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Appendix 1: The astronomically based seasonal calendar used by local opinion leaders and farmers in northern Nigeria

Season	Constellations	Period	Number of days
DAMINA (Rainy season)	Haka'a	27/5 - 8/6	13
	Hana'a	9/6 - 21/6	13
	Zara'a	22/6 - 4/7	13
	Nasara	5/7 - 17/7	13
	Darfa	18/7 - 30/7	13
	Jabba	31/7 - 13/8	14
	Harsan	14/8 - 26/8	13
KAKA (Early dry season)	Sarfa	27/8 - 8/9	13
	Iwa	9/9 - 21/9	13
	Shimaku	22/9 - 4/10	13
	Gufuru	5/10 - 17/10	13
	Zabban	18/10 - 30/10	13
	Ikililu	31/10 - 12/11	13
	Kalbu	13/11 - 25/11	13
DARI (Mid-dry season)	Shaula	26/11 - 8/12	13
	Nu'aima	9/12 - 21/12	13
	Bulda	22/12 - 3/1	13
	Sa'adu Zabiha	4/1 - 16/1	13
	Sa'adu Bul'a	17/1 - 29/1	13
	Sa'adu Sa'uda	30/1 - 11/2	13
	Sa'adu Ubbiya	12/2 - 24/2	13
BAZARA (Late dry season)	Far'u Mukaddam	25/2 - 9/3	13
	Far'u Muwahhar	10/3 - 22/3	13
	Badanu	23/3 - 4/4	13
	Nudha	5/4 - 17/4	13
	Budaina	18/4 - 30/4	13
	Sunuiya	1/5 - 13/5	13
	Dabaran	14/5 - 26/5	13
Total Number of Days			365

MOHAMMED et al. (1995), SA'IDU (1978), HISKETT (1978)

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Fadama crop residue production and utilisation in north-western Nigeria

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Abstract

The study examined resource use in crop residue production in the *fadama*, nature and quantities of residues produced, grain:residue ratio, extent of and constraints to crop residue utilisation for livestock feed, as well as crop residue marketing system. To achieve the study objectives, data were collected from 54 *fadama* farmers and 11 pastoralists in the Zamfara Reserve and three other locations in Sokoto and Zamfara States.

Data analysis revealed low utilisation of improved inputs, on the one hand, and high level of utilisation of manual labour on the other. Crops cultivated include rice, sorghum, cowpea, sweet potato, millet, pepper, tomato, onion, egg plant and garlic. However, only the residue from the first five were utilised for livestock feed in the area. All the pastoralists and farmers owning livestock utilised one form of *fadama* crop residue or another. Residue utilisation for feed reaches its peak during the dry season. The use of residue for building, thatching, fencing, and as cooking fuel constitute the major threat to crop residue availability for livestock feed. Another problem of residue use identified is rejection by livestock due to quality deterioration after storage, particularly if the residue is stored up to the time of the commencement of the next rainy season.

The weight of residue (straw) obtained from one hectare of rice appears to be lower than the weight of grains. The reverse is the case for sorghum, cowpea and millet. The weight of sweet potato tubers exceeds that of the shoot harvested.

Constraints to marketing identified include poor storage facilities, bulkiness of residue relative to its value, over-dependence on animal transport which restricts distance that could be covered within a given period of time, and absence of standard measures (most of the residue are measured in bundles which are highly variable). The quantities of *fadama* residues produced seem to have increased over the last few years, but so also have the prices.

Introduction

Background on *fadama* farming

North-western Nigeria, comprising Kebbi, Sokoto and Zamfara States, is an important livestock producing area in Nigeria harbouring an estimated 1.77 million cattle, 2.47 million goats, 2.57 million sheep, 247,989 donkeys, 24,685 horses and 43,960 camels (FDLPCS, 1992). Livestock production in the area, like elsewhere in Nigeria (and most of West Africa), is controlled by pastoralists most of whom are either transhumant or completely nomadic. A significant feature of the pastoral production pattern is low productivity which is attributable to inadequate feed availability, among other constraints. The animals are usually grazed in the open natural range in migratory herds. This system, at best, leaves the animals at the mercy and uncertainty of nature in terms of feed supply. The problem of feed availability is

particularly severe in the study area with low rainfall and a protracted dry season. During the rainy season, there is relatively abundant pasture for grazing in the open range. In the dry season, however, the fields become dry, leaving scanty vegetation for livestock feed. During such periods, feed availability becomes a critical problem. One of the strategies livestock producers often adopt to cope with the problem of feed scarcity is supplementary feeding with crop residue. Some of the herders also graze their livestock in the *fadama* during the critical period of feed scarcity.

Fadama is a Hausa word which refers to all the low-lying relatively flat areas either in streamless depressions or adjacent to the seasonally or perennially-flowing streams and rivers (KOLAWOLE and SCOONES, 1994; BABA and SINGH, 1996). *Fadama* is in contrast to *tuda* which means the upland. It is synonymous to *bas fond* in Sahel, *wadi* or *khor* in Sudan, and *dambo* in southern Africa (SCOONES, 1992).

