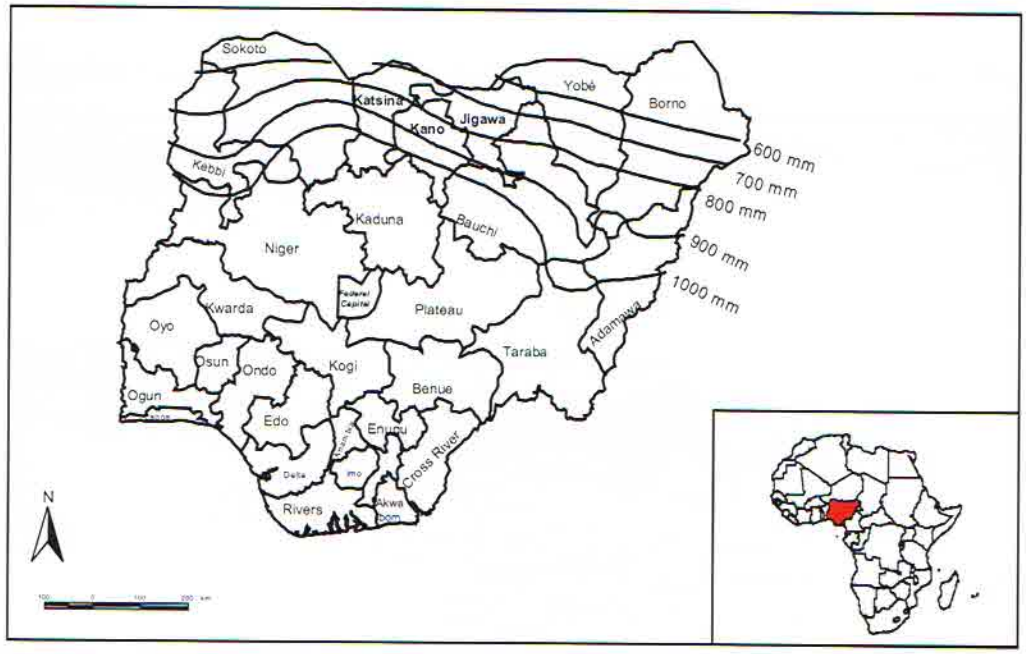

Figure 3.1. Mean annual rainfall (mm) in the Sudan Savanna zone.

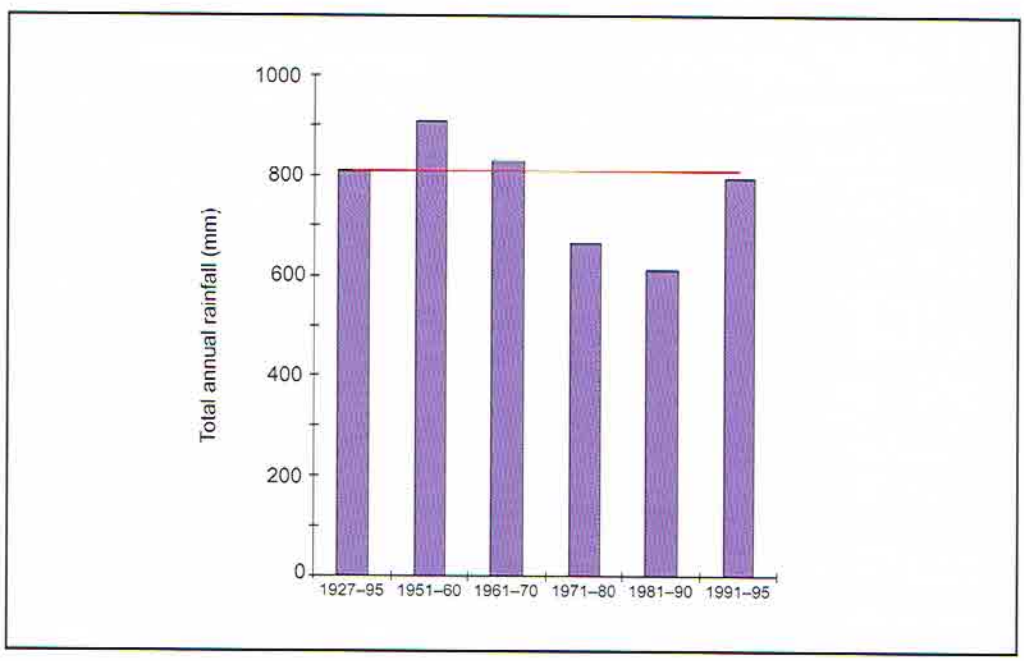

Figure 3.2. Total annual rainfall in different decades and the long-term mean (1927–95) at Kano, Nigeria.

