ECONOMIC ANALYSIS OF MILLET-BASED CROPPING SYSTEMS IN BINDAWA AND CHARANCHI LOCAL GOVERNMENT AREAS, KATSINA STATE, NIGERIA

BY

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DECLARATION

I hereby declare that this thesis was written by me and it is a record of my own research work, except where reference is made to published literature and duly acknowledged. It has not been presented before in any application for a degree.

_____ _____

Ahmed Danlami ABUBAKAR **Date**

CERTIFICATION

This thesis titled "ECONOMIC ANALYSIS OF MILLET-BASED CROPPING SYSTEMS IN BINDAWA AND CHARANCHI LOCAL GOVERNMENT AREAS OF KATSINA STATE, NIGERIA'' by Ahmed Danlami ABUBAKAR meets the regulations governing the award of the degree of Master of Science in Agricultural Economics of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my family members in the academia for their enduring support and words of encouragement throughout the period of the study.

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ABSTRACT

This study examined the economics of millet-based cropping systems in Bindawa and Charanchi LGA_S, Katsina state. The specific objectives were to identify and describe the millet-based cropping systems; determine the inputs and output levels; determine the production functions; determine the resource use efficiencies; determine the costs and returns; and identify and describe the constraints associated with millet-farmers. Primary data were collected for the study, based on the 2010 cropping season using structured questionnaire administered on 160 millet-based farmers. The analytical tools used were the descriptive statistics, production function analysis and farm budget technique. The results of the study showed that the commonest millet-based cropping systems in the study areas were millet/sorghum (26.25%) and millet/sorghum/groundnut (25.00%). For inputs used, millet/sorghum/groundnut had the highest amount of land allocation of 82.3 hectares and sole millet had the least of 44.99 hectares. For seed, 26.64 GEW, 115.78 GEW, 149.61 GEW, 65.46 GEW were used for millet/sorghum, millet/sorghum/groundnut/cowpea, millet/sorghum/groundnut, millet/sorghum/cowpea, respectively and 39 kg was used for sole millet. For labour, 856 man-hours, 1163 man-hours, 882 man-hours, 866 man-hours and 675 man-hours were used for millet/sorghum, millet/sorghum/groundnut/cowpea, millet/sorghum/groundnut, millet/sorghum/ cowpea and sole millet, respectively. For fertilizer, 299 kg, 366 kg, 276 kg, 217 kg and 216 kg wereused for millet/sorghum, millet/sorghum/groundnut/cowpea, millet/sorghum/groundnut, millet/ sorghum/cowpea and sole millet, respectively. For pesticides, 7.3 litres/ha and 7.2 litres/ha were used for millet/sorghum/groundnut/cowpea and millet/sorghum/cowpea, respectively. The mean yield of millet cropping systems showed that 1939.14 GEW/ha, 5910.54 GEW/ha, 5645.04GEW/ha, 2786.28 GEW/ha and 1902.3 kg/ha were obtained for millet/sorghum, millet/sorghum/ groundnut/cowpea, millet/sorghum/groundnut, millet/sorghum/cowpea and sole millet, respectively. The results of the production function analysis showed that for millet/sorghum, the coefficients of farm size ($P \leq 0.05$), seed ($P \leq 0.1$) and fertilizer ($P \leq 0.1$) were positive and significant. For millet/sorghum/groundnut/cowpea, the coefficients of farm size, labour and pesticide were positive and significant ($P \leq 0.01$ each). For millet/sorghum/groundnut, farm size ($P \leq 0.01$), labour ($P \leq 0.05$) and fertilizer ($P \leq 0.01$) were positive and significant. For millet/sorghum/cowpea, farm size ($P \leq 0.05$), seed ($P \leq 0.01$), labour ($P \leq 0.05$) and pesticide ($P \leq 0.1$) were positive and significant. For sole millet, only seed ($P \leq 0.1$) was positive and significant. The resource use efficiencies for the millet cropping systems showed that for millet/sorghum, farm size and seeds were under-utilized, but labour and fertilizer were over-utilized. For millet/sorghum/groundnut/cowpea, farm size was under-utilized but seeds, labour, fertilizer and pesticide were over-utilized. For millet/sorghum/groundnut, farm size, labour and fertilizer were under-utilised, but seed was over-utilised. For millet/sorghum/cowpea, farm size was under-utilized but seed, labour and fertilizer were over-utilized. For sole millet, farm size and seed were under-utilized but labour and fertilizer were over-utilized. The results of costs and returns analysis showed that the millet-based cropping systems were profitable, with gross margins per hectare of ₦5,713.85, ₦189,010.40, ₦42,744.3, ₦196,077.60 and ₦2,026.01 for millet / sorghum, millet / sorghum / groundnut/cowpea, millet / sorghum / groundnut, millet / sorghum / cowpea and sole millet, respectively. The average rates of return were 1.39, 9.28, 3.54, 12.63 and 1.17 for millet / sorghum, millet / sorghum / groundnut / cowpea, millet / sorghum / groundnut, millet / sorghum / cowpea and sole millet, respectively. The most

important constraint in the millet cropping systems was inadequate fertilizer. Some of the recommendations made include advising farmers to use of optimal levels of inputs.