In the semi-arid agro-ecology of north-western Nigeria, the *fadama* is a very critical resource, due to its high moisture retention in the rhizosphere throughout the year and its relatively fertile soils. Underscoring this fact, ARNBORG (1988) described the *fadama* as "a garden, a little paradise" in the vast drylands of northern Nigeria. Characteristically, he further noted, the *fadama* land is marked by a flush of new vegetation at the beginning of the rainy season before the adjacent upland turns green, and it is also most conspicuous after the cessation of the rains when it remains prominently green as the surrounding upland rapidly turns brown and eventually bare.

The above-stated characteristics make the *fadama* a significant resource not only in crop production but also in livestock farming in north-western Nigeria. Its flush of green vegetation provides feed for livestock at critical times, while the river or stream flowing through (where applicable), constitute important watering points for livestock. But perhaps the most significant contribution of the *fadama* to livestock production is in provision of feed in the form of residue of cultivated crops. This study examines the *fadama* crop residue production and utilisation processes.

Problem statement

Inadequate feed supply is probably the most critical constraint limiting livestock production in north-western Nigeria. During the dry season when feed becomes scarce in the upland, the *fadama* provides an alternative grazing land. The expansion of arable farming in the *fadama*, following the establishment of several irrigation projects in the area, in recent times, however, has drastically reduced the area of *fadama* land available for grazing. It is, however, believed that this loss could be compensated for if the expanding cultivation is also accompanied by increased production of crop residue for livestock feed. Whether or not the *fadama* is able to perform this role satisfactorily will depend, among other things, on the type, quantity, cost, and nutritive value of the residue produced. It would also depend on the accessibility of such residue to livestock producers through an efficient marketing system. Presently, empirical information on these crucial variables about crop residue production in the *fadama* lands of north-western Nigeria is lacking. This study was therefore designed to bridge this gap in knowledge.

Objectives of the study

The broad objective of the study was to examine the potentials and constraints of crop residue production, marketing and utilisation in the *fadama*. Specifically, the study was designed to:

a) identify the nature of crop residue produced in the *fadama*,
b) examine resource-use in residue production,

c) determine the cultural practices and cropping patterns in residue production,
d) examine marketing and pricing of residue,
e) determine grain and residue yield and ratio, and
f) identify alternative uses of crop residue which could hinder residue availability for livestock feeding.

Methodology

The study area

North-western Nigeria as used in this study refers to the old Sokoto State (prior to the state creation exercise of 1991) which now comprises Kebbi, Sokoto and Zamfara States although the actual data collection points were located in the last two. It is located between latitudes 10° and 14° N, and longitudes 3° and 7° E (ABDULLAHI, 1985), and covers an area of 102,535 km^2 (FOS, 1989).

The pattern of rainfall varies markedly across the area; in the south, the average annual total is more than 1000 mm while along the frontier with the Republic of Niger in the north, it is less than 500 mm. The rainy season is from April to September, with most rain in July and August, although the length of the season may vary by up to six weeks (FDLPCS, 1992). The mean monthly temperature ranges between 13 °C in December through February, and 38 °C in April and May. The relative humidity in the area varies from 10 % in February to 90 % in August (MOCO, 1981). The vegetation of the area is savanna with the boundary between Northern Guinea Savanna and Sudan Savanna cutting across the center. The predominant tree species are *Acacia spp.*, the desert date (*Balanites spp.*), *Isoberlinia doka* and the toothbrush tree (*Saltradora persica*). *Panicum, Andropogon, Hyparrhenia, and Brachiaria spp.*, are the common grasses (ABDULLAHI, 1985; FDLPCS, 1992).

The hydrology of the area is dominated by the Rima River and its tributaries. The main tributaries include Rivers Gagere, Bunsuru, Maradi, Zamfara, Sokoto, and Ka. The first three rise from the south-eastern part of the area and flow in a northerly direction until they unite to form the Rima River, while the last three flow westwards to join the Rima River which ultimately drains in to the Niger below Kende in the south-west (ABDU et al., 1982). The *fadama* along the flood plains of some of these rivers and numerous smaller ones have been developed for arable crop production.

The area is ethnically diverse, although the Hausa and Fulani people occupy most of its territory and minority groups are confined to relatively small areas. The minority groups include Tuareg, Zarma, Bariba, Kumbari, Dakarkari, and a few others. The major occupation of the people is arable and livestock farming, with 65 % of the land area devoted to agriculture, 20 % to forests and the remaining 15 % to rivers, mountains and buildings. Sorghum, millet and cowpea are the major rainfed crops, while rice, wheat, sweet potato and vegetable crops are cultivated mainly in the *fadama* (FDLPCS, 1992). Livestock production is undertaken by both settled and semi-settled farmers, and by pastoralists, but the latter predominate. The pastoral peoples include the Fulani and the Tuareg and they control more than 80 % of the total cattle population in the area (FDLPCS, 1992).