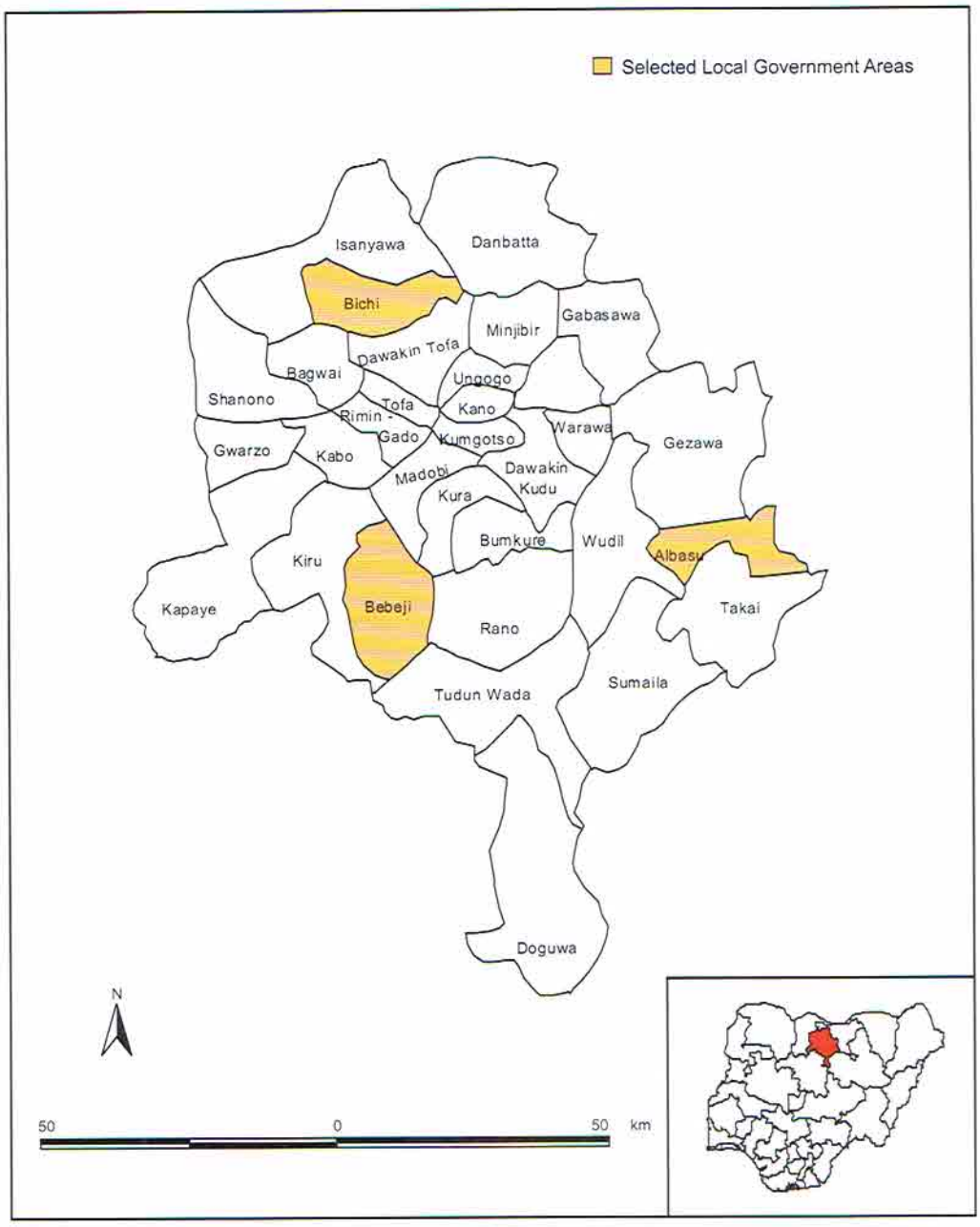

Figure 4.1. Kano State wth its Local Government Areas.