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CHAPTER ONE

INTRODUCTION

Millet is the staple food for over 100 million people in parts of tropical Africa and India (Brink and Belay, 2006). The International Crops Research Institute for Semi-Arid Tropics (ICRISAT) was established at Hydrabad, India, to provide world-class research and training on important millets (Onwueme and Sinha, 1991). Estimates based on total millet production (FAO statistics) and relative importance of millet in different countries indicate an annual grain production of about 18 million tonnes from a planted area of 26.5 million hectares mostly in the dry regions of Africa (60% of area and 58% of production) and the Indian subcontinent (38% of area and 41% of production (Brink and Belay, 2006). Production statistics over the past 10 years show a 20% increase in area planted in Africa, with a 12% increase in yield. Most of the area increase is in Burkina Faso, Chad, Mali, Niger and Nigeria but yield levels increased only in latter two countries (Brink and Belay, 2006).

In general, the millets are useful where a grain crop is needed to capitalize on short growing periods. This role is most important in the dry tropics where the period with adequate rainfall for crop growth is short (three to five months) or in regions of more adequate rainfall where a short-season grain crop can be grown as a secondary planting following a main crop on the same land (Onwueme and Sinha, 1991). In regions of severely limited rainfall, millet may be the principal cereal because of its flexibility in management to avoid drought (Onwueme and Sinha, 1991).

1.1 Problem Statement

In Nigeria, the increase in food production in recent years has not been able to keep pace with the rapid population growth. The population is growing geometrically by nearly 4% annually but food production is increasing arithmetically at only half of that rate (Okumadewa, 2001). The United Nation's Population Fund in a report in 1993 posited that the demand for food is expected to reach unprecedented levels in the near future as world population is estimated to double in 50 years to about 11 billion, with 98 per cent of the future population growth likely to be in developing countries. Such countries are expected to be characterized by high prices of food items and precarious food insecurity situations. Millet-based cropping systems are practised with simple tools by traditional methods, using practices based on trial and error under low level of adoption of new technologies (Elemo *et al.*, 1990). The almost complete lack of capital and the often restricted availability of labour have led to limited production capacity (Steiner, 1982). Consequently, farmers produce only slightly more food than is required by their household. Given the place of millet in the diet of rural people, there have not been the required increases in output necessary to meet the demand for food and as industrial raw-material. For example, the average millet grain yield under local practices of agriculture in tropical Africa is 0.25 to 1.5 tonnes per hectare. This is low compared to yields of up to 5 tonnes per hectare that are obtained under experimental conditions with improved cultivars, optimal weed control and use of fertilizers (Brink and Belay, 2006). It will thus be valuable to document the types of cropping systems involving millet, determine the level of productivity and which of the mixtures is more profitable than others. It will also be of great value to determine which resources are efficiently used and enumerate the constraints to millet-based cropping systems. Consequently, this study aims to provide answers to the following questions:

(i) what are the common millet-based cropping systems in the study area

(ii) what are the inputs and output levels for these millet-based cropping systems

(iii) what are the production functions of the different millet enterprises

(iv) what are the resource use efficiencies in millet-based cropping systems

(v) what are the costs and returns in millet-based cropping systems

(vi) what are the constraints associated with millet-based cropping systems

1.2 Objectives of the Study

The broad objective of the study is to examine the millet-based cropping systems in the study areas. The specific objectives are to:

(i) identify and describe the millet-based cropping systems in the study areas

(ii) determine the inputs and output levels for these millet-based systems

(iii) determine the production functions for the millet-based cropping systems

(iv) determine the resource use efficiencies for the millet-based cropping systems

(v) determine the costs and returns for the millet-based cropping systems

(vi) identify and describe the constraints associated with millet-based cropping systems

1.3 Justification

The crops that farmers choose to grow in an area depend not only on physical factors such as rainfall and temperature, but also on economic, social and political considerations (Baker and Norman, 1975). The general objective of farmers is sustainable production at minimal risk, to satisfy subsistence and commercial needs (Beets, 1990).

Smallholder agriculture is mainly subsistence agriculture. This is to say, the primary objective of production is to satisfy the needs of the family, but not to produce for the market. Developing small farms requires a proper analysis of existing farming systems to identify situations in which the existing farming resources are insufficiently utilized (Steiner, 1982). This study seeks to provide information on production efficiency in millet-based cropping systems and help identify the most profitable millet enterprises in terms of profitability and the efficiency of use of resources.

Farmers also need to have proper understanding of the millet-based enterprises that are more profitable, because farmers with limited resources have limited capacity to tolerate failure in production (Henriet *et al.*, 1997a). It is also possible for the researchers, policy-makers, non-governmental organizations and international organizations to obtain further information on the problems associated with millet-based cropping systems in the areas of resource allocation and farmer's socio-economic environment.