Data collection and analysis

For the purposes of this study, which was conducted in 1996/97, four irrigation areas were delineated for data collection. These were Kwalkwalawa, Wurno, Bakolori Irrigation Scheme, and Shamashalle (in the Zamfara Reserve). In Kwalkwalawa area, 11 *fadama* farmers were

randomly selected initially, but two were later dropped due to lack of co-operation, bringing the sample size for this location to nine. Fifteen *fadama* farmers and seven transhumant Fulani pastoralists were studied in the Wurno area, while 10 farmers and four pastoralists were randomly selected at Shamashalle in the Zamfara Reserve. The survey also covered 20 randomly sampled farmers at Bakolori. The study, therefore, covered a total of 54 *fadama* farmers and 11 transhumant Fulani pastoralists. The selected *fadama* farmers produced and utilised crop residue while the transhumant pastoralists utilised, but did not produce *fadama* crop residue.

From the selected *fadama* farmers, data were collected on crop residue production, disposal and utilisation, while data on crop residue purchase and utilisation were collected from the transhumant pastoralists. Data collection techniques used were interviewing with a questionnaire (which contained both structured and open-ended questions), participatory observation and physical measurement of some variables such as land area, economic yield and crop residue output. In each of the locations, the farm sizes of five respondents were measured and were found to be reasonably close to the values obtained from the interviews. Economic (or primary product) yield figures were given by the respondents in local units such as bags, baskets and bundles. Each farmer was asked to produce samples of his harvested crops in the local units of measurement which were then weighed to obtain the yields in kilograms. With the exception of groundnut haulm which was measured in bags, all the other residue types were measured in bundles. Each of the farmers was asked to produce samples of the bundles and/or bags for weighing in a similar manner with the economic grain yields. The prices obtained for the various units of the economic and residue yields by the farmers were recorded during the interviews. In the case of residues, five samples of each of the residue being offered for sale at the rural markets were also weighed and the retail prices recorded. The collected data were analysed using descriptive statistics.

Results and discussion

Crop residue production

Resource use

Tables 1 and 2 present the expenses incurred by farmers on the various inputs employed in crop production in the *fadama*. As is evident from the tables, labour dominated the production cost accounting for more than 72 % of total costs at Kwalkwalawa and more than 67 % at Wurno. At Shamashalle and Bakolori, it accounted for about 69 % and 53 %, respectively. The high level of labour cost is perhaps attributable to the fact that most *fadama* farming operations in the area were accomplished manually. Both family and hired labour were employed by 67 %, 44 %, 40 % and 70 % of the farmers in Wurno, Kwalkwalawa, Shamashalle and Bakolori areas, respectively. The remaining farmers used family labour alone and none relied solely on hired labour. The cost of family labour was imputed by multiplying the number of man-days worked by the wage rate which was N120/man-day at Wurno, and N100/man-day in the remaining locations.

Labour cost was followed by seed in the case of Kwalkwalawa and Shamashalle, and by fertiliser in Wurno and Bakolori areas. Chemicals accounted for small proportions of the production cost at most of the sites.

A striking feature of resource use in the area, as is evident from these results, is the relatively low level of employment of improved inputs. At Bakolori, 75 % of the rice-growing farmers indicated using improved varieties of rice as compared with 50 % at Wurno and 35 % at Kwalkwalawa. None of the farmers at Shamashalle indicated using improved rice variety. The varieties of all other crops produced in the *fadama* were local.

Table 1: Average costs of farm inputs (N/ha) - Wurno and Kwalkwalawa.

Input	Wurno		Kwalkwalawa	
	Cost	% of total	Cost	% of total
Land/water	2229 ± 2572	8.1	321 ± 2074	1.2
Labour	18650 ± 18552	67.6	18892 ±1 2127	72.1
Seed	1498 ± 1432	5.4	2546 ± 3577	9.7
Fertiliser	2930 ± 3738	10.6	1796 ± 4273	6.9
Chemical	278 ± 795	1.0	472 ± 1038	1.8
Fuel & repairs	575 ±.1070	2.1	1014 ± 607	3.9
Depreciation	1155 ± 400	4.2	701 ± 830	2.7
Others	280 ± 905	1.0	479 ± 540	1.8
Total	27595	100.00	26220	100.00

Table 2: Average costs of farm inputs (N/ha) - Shamashalle and Bakolori.

Input	Shamashalle		Bakolori	
	Cost	% of total	Cost	% of total
Land/water	538 ± 379	0.8	972 ± 2706	4.0
Labour	49188 ± 21320	69.3	12838 ± 7914	53.5
Seed	9440 ± 1978	13.3	2081 ± 1924	8.7
Fertiliser	4051 ± 1606	5.7	2731 ± 6162	11.4
Chemical	3734 ± 2351	5.3	796 ± 1572	3.3
Fuel & repairs	0	0.0	146 ± 229	0.6
Depreciation	200 ± 90	0.3	345 ± 6	1.4
Others	3791 ± 787	5.3	4095 ± 1199	17.1
Total	70941	100	24004	100

Furthermore, chemicals were used widely only at Bakolori where 75 % of the respondents used herbicide (Ronster) in rice production, and 55 % used pesticides (Gammalin A and Cymbush) in cowpea and vegetable crops production. In other areas, chemical use was restricted to small quantities and few farmers. The low level of chemicals utilisation in the area implies that the danger of poisoning to livestock due to residual chemical on crop residue is minimised, although this contributed to the high level and cost of the labour input, particularly for weeding which had to be accomplished manually using hoes. Where herbicides were employed, manual weeding requirement for rice was reduced to once or twice. The other crops were weeded one to three times manually.