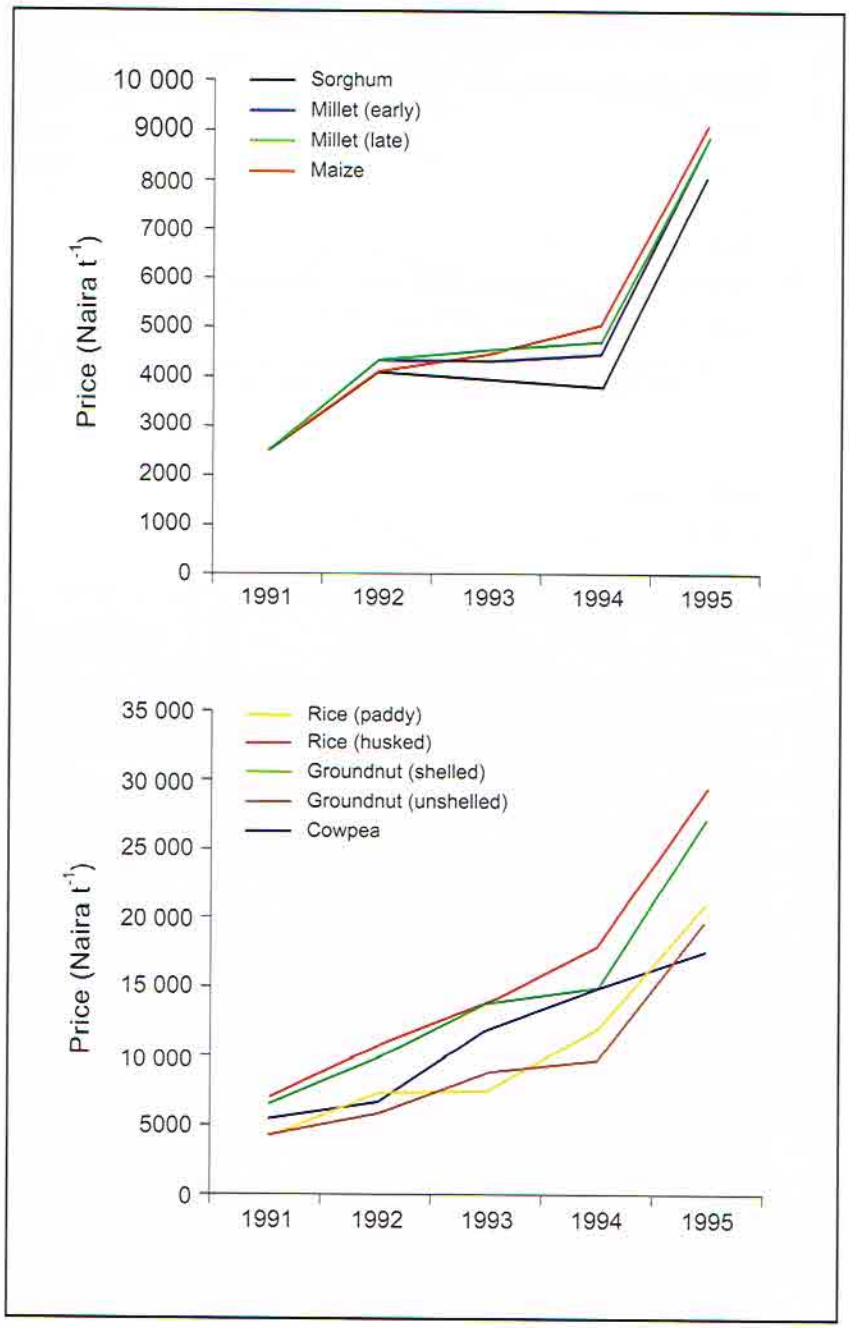

Figure 4.2. Price trends for major crops in Kano, Nigeria, 1991–95 (1 US $ = 80 Naira).

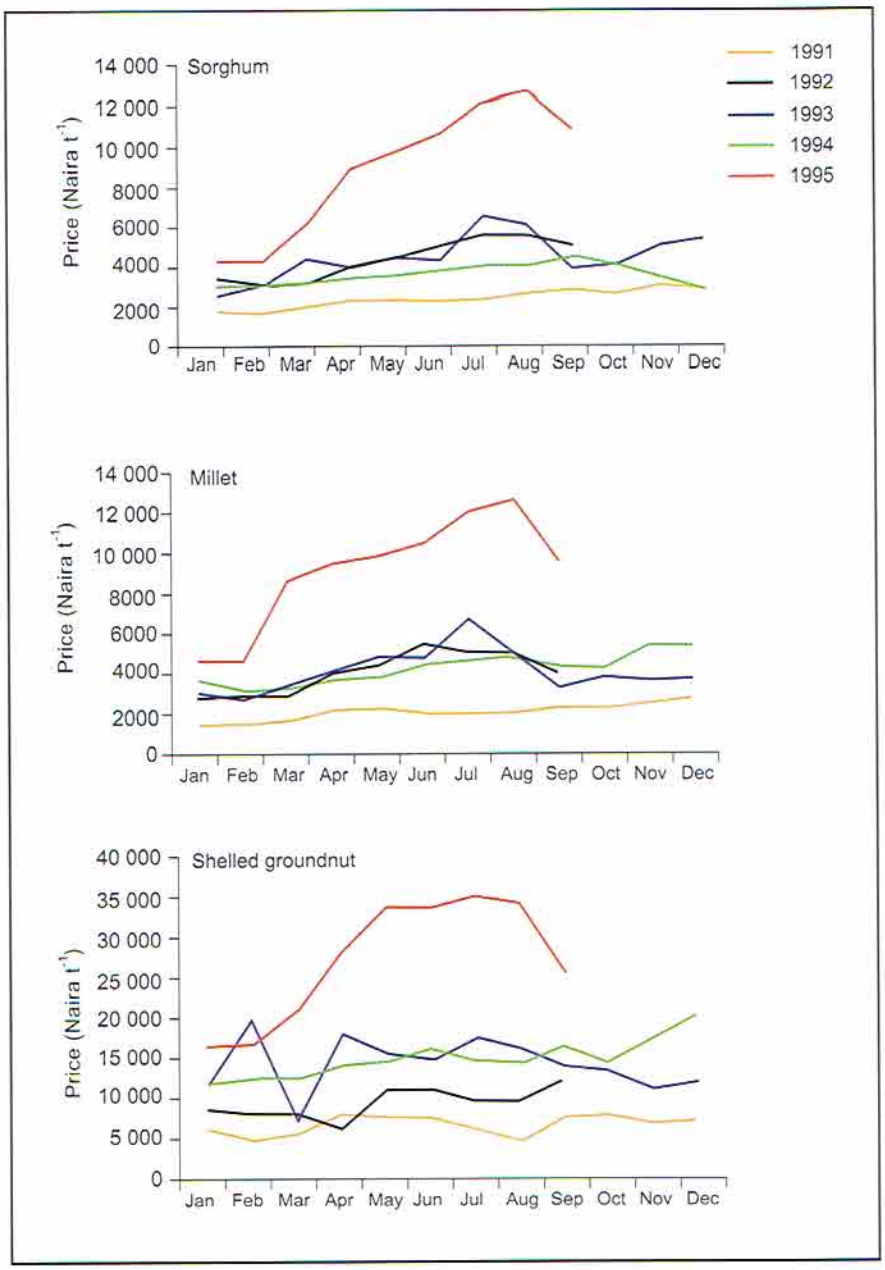

Figure 4.3. Monthly mean prices of sorghum, pearl millet, and shelled groundnut during 1991–95 in Kano State, Nigeria (1 US $ = 80 Naira).

