COMMUNICATIONS

crop mixtures as a land use strategy in northern Nigeria

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ABSTRACT

Because the landbase of the small-holder farmer in northern Nigeria is inadequate, he is forced to plan purposefully if he is to meet the food requirements of his family. Faced with this type of scenario every year, he has come to adapt a land use strategy which best accomodates the situation in which he finds himself.
Over the years, farmers in northern Nigeria have come to prefer growing their corps in mixtures rather than sole. With the aid of an income model, a risk aversion model, and a minimum nutrition model, this paper attempts to establish the rationality behind farmers' preference for crop mixtures.
While no conclusion is reached as to whether or not they are making the best use of their land, it is clear from the analysis that there are clear-cut rationality behind their choice of cropping patterns.
The paper concludes that problems of indigenous cropping systems and, hence, of land use patterns should aim at identifying the rationality behind the strategies employed by farmers to meet their goals, then avoiding actions which weaken those strategies and encouraging measures to strengthen them.

RÉSUMÉ

Le petit agriculteur du nord de la Nigeria, du fait de l'insuffisance des terres cultivables, est obligé de planifier méthodiquement son exploitation s'il veut faire face aux besoins alimentaires de sa famille. Confronté à la répétition, année après année, de ce scénario, il a fini par adopter une stratégie d'utilisation des terres qui s'accorde au mieux avec la situation dans laquelle il se trouve.
Au fil des années, les paysans nord-nigérians ont finalement opté pour les cultures associées, de préférence à la monoculture. En s'appuyant sur des modèles appliqués aux revenus de l'exploitation, aux risques encourus et aux besoins alimentaires minimum, la présente communication s'efforce de démontrer la rationalité qui gouverne la préférence accordée par les petits exploitants à leur système de cultures associées.
Bien qu'aucune conclusion ne puisse être donnée sur le bien-fondé de ce type d'utilisation des terres, l'analyse établit clairement l'existence d'une rationalité très précise derrière ces choix de systèmes culturaux.
En conclusion, la communication estime que les études concernant les systèmes de cultures « traditionnels » et, par là même, les structures d'utilisation des terres, devraient s'employer à identifier les choix rationnels qui sous-tendent les stratégies suivies par les paysans pour atteindre leurs objectifs, à éviter ainsi les projets de développement qui leur nuisent et à encourager enfin les mesures susceptibles de renforcer ces systèmes.

INTRODUCTION

Due to lack of written documentary and statistical records the nature of pre-nineteenth century use and development of land in Nigeria is not well known. Not until 1900 was there a formal undertaking to define a land tenure structure within which land could be managed and developed (PARSONS, 1970).

Before the advent of either the Fulanis or the British parcels of land were owned by families, clans, and lineages. A member of a community could obtain access to a communal land with the approval of the leadership of the community. He was however prevented from selling or alienating any portion of the family land (OLUWASANMI, 1966). This communical ownership of land, with a mythical and fluctuating membership (the dead, the living, and the unburn) has remained largely intact over the years. The prevailing land tenure system in northern Nigeria that allows land for agricultural use to be acquired mainly through inheritance within the family has resulted in a large number of fragmented small land holders in the area.

This small-holder agriculture is characterized by a situation where :

1. the bulk of the labour force, management, and capital come from the same household;
2. production is either consumed on the farm and/or traded in local markets;
3. the decision-making process is hampered by limited access to marketing and political institutions;
4. the bulk of the farmers do not live much above the culturally determined subsistence level (HARRISON et. al. 1974).

There is a marked seasonal distribution of rainfall in northern Nigeria. The rains generally begin in April or early May and continue to the end of September or middle October. During the rainy season, upland fields are cleared, plowed, planted, weeded and ridged. The first crop to be harvested is millet, in August-September. Other crops (groundnuts, cowpeas, cotton, peppers, etc.) are harvested as they mature, with the major grain crop, sorghum, being harvested last around January (SIMMONS, 1978).

The crops farmers come to choose to grow will not only depend on physical factors like rainfall, temperature, soil fertility etc; they will also depend on economic social and political considerations (BAKER et. al. 1975). Also, the land use pattern that emerges will be influenced by the level of technology and the availability of factors of production. The farmer is forced to make decisions concerning how to combine the resources available to him to produce agricultural output in accordance with the goals he is pursuing and within the limits of the environment under which he operates.