Although the contribution of fertiliser to total cost may appear slightly high in some cases, this should not be mistaken for high level of utilisation of the input. Rather, it is the result of an excessively high cost of the input. Table 3 shows the distribution of farmers according to price paid per 50 kg bag of fertiliser. Although the official price of the input was N150 per 50 kg bag, it can be seen from Table 3 that the majority of the farmers at all locations paid more than N600. In fact, fertiliser price ranged from N150 to as high as N2,000 per bag.

Table 3: Distribution of respondents according to fertiliser prices (percentages)

Price range (N/bag)	Wumo (n=15)	Kwalkwalawa (n=9)	Shamashalle (n=10)	Bakolori (n=20)	Total (n=54)
1-150	20	22	10	0	11
151-300	7	0	0	5	4
301-450	0	12	0	0	2
451-600	0	22	20	5	9
601-750	13	0	10	5	7
751-900	13	0	10	20	13
901-1050	13	22	20	5	13
>1051	7	0	30	60	30
Did not use	27	22	0	0	11
Total	100	100	100	100	100

Cultural practices and cropping patterns

More than 30 types of crops and crop combinations were identified in the study area (see MANÉ-BIELFELDT et al., this volume). Most of these crops and crop combinations, as well as the number of farmers cultivating, and *foulmo* land areas devoted to each of them, are presented in Tables 4 - 8. Rice was the most widely cultivated crop accounting for about 36 %, 11 %, 60 % and 23 % of the total area cultivated by the respondents at Wumo, Kwalkwalawa, Shamashalle and Bakolori, respectively. Other important crops in terms of the area cultivated were millet and cowpea at Wumo, onion and rice/okra mixture in Kwalkwalawa, onion and sweet pepper in Shamashalle, and sorghum, sweet potato, cowpea and cotton at Bakolori. From the viewpoint of crop residue production for feeding livestock, however, the most important crops were rice, millet, sorghum, cowpea, groundnut, and sweet potato. Jointly, these crops accounted for 88 %, 41 %, 60 % and 79 % of the land area cultivated by the respondents at Wumo, Kwalkwalawa, Shamashalle and Bakolori, respectively. The figure for Bakolori includes area devoted to maize and groundnut as well. When all the crops are taken together, the average farm size per farmer was 2.99 ha at Wumo, 3.01 ha at Kwalkwalawa, 3.87 ha at Shamashalle and 6.91 ha at Bakolori. The overall farm size per farmer across the locations was 4.20 ha.

The cultural practices in the area frequently include land preparation, planting (or transplanting), weeding, watering and harvesting. Greater than 60 % of the farmers at Wumo and Kwalkwalawa used tractor in ploughing and harrowing their plots. While all farmers at Bakolori used tractor for similar purposes, no farmer at Shamashalle used tractor. Levelling, as well as water channel and irrigation basin construction were all accomplished manually by all respondents using hoes. Planting was also done manually. The planting method varied with the crop type. Onion, garlic, tomato, sweet potato and pepper were first planted in the nursery before transplanting to the field. Very few farmers transplanted rice.

Information on plant spacing and plant population per hectare adopted for various crop species is presented in Table 4. While majority planted their rice by broadcasting, others drilled at an average intra-row spacing of 0.29 m and inter-row spacing of 0.34 m. Tomato was planted at intra-row spacing of 0.30 m and inter-row also of 0.30 m, while onion had an average intra and inter-row spacings of 0.15 m and 0.20 m, respectively. Spacing for other crops are as presented in Table 4. Using data on spacing, the plant stands per hectare were calculated as 333,335, 213,677, 101,420, 11,111 and 13,899 for onion, garlic, rice, millet and sorghum, respectively. The stands per hectare for the other crops are shown in the Table 4.

Table 4: Plant spacing and population/ha

Crop	n	Intra-row spacing (m) Mean	SD	Inter-row spacing (m) Mean	SD	No. of stands/ha Mean	SD
Onion	10	0.15	0.12	0.20	0.30	333335	95000
Garlic	7	0.18	0.20	0.26	0.16	213677	12233
Rice	20	0.29	0.14	0.34	0.54	101420	44400
Millet	1	0.90	0.00	1.00	0.00	11111	1200
Sorghum	1	0.60	0.00	1.20	0.00	13889	0
Cowpea	8	0.68	0.74	0.73	0.60	22833	0
C. pepper	4	0.35	0.23	0.36	0.31	79364	35000
Tomato	5	0.30	0.34	0.30	0.22	111111	120
Okra	2	1.55	1.10	1.55	0.12	4162	5444
Egg plant	1	0.40	0.00	0.54	0.00	46296	0
S. pepper	6	0.34	0.04	0.40	0.72	73830	62000

Table 5: Field sizes and crop types - Wumo (multiple responses possible)