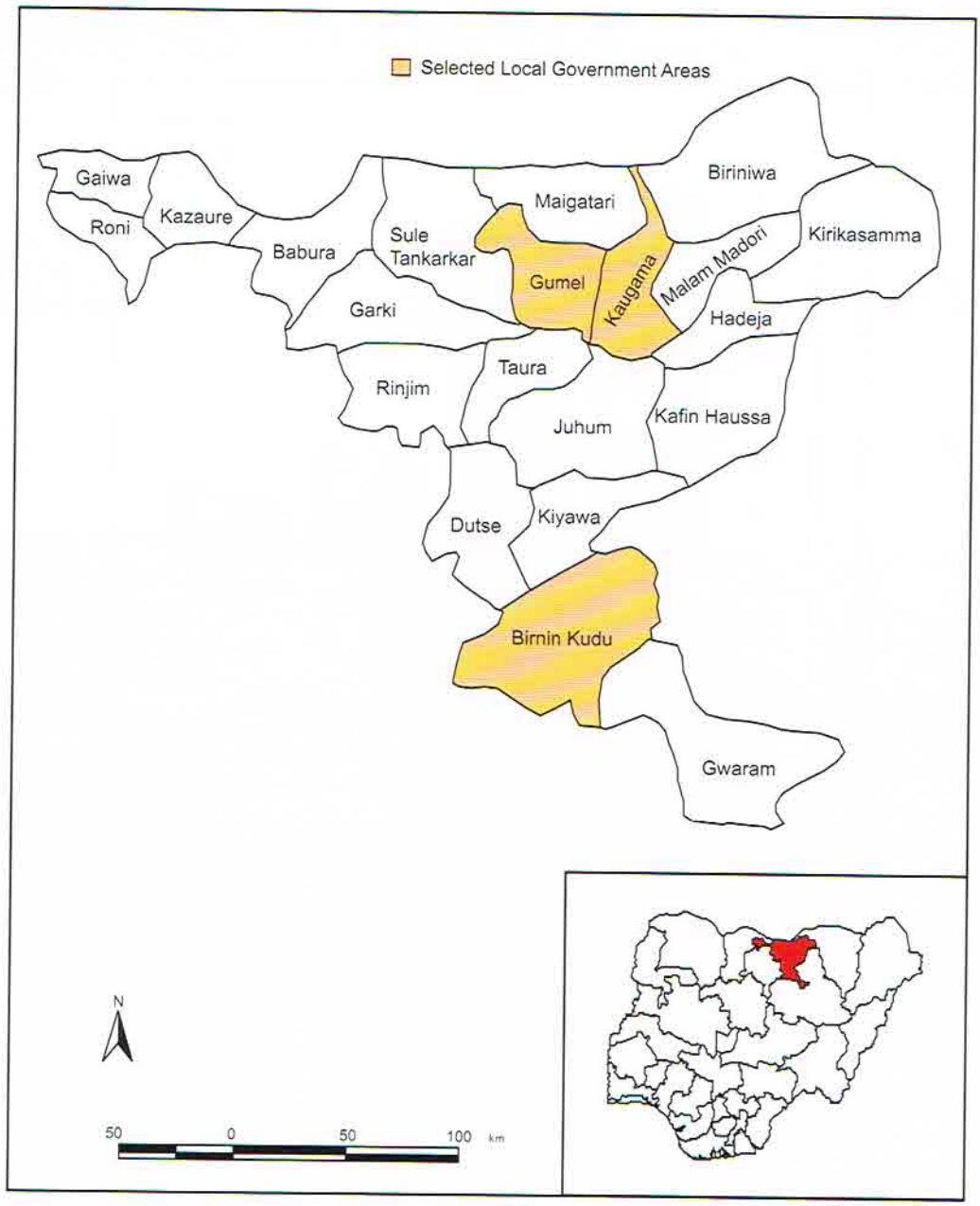

Figure 4.4. Jigawa State in Nigeria with its Local Government Areas.