Because his landbase is often inadequate, the farmer is forced to plan purposefully if he is to meet his food requirements and those of his family. Towards the end of the dry season his food is short supply and farming activities are at their peak. Heavy mannual labour is required for land preparation and for weeding. At the same time, food prices are high and poor road conditions in the rains make it difficult for either central authorities or the open market to relieve local shortages. But the farmer has to cater for his and his familys' food requirements.

Faced with this type of a scenario year after year out, he has come to adopt a land use strategy which best accomodates the situation in which he perennially finds himself. But is this land use pattern he has come to adopt and prefer rational and logical? In the past, land use strategies by farmers in northern Nigeria have often been viewed as irrational and illogical. Recently, however, studies have pointed to clear-cut rationality.

In the rest of this paper, we examine the rationality behind farmers' preference for crop mixtures in northern Nigeria.

WHY CROW CROPS IN MIXTURES?

The growing of crops in mixtures is a widely used traditional practice in northern Nigeria. NORMAN (1975) found 24 different crops on rainfed (gona) land in a total of 174 different crop mixtures. Sole crops accounted for only 17 percent of the total cultivated acreage. Common crop mixtures and their relative popularity are shown in Table 1.

Although there are technical reasons in support of growing crops in mixtures (1), there has, however been a long standing tradition to associate progressive agriculture in the area with sole cropping (NORMAN, 1974). This has probably been the case because researchers have often held that the biology of crop production suggests a strong relationship between physical inefficiency in land use and the growing of crops in mixtures.

However, despite the alleged superiority of sole cropping to mixed cropping, and despite efforts by researchers and extension workers to impress farmers to the contrary, there has been no apparent shift from crop mixtures to sole cropping. What then is the rationality behind this persistance in crop mixtures?

Maximizing Income (2)

In his study of the rationalization behind mixed cropping under indigenous conditions in northern Nigeria, Norman found that individual physical yields of sorghum, groundnuts and cotton are depressed when grown in mixtures rathern than in sole stands. However, this was not always true for crops that are normally grown in mixtures like cowpeas and millet. Sole stand cowpeas appear to be more prone to insect and disease attack than when they are grown in mixtures, and millets, which are the first seed planted at the beginning of the rains and the first crop harvested in the growing season, are unlikely to suffer greatly from competition with other crops.

Average gross and net returns from sole crops and crop mixtures are presented in Table 2. Average gross returns per acre are about 62 percent higher for crop mixtures. Average

(1) These include utilisation of environmental factors like light, water, and nutrient; reducation of adverse condition in the eco-system, and soil protection, (NORMAN, 1974).

(2) This section draws from NORMAN'S (1975) work on crop mixtures.

net returns per acre show the same trend. It is obvious from Table 2 that crop mixtures show higher returns per unit of land than sole cropping. By this criteria, therefore, the preference of crop mixtures represents a rational land use strategy.

Risk Minimization

Numerous writers have incorporated yield and price variability into models representing the decision framework of small-holder farmers (WHARTON, 1968). Farmers in Northern Nigeria are faced with a limited growing season and constrained by limited resources. They are therefore concerned with ensuring a stable income in the face of biological and economic occurences whose future outcomes they cannot determine exactly in advance. Their land use patterns would therefore be influenced by formulations of expectations about future price and production situations which they make subjectively. On the basis of long established traditional procedures, they are able to arrive at complex calculations concerning probable future price and yield outcomes. On this basis, they may choose not to cultivate single crops over time, even where substitution ratios and price ratio expectations may so dictate, but to cultivate crop mixtures in somewhat fixed proportions over time. The rationality behind their strategy here is simply not to put all of their « eggs in one basket ».

TABLE 1. COMMON CROP COMBINATIONS IN THE ZARIA AREA

Crop Specification		Percent of total cultivated acreage
Sole crops		
sorghum		8.4
Groundnuts		1.8
Cotton		3.1
Other crops : 15 (3)		3.3
	Sub total	16.6
Two crop mixtures		
Millet/sorghum		25.8
Sorghum/groundnuts		2.8
Cotton/cowpeas		3.9
Other crop combinations : 35		9.6
	Sub total	42.1
Three crop mixtures		
Millet/sorghum/groundnuts		5.0
Millet/sorghum/cowpeas		3.9
Cotton/cowpeas/sweet potatoes		4.3
Other crop combination : 47		10.5
	Sub total	23.7
Four crop mixtures		
Millet/sorghum/groundnut/cowpeas		5.4
Other crop combinations : 38		6.7
	Sub total	12.1
Five and six crop mixtures		
Combinations : 19		5.5
	Total	100.0

Source : NORMAN (1975).
Note : A total of 890.7 cultivated acres of rainfed land, i.e., upland, where included in the survey.