Crop	No. of Farmers growing	% of all farmers (n = 15)	Area of land under (ha)	% of total area cultivated	Average field size (ha)
Onion	8	53	3.12	7.0	0.39
Garlic	6	40	1.92	4.3	0.32
Rice	13	87	16.38	36.5	1.26
Millet	4	27	11.6	25.8	2.90
Cowpea	3	20	5.61	12.5	1.87
Sorghum	3	20	3.80	8.5	1.27
Sweet potato	1	7	1.60	3.6	1.60
Onion/ garlic	1	7	0.40	0.9	0.40
Millet/ sorghum	1	7	0.40	0.9	0.40
Total			44.83	100	

Planting of onion in Wumo was mainly undertaken in September (20 % of all farmers at the location) although a few also planted in January (7 %) and February (7 %). Harvesting was done mainly in April (13 %) and December (13 %). 20 % of farmers at this location planted rice in March and 46 % in June/July. Harvesting took place in November (60 %). Millet and sorghum planting was in June and harvesting in September for millet and September to November for sorghum. The planting of cowpea was accomplished in June/July (20 %) and harvesting in November/December (20 %).

In the Kwalkwalawa area, onion was planted in the dry season, from October to December (33 %), and harvesting from February to March (33 %). At this location, the planting of rice extended from June to December (66 %) and harvesting from January to April (66 %). Planting of millet in this area was in June (11 %) and harvesting in October (11 %). Sorghum was planted mainly in July (22 %) and December (22 %). Harvesting was in November (22 %) and

March/April (22 %). Cowpea and sweet potato planting was in November and harvesting in April. The planting of chilly pepper in this area was from August to December and harvesting was from January.

Table 6: Farm sizes and crop types - Kwalkwalawa (multiple responses possible)

Crop	No. of farmers growing	% of all farmers (n=9)	Area of land under (ha)	% of total area cultivated	Average field size (ha)
Onion	3	33	3.21	11.8	1.07
Rice	3	33	3.21	11.8	1.07
Carrot	1	11	0.20	0.7	0.2
Millet	1	11	0.80	2.9	0.8
Sweet pepper	1	11	2	7.4	2
Sorghum	2	22	2	7.4	1
Hot pepper	1	11	2.4	8.9	2.4
Sweet potato	1	11	0.8	3.0	0.8
Tomato	1	11	2.4	8.9	2.4
Okra	1	11	0.4	1.5	0.4
Millet/sorghum	1	11	2.4	8.8	2.4
Rice/okra	3	33	3.99	14.7	1.33
Cowpea/s.potato/tomato	1	11	1.2	4.4	1.2
Onion/s.pepp./tom./okra	1	11	0.6	2.2	0.6
Sorghum/s.potato/okra	1	11	0.7	2.6	0.7
Onion/sweet pepper/okra	1	11	0.8	3.0	0.8
Total			27.11	100	

Table 7: Farm sizes and crop types - Shamashalle (multiple responses possible)

Crop	No. of farmers growing	% of all farmers (n = 10)	Area of land under (ha)	% of total area cultivated	Average field size (ha)
Onion	7	70	4.41	11.4	0.63
Rice	10	100	23.4	60.5	2.34
Sweet pepper	5	50	5.2	13.4	1.04
Tomato	2	20	0.6	1.5	0.3
Wheat	1	10	0.4	1.0	0.4
Okra	1	10	0.2	0.5	0.2
Chilly pepper	2	20	2.4	6.2	1.2
Sweet pepper/tomato	1	10	1.2	3.1	1.2
Tomato/onion/lettuce	1	10	0.8	2.1	0.8
Onion/sweet pepper	1	10	0.1	0.3	0.1
Total			38.71	100	

Onion planting at Shamashalle was in April/May (70 %) although a few also planted June/ July (20 %). The harvesting of the crop extended from July to November. Rice was planted at this location from October to December and harvested from February to May. The vegetable crops such as chilly pepper, sweet pepper, tomato and okra were planted about April/May and harvested from May to December depending on the crop in question.

Planting of rice at Bakolori took place mainly between January and March (45 %) although some farmers also planted from September to November (15 %). Harvesting was mainly in May/June (35 %) and January/February (15 %). Sweet potato here was planted February/March and harvested July through October.

Table 8: Farm sizes and crop types - Bakolori (multiple responses possible)

Crop	No. of farmers growing	% of all farmers (n=15)	Area of land under (ha)	% of total area cultivated	Average field size (ha)
Garlic	1	5	0.80	0.6	0.80
Rice	14	70	33.04	23.9	2.36
Millet	4	20	7.80	5.6	1.95
Sorghum	7	35	24.64	17.8	3.52
Cowpea	5	25	15.80	11.4	3.16
Sweet potato	7	35	22.68	16.4	3.24
Sweet pepper	2	10	2.10	1.5	1.05
Chilly pepper	2	10	4.80	3.5	2.40
Tomato	3	15	1.80	1.3	0.60
Egg plant	1	5	0.50	0.4	0.50
Maize	5	25	2.00	1.4	0.40
Cassava	3	15	4.50	3.3	1.50
Cotton	5	25	14.60	10.6	2.92
Groundnut	1	5	0.40	0.3	0.40
Sorghum/cowpea/millet	1	5	0.80	0.6	0.80
Cotton/millet	1	5	1.20	0.9	1.20
Cassava/maize	1	5	0.40	0.3	0.40
Egg plant/tomato	1	5	0.40	0.3	0.40
Total			138.26	100.00	