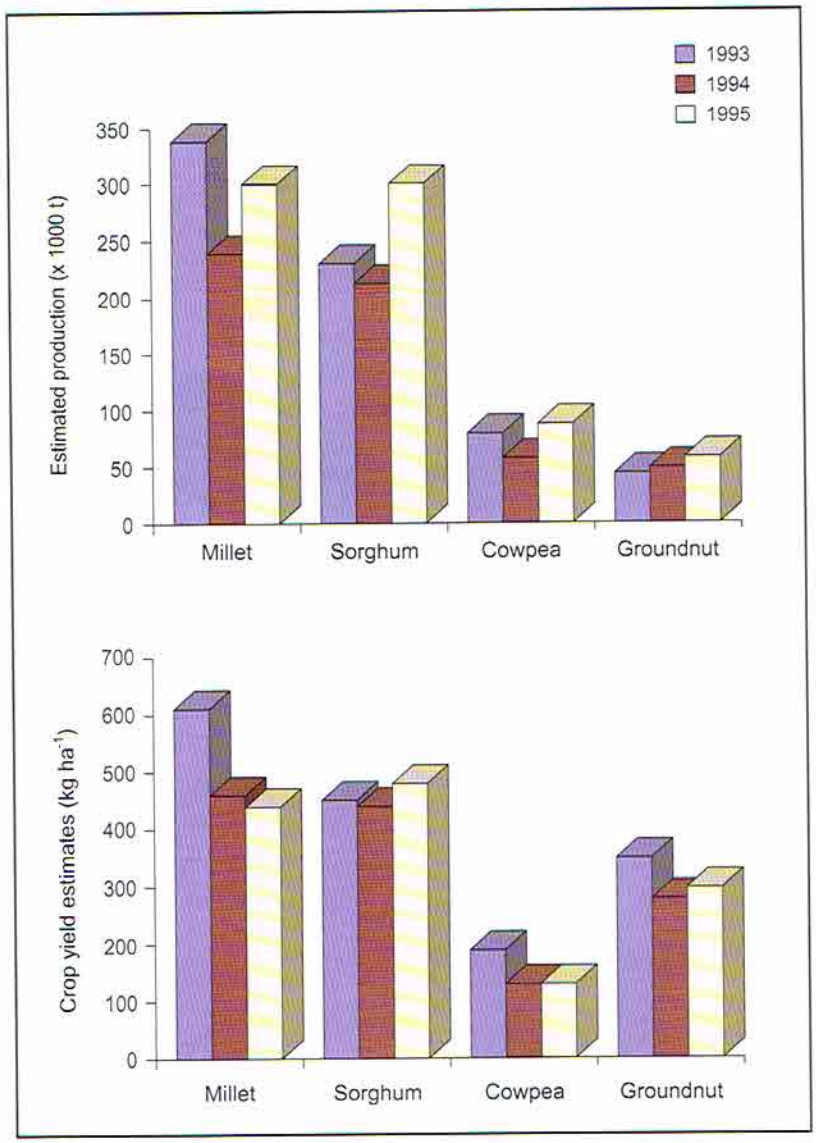

Figure 4.5. Production and yield estimates of major crops in Jigawa State, Nigeria, 1993–95.

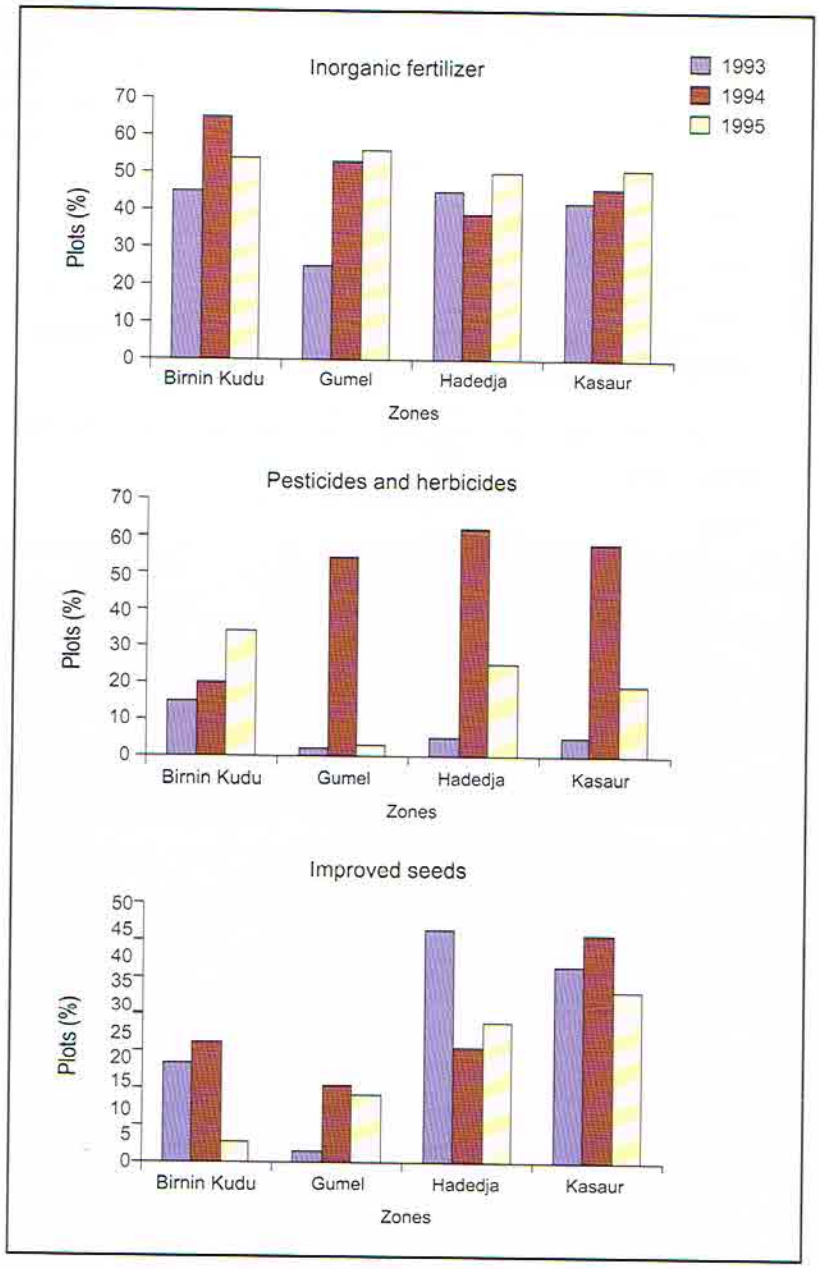

Figure 4.6. Input use by zones in Jigawa State, Nigeria.