(3) These are the number of crop enterprises not specified by name in the table.

TABLE 2 . AVERAGE GROSS AND NET RETURNS FROM SOLE CROPS AND CROP MIXTURES (IN SHILLINGS)

Variable	Crop mixtures					
	Sole crops	Two crops	Three crops	Four crops	All mixtures	Overall
Gross return per acre :	153.6 ± 22	240.6 ± 19	229.8 ± 30	340.9 ± 80	248.3 ± 16	228.5 ± 13
Net return per acre. Labour :						
Not costed	148.9	235.7	220.3	322.9	240.8	221.6
Hired costed	135.2	213.6	199.1	297.4	218.6	201.2
June-July costed	133.7	204.7	189.0	276.8	208.2	190.2
All costed	74.1	115.5	105.3	184.6	119.8	110.1

Source : NORMAN (1975).
Note : June-July is a labour bottleneck period when land preparation, weeding and planting are taking place simultaneously.

The use of crop mixtures as a diversification precuation against uncertainty can be accomplished in two different ways;

1. The amount of resources can be increased so as to be able to produce both products A and B or
2. The amount of resources can be held constant while part of it is shifted to the production of other products.

Since factors of production have been shown to be limiting in the agriculture of the area, it is the later method that seems to be more applicable. Because of the marked seasonal distribution of rainfall in the area, the diversification strategy has tended to be pursued through mixed cropping rather than through multiple or relay cropping. (BAKER, et. al. 1975).

The question may be raised that if the farmer is dealing solely with risk aversion why should be, for example, mix Crop A and Crop B over his entire field rather than divide his field between Crop A and Crop B, and sow pure stands in each part of the fields. One possible answer to this question is that the farmer, realizing that he is faced with a limited growing season, attempts to choose crops with complementary growing cycles. Because of this, he is able to grow the crops closer together than if they were grown alone. He therefore ends up not only maximizing his return per unit of land but also experiencing less difficulties with the June-July labour bottleneck period.

Using a mean-variance framework, an attempt was made to test the hypothesis that risk aversion is a critical item in explaining farmers' decision concerning land use and development (4).

Table 3 contains information on the average value, range and standard deviation of income derivable from one acre of land monthly over the period January 1971 to January 1975. On the basis of the table and information on the correlation between net incomes of crops, the proportions of resources devoted to pairs of crop enterprises which will minimize the relative variability of income overtime are derived. The proportion of resources devoted to pairs of crop enterprises under the stated conditions are given in Table 4 together with the actual observed proportion of land devoted to each enterprise in the pair relative to the total land devoted to the pair of crop enterprises. Paired comparison of the proportion of land devoted to the pairs of crop enterprises as determined by applying a minimum variance model and the actual proportions calculated for the pairs in the study area suggests that we accept a null hypothesis of no differences between the two series of proportions (5). The results indicate that the land use pattern by small-holder farmers in the area can be rationalized by a risk-minimizing strategy.

Meeting Protein and Calorie Requirements

Malnutrition has very serious repercussions for the small-holder farmer. At any point in time there is a balance between the nutritional resources that are available to him (which depends largely on how much food was produced during the preceeding harvest) and the nutritional requirements that he needs to maintain the existing and future livelihood of his family. This ratio of available resources to required inputs will vary depending on the crops that the farmer chooses to grow on his limited land base.

The farmer would be expected to adjust and reallocate agricultural resources available to him and adopt or discard land use practices in the face of threats of malnutrition to him and

(4) Details about the methodology employed can be found in Abalu (1976).

(5) Under the null hypothesis of no difference between the two series of proportions against the alternative hypothesis that the two series are different, the calculated value was equal to at-value of 0.333, suggesting that we accept the null hypothesis at a very high level of confidence. It should be pointed out that comparisons were made only for the rows where information existed for both series.