All the respondents irrigated one crop or another. About 27 % of the farmers in Wurno, 44 % in Kwalkwalawa, 50 % in Shamashalle and 35 % in Bakolori irrigated all their *fadama* crops, while the remaining farmers at each location irrigated only some of their crops. Different irrigation systems were used for various crops. At Wurno and Bakolori, rice was irrigated mainly through canal (gravity) under the Wurno and Bakolori Irrigation Schemes, respectively. The vegetable crops, on the other hand, were irrigated through small-scale irrigation using water-lifting devices. At Wurno, for instance, onion, garlic and onion/garlic mixture were irrigated by 53 %, 40 %, and 7 % of the respondents, respectively, using small petrol water pumps. Similarly, 33 % of the farmers at Kwalkwalawa produced onion with pump irrigation. Farmers at Bakolori used the same type of pumps to grow tomato (15 %), sweet pepper (10 %), chilly pepper (10 %), and

garlic (5 %). At Shamashalle, all vegetable crop growers used *shaduf*, a traditional way of gravity irrigation[1].

Of all *fadama* crops in the study area, sorghum, millet and cowpea were the least dependent on irrigation. Usually the crops were grown either rainfed or they depend on residual moisture in the *fadama* soils. Nevertheless, 20 %, 35 %, 25 %, and 35 % of the respondents at Bakolori produced sole millet, sorghum, cowpea, and sweet potato, respectively, under sprinkler irrigation.

Generally, no elaborate plant protection measures were undertaken. The use of pesticides was restricted to few farmers who sprayed mostly Cymbush against insects in cowpea and cotton. Harvesting of all crops was manual. This was accomplished through hand picking (for the vegetable crops and cowpea), cutting with cutlass and/or sickle (in the case of cereals), and digging (in the case of tuber crops).

Crop yields

The average economic and residue yields of crops produced in the *fadama* are presented in Table 9. The economic yields of the crops were lower than the attainable yields or even the national averages. For instance, the yield of tomato (2,912 kg/ha) was far below the 13,924 kg/ha obtained in Bauchi State of Nigeria (BABA, 1993) and the national average of 12,345 kg/ha (FAO, 1990). The onion yield of 9,819 kg/ha was also lower than the 26,393 kg/ha reported for Kano State of Nigeria. The sorghum yield of 392 kg/ha was far short of the range of 1,037 kg/ha - 2,566 kg/ha reported in northern Nigeria by IWUAFOR *et al* (1988). Rice yield was, however, higher than the national average which ranged from 1,486 kg/ha - 1,942 kg/ha between 1971 and 1974 (ADENIYI, 1988). The generally poor yield performance of most of the crops could probably be attributed to inadequate utilisation of improved inputs by the farmers.

As the economic yields were low, so also were the residue yields. The residue yields, as shown in Table 9, were 2,482 kg/ha, 1,947 kg/ha, 4,145 kg/ha, 702 kg/ha, and 553 kg/ha for rice, millet, sorghum, cowpea and sweet potato, respectively. Also presented in Table 9 are the grain (economic yield): residue ratio of some of the crops. The ratios were only calculated for crops that are relevant as far as livestock feeding is concerned. The weights of the residue were taken when dry. Curiously, the weight of residue obtained from rice was lower than that of the grains. However, the weights of sorghum, cowpea and millet residue were much higher than those of their respective grains. The economic yield: residue ratio were 2.04, 0.40, 0.09, 0.49, and 9.59 for rice, millet, sorghum, cowpea and sweet potato, respectively.

Table 10 presents information on the average net farm incomes of farmers according to the location. Farmers in Wurno, Kwalkwalawa, Shamashalle and Bakolori obtained net farm incomes of N41,978/ha, N5,481/ha, N31,626/ha and N58,653/ha, respectively. These figures were significantly different ($P<0.05$).

Crop residue utilisation

Majority (about 93 %) of the farmer respondents combined arable farming with livestock production. Cattle, owned by 49 % of all the farmers, was the most popular. Goats, sheep and donkeys were owned by 38 %, 36 % and 22 % of the farmers, respectively. Information on how these livestock types were combined by the farmers in the various locations and by the pastoralists is presented in Table 11. Ownership of cattle alone (reported by 13 % of the farmers), cattle and donkey (13 %), goat and sheep (13 %), as well as cattle, goat and sheep (13 %) were the most popular at Wurno. Twenty per cent of farmers at this location did not own livestock. At Kwalkwalawa combinations of goat and sheep, as well as goat, sheep and donkey, each reported by 22 % of the farmers were the most common.

[1] Variously known as shadouf, shaduf, counterpoise, dhunkali, Kheteraz, and guinina, the shadouf is a simple device for lifting water using the principle of the lever. A container is suspended from one end of a long pole; with the aid of a counterweight at the opposite end of the pole and a fulcrum, water is lifted from a source such as a stream, pond or open well (BABA, 1993).