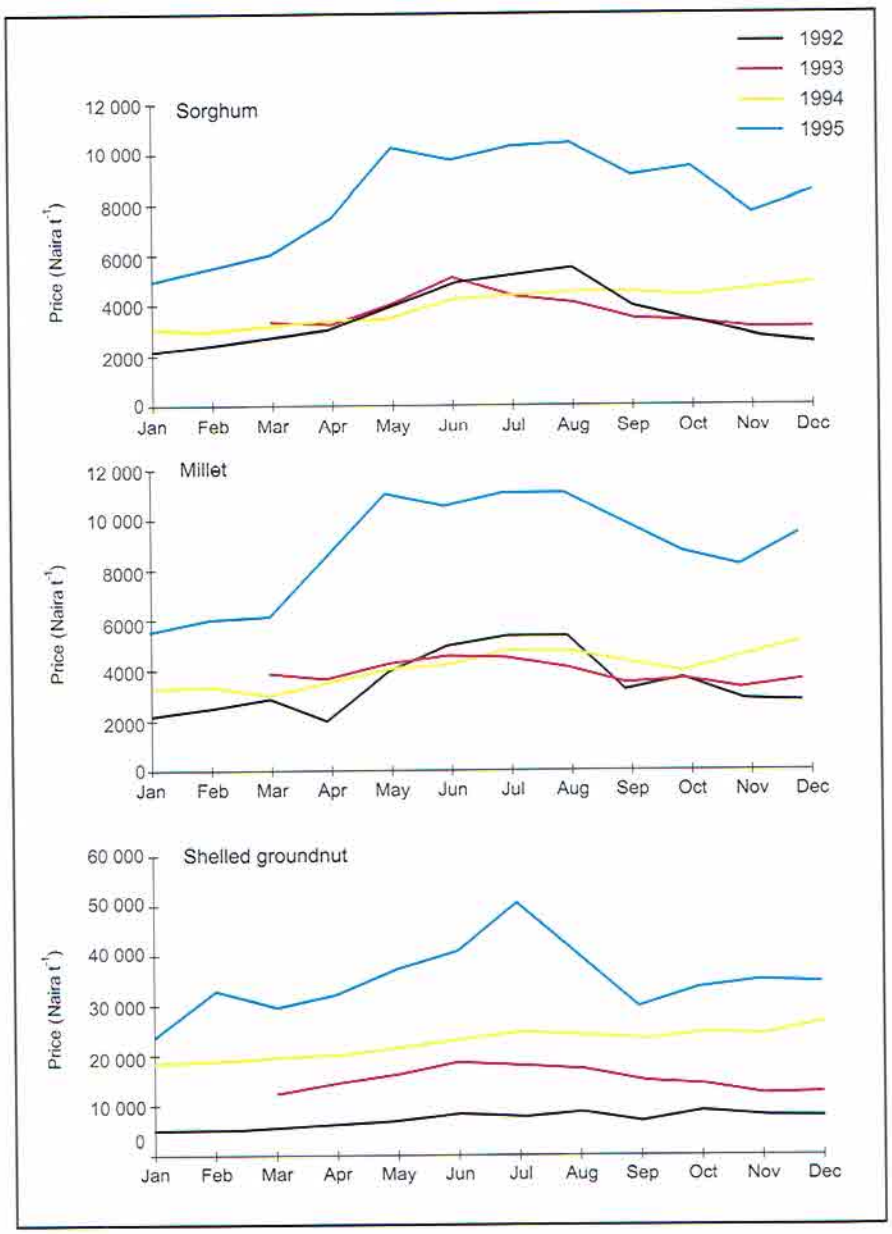

Figure 4.7. Monthly average prices of sorghum, millet, and shelled groundnut during 1992–95 in Jigawa State, Nigeria.

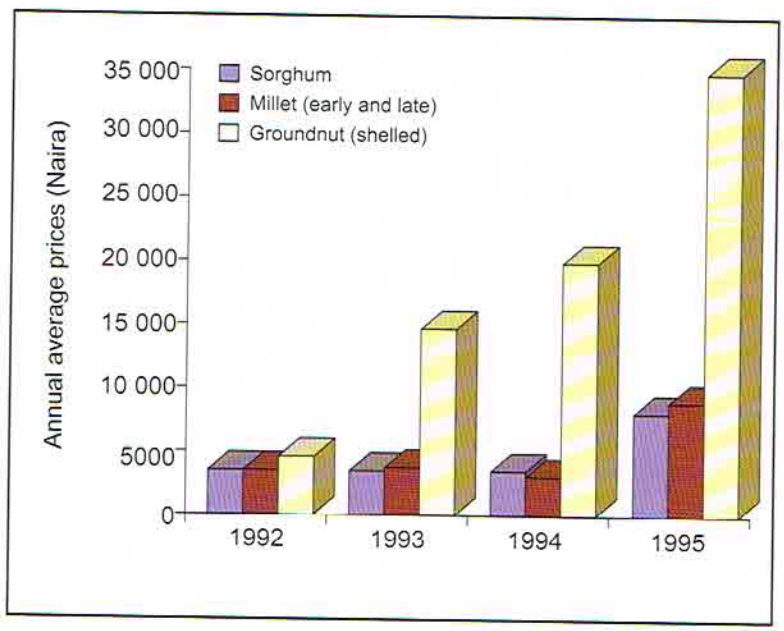

Figure 4.8. Price trends for major crops in Jigawa State, Nigeria, 1992–95.