TABLE 3. AVERAGE VALUE, MINIMUM VALUE AND STANDARD DEVIATION PER ACRE OF LAND, JANUARY 1971 - JANUARY 1975 (6)

CROP ENTERPRISE	MEAN	MINIMUM VALUE	MAXIMUM VALUE	STANDARD DEVIATION
Sorghum	602.17	346.92	1062.00	169.95
Groundnuts	657.61	298.68	1110.88	210.92
Millet/Groundnuts	989.41	196.38	1663.63	305.97
Groundnut/Cowpeas	681.41	316.96	1103.10	204.40
Millet/Sorghum/Groundnut	1014.74	567.58	1699.16	271.68
Millet/Sorghum/Cowpeas	898.74	479.28	1770.37	245.86
Sorghum/Groundnut/Cowpeas	689	365.16	1173.40	196.53

his family. The beginning of the rains witnesses an increase in agricultural activities associated with land preparation, planting, weeding and harvesting. This is also the period when many people are in negative nutritional balance because of shortage of food. It has been suggested that some of the most serious debilitating diseases like malaria, diarrhoeal diseases, guinea worm and infections of the skin peak during this time as well (LONGHURST, 1978). Coinciding with a peak labour demand, when failure to cultivate, plant, weed or harvest may critically affect future income and food supplies, these infections diseases increase the risk and vulnerability of small-holder farmers in the area (LONGHURST, 1978). HILL (1972) has suggested that the ability of the farmer to survive this period determines to a large extent the welfare of the family during the rest of the year.

Is the small-holder farmer's land use pattern in terms of his choice of the crops he would like to grow consistent with his body requirements and those for the rest of his family? Does his choice of crops satisfy the nutritional requirements of his family? An attempt is made to answer these questions with the aid of a linear programming model. The model has as an objective the maximization of farm income in the face of a minimum nutrition constraint. Constraints were also imposed on available farm labour and farm land. Nine different cropping activities reflecting the most common cropping activities in the area were considered.

The data used in the analysis are derived from work by SIMMONS (1976) and NORMAN (1972).

Yearly requirements for an average family in the Zaria area of protein and calories are shown in Table 5. The program was analyzed using farm sizes of 3, 5, 10, 12 and 18 acres (average farm size in the area is 7.9 acres, NORMAN, 1972). The results thus obtained would show a relationship between farm size, and nutritional balance.

The results of the analysis are presented in Table 6. A farm size of 3 acres resulted in an infeasible solution. All the other farm sizes, however, were able to meet the nutritional constraints. In fact, a surplus of both protein and calories was found to exist in all cases. Over 70 percent of the protein and 40 percent of the calories supplied by the crop activities in the plan were in surplus.

Or significant interest in Table 6 is the fact that all crop activities in the optimal plans for all farm sizes are crop mixtures. This is all the more striking since provision was made in the model for non-protein and non-calorie generating crop activities to be able to enter the optimal plan provided they were able to generate enough income to purchase the minimum protein and calorie requirements.

It is also interesting to note that the farm size of 3 acres showed an infeasible solution suggesting that only a larger acreage is capable of meeting the protein and calorie requirements. Consequently, a farmer confronted with a limited land base would have to take alternative action if he is to feed his family adequately. One such action is for him, to (knowing that the land available to him is too small to meet the minimum nutritional requirements of his family if he grew food crops), choose the production of the most profitable crops that are compatible with his low income position. In most cases this would be a cash crop. Revenue received from the sale of the crop would thus allow a higher level of consumption of food (as well as meeting the minimum non-food cash needs) than if the entire land base had been allocated to less profitable food crops.

Although this paper does not further analyze the protein strategy of small-holder farmers who own farms that are three acres or less, a recent study of the study area does, however, provide some information on the nutritional strategy of land-scarce farmers. MATLON (1977) finds that groundnut pro-

(6) Value computations based on yield estimates from Norman, 1967, and price measurements from Hays, 1975.

duction was given relatively greater emphasis by low income farmers. The value of agricultural production was inadequate to meet their minimum nutritional requirements yet groundnuts constituted a disproportionately large component of their total harvest.

It would therefore appear that a nutrition strategy is also reflected by the land use patterns of farmers in northern Nigeria.

SUMMARY AND CONCLUSIONS

In this paper we have tried to show that small-holder farmers in northern Nigeria employ land use practices which are well adapted to the environment in which they operate. While no conclusion is reached as to whether they are making the best use of the land available to them, it is clear from the analysis in the paper that there is clear-cut rationality behind