Table 9: Economic and residue yield

Crop	n	Economic yield (kg/ha)	Residue yield (kg/ha)	Grain : residue ratio
Onion	18	9819 ± 5382	na	na
Garlic	7	3250 ± 2380	na	na
Rice	40	5073 ± 9881	2482 ± 4201	2.04
Millet	10	775 ± 2771	1947 ± 2420	0.40
Sorghum	16	392 ± 1583	4145 ± 897	0.09
Cowpea	8	344 ± 2653	703 ± 5730	0.49
Sweet potato	10	5310 ± 19442	553 ± 2608	9.59
Sweet pepper	5	13954 ± 7564	na	na
Chilly pepper	5	2292 ± 6336	na	na
Tomato	9	2913 ± 497	na	na
Wheat	5	2500 ± 887	2500 ± 1056	1.00
Okra	3	3125 ± 1346	na	na
Cotton	5	678 ± 554	na	na
Groundnut	1	2000	1900	1.05

Table 10: Average net farm income according to location (N/ha)

Location	Net farm income		
	n	Mean	SD
Wurno	15	41978	33131
Kwalkwalawa	9	5481	11720
Shamashalle	10	31626	58971
Bakolori	20	58653	81761

The most frequent combinations at Shamashalle were cattle and goat, cattle and donkey, as well as cattle, goat and sheep, each reported by 20 % of the farmers. By far the most frequently reported combination at Bakolori was cattle, goat and sheep (55 %). This same combination reported by 73 % was also the most popular among the pastoralists. Ownership of camel was reported by only one pastoralist.

Table 12 presents information on the herd sizes of the farmer respondents. This information was collected only with respect to farmers at Shamashalle and Bakolori. The average number of cattle, goat, sheep and donkey owned by a farmer at Shamashalle were 1.17, 8, 7.17 and 0.5,

respectively. The average number of the same livestock in the order presented above were 2.58, 5.10, 3.20 and 0.44 at Bakolori. Excluding the donkeys, the above livestock figures is equivalent to 2.32 and 2.58 Tropical Livestock Units (TLU) for Shamashalle and Bakolori, respectively. A head of cattle is equivalent to 0.68 TLU while one sheep or one goat is equal to 0.1 TLU (SCHÄFER et al., this volume). With an average farm size of 3.87 ha at Shamashalle and 6.91 ha at Bakolori, the TLU/ha were 0.60 and 0.37, respectively.

Table 11: Distribution of respondents according to type of livestock owned (%)

Livestock combination	*Fodama* farmers				Pastoralists
	Wurno (n=15)	Kwalkwalawa (n=9)	Shamashalle (n=10)	Bakolori (n=20)	(n=11)
Cattle	13	0	0	5	0
Goat	7	0	10	5	0
Sheep	7	11	10	0	0
Donkey	0	0	0	0	0
Cattle + goat	0	11	20	10	0
Cattle + sheep	7	0	0	5	16
Cattle + donkey	13	11	0	0	0
Goat + sheep	13	23	20	0	0
Goat + donkey	0	11	0	0	0
Sheep + donkey	0	0	10	0	0
Cattle + goat + sheep	13	0	20	55	76
Cattle + goat + sheep + donkey	7	11	10	10	0
Goat + sheep + donkey	0	22	0	5	0
Cattle + sheep + camel	0	0	0	0	8
None	20	0	0	5	0
Total	100	100	100	100	100

Table 12: Average number of livestock per farmer

Livestock	Shamashalle			Bakolori		
	n	Mean	SD	n	Mean	SD
Cattle	10	1.17	2.04	20	2.58	2.43
Goat	10	8.00	8.37	20	5.10	3.03
Sheep	10	7.17	11.41	20	3.20	2.04
Donkey	10	0.50	0.84	20	0.44	0.73

All the farmers owning livestock and the pastoralists used one form of crop residue or another as livestock feed. Sorghum straw (used by 88 % of the farmers and 90 % of the pastoralists) was the most common. This is in agreement with ALHASSAN (1989) who asserted that sorghum stover is the most widely used crop residue in northern Nigeria. Sorghum was followed, in the case of the farmer respondents, by cowpea hay (81 %), groundnut haulm (44 %), rice straw (39 %), millet straw (17 %), sweet potato hay (11 %), and maize straw (1 %). The situation was slightly different with the pastoralist respondents all of whom used rice straw. Cowpea hay, groundnut haulm and millet straw were used by 45 %, 27 % and 18 % of them, respectively.

The other major uses of crop residue in the area, apart from feeding it to animals, include fencing, roofing, mixing with mud for building, and as cooking fuel. Table 13 shows that removal for cooking fuel (reported by 67 % of all the farmers) was the most popular, followed by building (including fencing, mixing with mud, and roofing) (54 %), selling (20 %) and craft work (4 %). About 28 % sometimes leave residue on the field.

Table 13: Other uses of crop residue (percentage of respondents using)

Use	Wurno (n=15)	Kwalkwalawa (n=9)	Shamashalle (n=10)	Bakolori (n=20)	All farmers (n=54)
Cooking Fuel	33	89	60	85	67
Craft work	13	0	0	0	4
Building/ fencing	53	56	90	35	54
Selling	40	33	20	0	20
Left at the farm	20	0	10	55	28

* Figures may be greater than 100 due to multiple response.