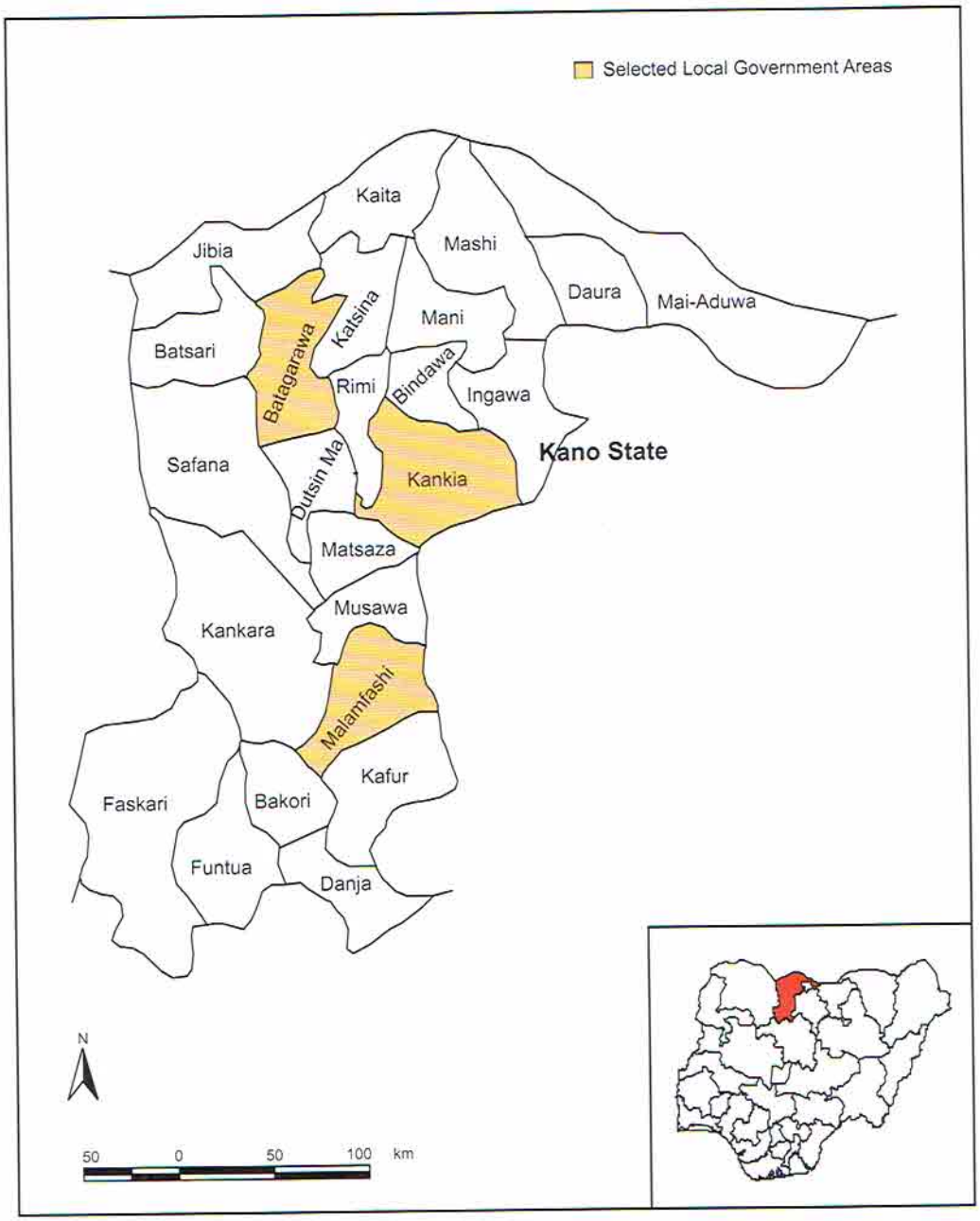

Figure 4.9. Katsina State in Nigeria with its Local Government Areas.

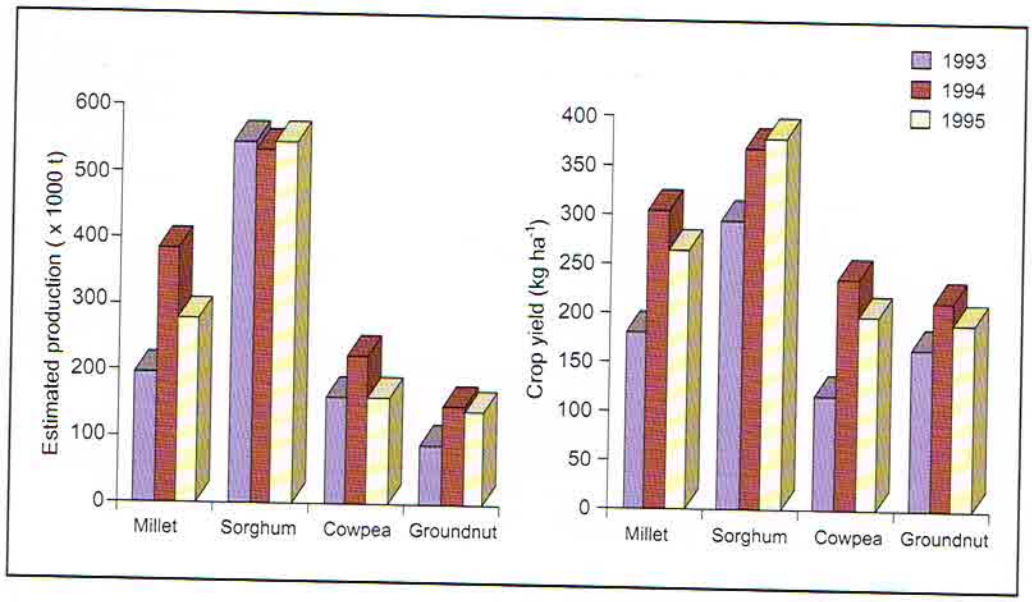

Figure 4.10. Production and yield estimates of major crops in Katsina State, Nigeria, 1993–95.