TABLE 4. PROPORTION OF RESOURCES ALLOCATED TO PAIRS OF CROP ENTERPRISES

Crop Enterprises		Model Allocation of Resources (7)		Observed Allocation of Resources (8)	
A	B	P	1 - P	P	1 - P
Sorghum	Millet/Sorghum	0.27	0.73	0.25	0.75
Sorghum	Groundnuts/Sorghum	1.00	0.00	0.75	0.25
Sorghum	Millet/Groundnuts/Sorghum	0.70	0.30	0.62	0.38
Sorghum	Millet/Cowpeas/Sorghum	0.48	0.52	0.68	0.32
Sorghum	Groundnuts/Cowpeas/Sorghum	0.97	0.03	n.a.	n.a.
Sorghum/Groundnuts	Millet/Sorghum/Groundnuts	0.26	0.74	0.39	0.61
Sorghum/Groundnuts	Cowpeas/Sorghum/Groundnuts	0.18	0.82	n.a.	n.a.
Sorghum/Groundnuts	Millet/Cowpeas/Sorghum	0.69	0.31	0.71	0.29
Sorghum/Millet	Groundnuts/Sorghum/Millet	1.00	0.00	0.84	0.16
Sorghum/Millet	Millet/Cowpeas/Sorghum	0.53	0.47	0.86	0.14
Groundnuts	Groundnuts/Sorghum	0.66	0.34	0.40	0.60
Groundnuts	Groundnuts/Cowpeas	0.48	0.52	n.a.	n.a.
Groundnuts	Millet/Groundnuts/Sorghum	0.37	0.63	0.27	0.73
Groundnuts	Groundnuts/Cowpeas/Sorghum	0.20	0.80	n.a.	n.a.
Groundnuts/Cowpeas	Groundnuts/Cowpeas/Sorghum	0.11	0.89	n.a.	n.a.
Groundnuts/Cowpeas	Millet/Groundnuts/Sorghum	0.66	0.34	n.a.	n.a.
Groundnuts/Cowpeas	Millet/Cowpeas/Sorghum	0.53	0.40	n.a.	n.a.

(7) Proportion is computed as the quantity of land devoted to an enterprise relative to the total land devoted to the pair of enterprises.

(8) N.A. : Information not available. P. Is proportion of resources allocated to enterprise A and 1-P is proportion of resources allocated to Enterprise B.

their preference for crop mixtures. To the extent that the crops grown in a particular area are function of factors like water, temperature, radiation, evapo-transpiration and soil condition, the choice of cropping pattern would have a marked influence on the development of land resources in the area.

Farmers in northern Nigeria have continued to emphasize the growing of crops in mixtures despite strong efforts to dissuade them. It is obvious that the growing of crops in mixtures is a logical practice that has evolved over generations and which represents a kind of balance between technical (biological and physical) and human (economic and social) factors.

Solutions to problems of indigenous cropping systems and, hence, land use patterns should therefore aim at identifying the rationality behind the strategies used by small-holder farmers to meet their goals, then avoiding programmes or actions which weaken those strategies and encouraging and seeking measures to support, and strengthen them.

It is therefore clear from our analysis that rather than discourage the development of crop mixtures in northern Nigeria, efforts should be intensified to evolve improved mixed cropping systems which meet desirable land use standards. What clearly emerges from this paper is the fact that the development of crop mixtures relevant to the environment in which the farmer finds himself in northern Nigeria has to take into account both technical and human factors. It is, therefore, essential for this effort to have the participation of both technical and social scientists, so as to improve productivity and meet stated goals concerning agricultural production.

TABLE 5. CALORIE AND PROTEIN REQUIREMENTS FOR AN AVERAGE FAMILY, ZARIA

Age Category	Average Number	Annual Requirements	
		Calories (kg cal.)	Protein (gm.)
Less than 7 years	2.18	1.252	13.893
Between 7 - 14 years	1.54	1.313	16.919
Female over 14 years	2.62	1.913	33.941
Male over 14 years	2.15	2.119	30.642
	Total	6.597	95.395

TABLE 6. SOLUTIONS OF PROGRAM FOR DIFFERENT LAND SIZES

Land constraint (acres)	Crop Activities in the plan	Net Farm Income	Monts of labour hiring
3	Infeasible	—	—
5	Millet/Sorghum/Cowpeas	855	May
10	Millet/Sorghum/ G'nuts (5.99 acres) Millet/Sorghum/Cowpeas (4.01 acres)	1382	May, June July, August
12	Millet/Sorghum/G'nuts (9.64 acres) Millet/Sorghum/Cowpeas (2.36 acres)	1540.16	May, June, July Aug. November
18	Millet/Sorghum/G'nuts (15.99 acres) Millet/Sorghum/Cowpeas (2.56 acres)	1868	April, May, June July, August, October, November

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