Crop residue marketing

As stated above, 28 % of all respondents sometimes leave crop residue in the field. The farmer may graze his livestock on the harvested plots or sell the plots to other farmers or pastoralists. For instance, all the pastoralists interviewed in this study purchased harvested farm plots for grazing their animals. They negotiated with farmers and paid either in cash or in the form of manure. The amount charged depends on the size of the farm and the type of residue in question. In general, an average of N1,250/ha was charged at Wurno and Kwalkwalawa, N1,260/ha at Shamashalle and N1,879/ha at Bakolori.

Table 14: Weights of local units of sale of residue (kg/bundle)*

Residue type		Wurno		Kwalkwalawa		Shamashalle		Bakolori	
	n	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sorghum straw	5	33.0	9.1	21.9	4.9	29.6	8.6	27.4	11.2
Cowpea hay	5	6.8	1.3	9.8	5.1	8.9	2.4	5.4	2.88
Rice straw	5	na	na	55.0	26.7	103	25.4	105	25.5
Groundnut hay	5	10.3	2.9	na	na	16.6	4.7	19.7	4.4
Millet straw	5	37.8	11.2	na	na	na	na	30.1	11.1
S. potat hay	5	na	na	na	na	na	na	16.0	6.1

* Groundnut haulm was measured in bags

A more conspicuous commercial transaction is seen in various towns and villages where crop residue is sold in bales and bundles for cash. The prices of residue varied considerably from one location to another even for the same species. This is only to be expected since the units of sale (bundles) are not standardised. Table 14 shows that the weight of a bundle of sorghum hay varied from an average of 21.86 kg in Kwalkwalawa to 33 kg in Wurno. The weight of cowpea hay bundle also varied from 5.4 kg at Bakolori to 9.8 kg at Kwalkwalawa. Similar differences

were observed for other crop species. These variability in weight might have contributed to the observed differences in prices among the locations (see Table 15).

The mode of transporting crop residue included head portage, animal transport (mainly donkey) and motor vehicles. Head transport was used by 7 % of farmers in Wurno, 33 % in Kwalkwalawa, 20 % in Shamashalle, and 30 % in Bakolori. Vehicle transport was used by 13 % in Wurno, 10 % in Shamashalle and 40 % in Bakolori. No farmer used vehicles in Kwalkwalawa. Animal transport was used by 53 % in Wurno, 11 % in Kwalkwalawa, 30 % in Shamashalle and 25 % in Bakolori. Animal transport was, therefore, the most frequently used mode of transporting crop residue.

The average cost of transporting residue with animals was N0.42/kg, N0.58/kg and N0.72/kg at Wurno, Shamashalle and Bakolori, respectively. The cost of transporting with vehicle in the same order was N0.92/kg, N1.26/kg and N0.43/kg. Charging money for head transport was practised only at Shamashalle and Bakolori where head transport attracted N0.34/kg and N0.60/kg, respectively. Transportation costs were not directly incurred at Kwalkwalawa because the farmer either transported his own residue on head or used his own donkeys.

Table 15: Crop residue retail prices at the rural markets in each of the locations (N/kg)

Residue type		Wurno		Kwalkwalawa		Shamashalle		Bakolori	
	n	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sorghum straw	5	2.87	1.10	1.13	2.20	1.29	1.83	2.88	2.60
Cowpea hay	5	7.47	9.20	6.11	1.82	3.75	2.77	3.31	1.54
Rice straw	5	na	na	3.69	5.82	0.6	0.96	0.50	0.35
Groundnut hay	5	6.96	3.60	na	na	7.01	5.78	9.27	12.84
Millet straw	5	1.29	0.87	na	na	na	na	na	na

Storage costs in the area were minimal because most of the residue were stored in fenced areas, roof tops and living houses. Probably because of lack of good storage facilities, the farmers complained of quality deterioration in storage leading to rejection of residue by livestock. This was particularly noticeable when the residue was stored up to the time of arrival of the next rains. Under such circumstances, the high relative humidity accelerates the rate of deterioration.

Looking back the past few years, most farmers agreed that more crop residue is available because of the expanding cultivation of the *fadama* land, but they also indicated that the prices of the residues have been on the increase. The latter may suggest increasing pressure on available feed resources in the area.

Summary and conclusion

The paper examined different aspects of crop residue production and utilisation in the study area. In crop residue production, labour utilisation was high, while utilisation of improved inputs was low. The low level of utilisation of improved inputs was attributed to inadequate supply and their prohibitively high costs. Probably as a result of this inadequate utilisation of improved inputs, both economic and residue yields were generally low. The yields could therefore be improved through easier accessibility of farmers to the inputs.

From the viewpoint of residue utilisation for livestock feed in the area, only sorghum, cowpea, rice, groundnut, millet and sweet potato seem to be important. Quite a substantial proportion of

the area cultivated in the *fadama* is devoted to these crops. It is, therefore, tempting to conclude that the *fadama* could play a major role in crop residue supply, especially if efforts are made to increase both economic and residue yield through increased utilisation of improved inputs especially since *fadama* crop production in the area has been shown to be profitable.

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