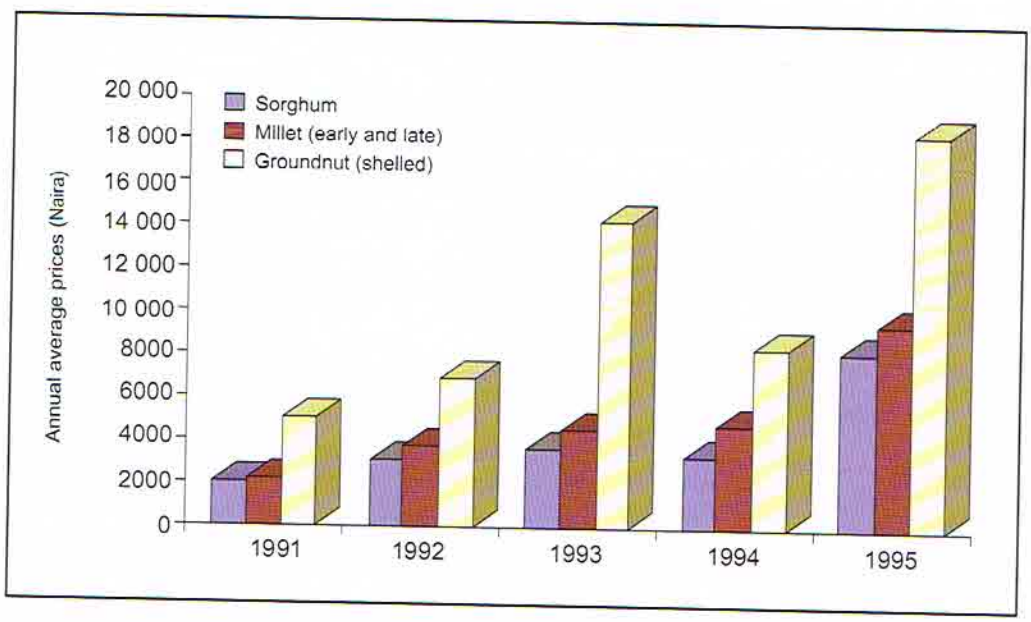

Figure 4.11. Price trends for major crops in Katsina State, Nigeria, 1991–95.

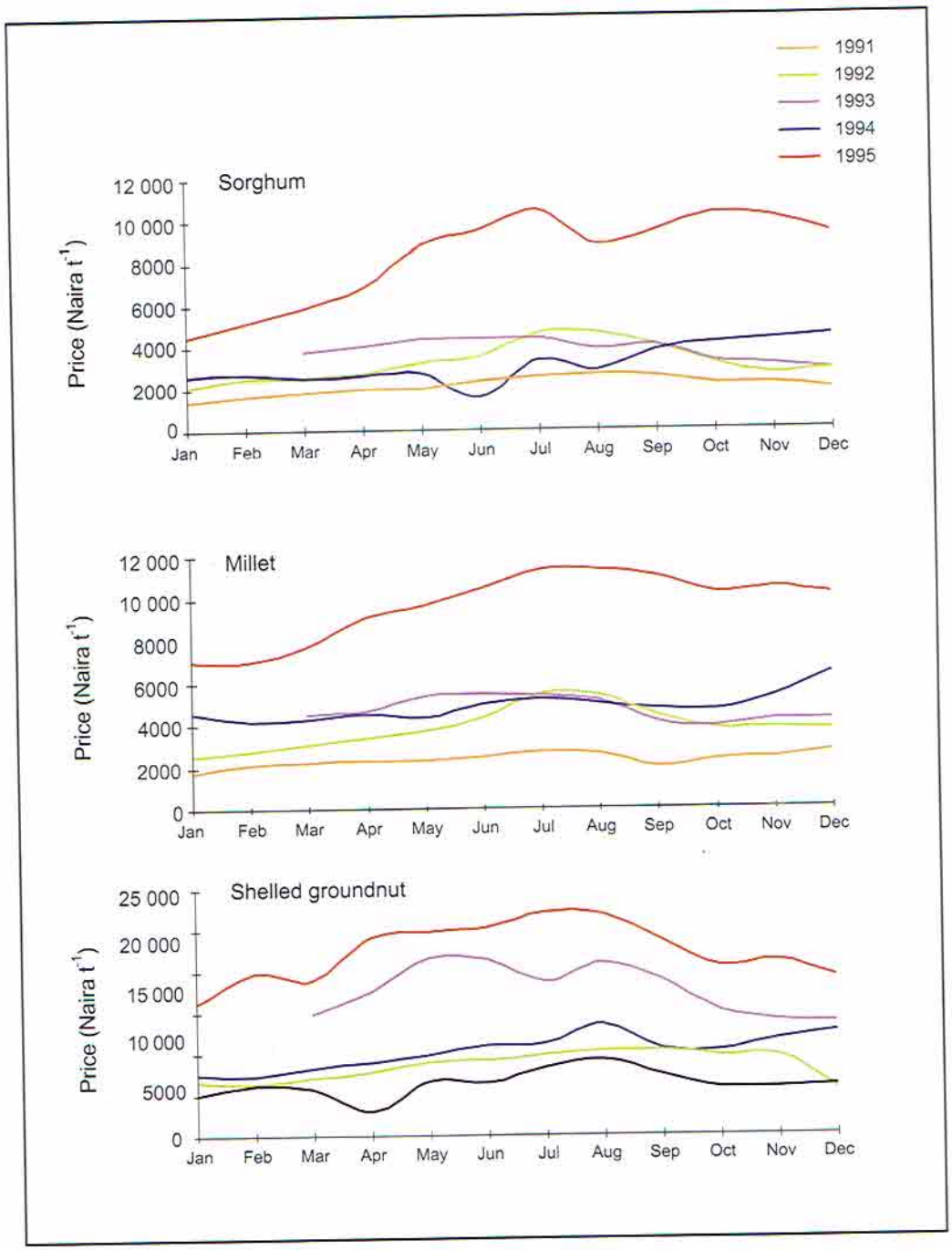

Figure 4.12. Monthly average prices of sorghum, millet, and shelled groundnut during 1991–95 in Katsina State, Nigeria.