CHAPTER 2

LITERATURE REVIEW

2.1 Intercropping in smallholder Agriculture of Tropical Africa

A central part of traditional farming systems in most parts of tropical Africa is intercropping (Steiner, 1982).Specific intercropping systems have developed over the centuries in the different regions and they are closely adapted to the prevailing ecological and socio-economic conditions (Steiner, 1982). These systems evolved over centuries of experience to ensure optimum use of available resources for sustainable production (Henriet *et. al*., 1997b). Intercropping therefore, differs frequently from one area to another with changes in soils and local climates. Social and cultural conditions may be superimposed on the ecological and economic ones, leading to different cropping systems in the same ecological zone. Ethnic groups differ, for example, in food preferences or their organization of labour. The reason for these variations can sometimes be found in migration from other ecological zones (Steiner, 1982).

Intercropping is the growing of two or more crops simultaneously on the same field. Multiple cropping is the general term for all cropping patterns where more than one crop is cultivated on a field in one year (Andrews and Kassam, 1976). The various patterns of multiple cropping reflect essentially two underlying principles: that of growing crops simultaneously on a given piece of land, that is, intercropping, and that of growing individual crops in sequence during one growing season on the same piece of land, that is, sequential cropping (Steiner, 1982). In this context, growing crops 'simultaneously' mean those crops is grown together for most of the growing period. This does not require that the crops are planted or harvested on the same date. However,

when the overlap in time is too small, for example, only 4 weeks out of a growing season of 3-4 months, the term relay crop is used (Steiner, 1982).

Intercropping systems themselves can be distinguished by spatial arrangement of the component crops, as the intimacy of the crop mixtures has important effects on the interactions between the crop species (Steiner, 1982). The term 'row intercropping' is used when crops are planted in alternate rows, while 'mixed intercropping' is used when no specific spatial arrangement can be distinguished (Steiner, 1982).

Mixed cropping is a common practice among traditional farmers of the Nigerian Savanna. On the average, not less than 60-70% of cropped land is devoted to growing of crops in mixtures. While two-and three-crop mixtures are more common, it is possible to get up to eight crops in a mixture and in the Zaria area alone Norman found about 230 different types of crop mixtures (Elemo, *et al.,* 1990).

In general, there is no indication of any decrease in the importance of intercropping. On the contrary, as efforts of extension services to introduce sole cropping have often failed, it has now sometimes become government policy to increase production by improving intercropping systems (Steiner, 1982).

2.2 Millet cropping systems in the Nigerian savanna

A cropping system is the crop production activity of a farm. It comprises all cropping patterns grown on the farm and their interaction with farm resources, other household enterprises and the physical, biological, technological, and socio-economic factors or environments (Elemo *et al*., 1990). Given the wide variation in the human and technical

elements existing in the Nigerian Savanna, a great diversity exists in the traditional farming systems (Elemo *et al*., 1990).

2.2.1 Sahel savanna

Millet is the most important crop of the Sahel agroecological zone and it is the staple food crop. The most important crop mixture is millet/sorghum (Elemo *et al.*, 1990).

2.2.2 Sudan savanna

In this agroecological zone, crops cultivated include millet, groundnut, and cowpea mainly in the northern part (Elemo *et al.*, 1990). The southern part of the zone is dominated by millet, sorghum and cowpea while other crops of less importance are sweet potato, cassava, swamp rice and vegetables like onion and pepper (Elemo *et al.*, 1990). The major millet cropping systems are sorghum/millet/cowpea, millet/cowpea and sorghum/millet. Groundnut may or may not be included in these mixtures.

2.2.3 Northern guinea savanna

Northern part of the northern Guinea savanna is dominated by sorghum, millet and cowpea. In the southern part, sorghum, maize and millet are the most important crops (Elemo *et al.*, 1990). Whenever the growing season begins, millet is always the first crop to be planted. Important millet crop mixtures in this zone is sorghum/millet (Elemo *et al.*, 1990)

2.2.4 Southern guinea savanna

Sorghum, maize and millet are predominant in the northern part of the Southern Guinea Savanna where sorghum and *dauro* millet are the major staple food crops. The major

millet crop mixtures include sorghum/*dauro* millet/ maize/groundnut and yam/maize/*dauro* millet (Elemo *et al.,* 1990).

2.3 Advantages and disadvantages of mixed cropping systems

Mixed cropping is the growing of two or more crops together on the same piece of land at the same time in a haphazard or systematic manner that the growth of some or all of the component plant types overlaps in space and time. Generally, this is synonymous with interplanting, intersowing, intercropping and crop mixture (Elemo *et al.,* 1990).

2.3.1 Advantages of mixed cropping

The advantages of mixed cropping include:

(i) It has been shown that mixed cropping gives higher total yields than sole cropping even if yields of individual components are reduced (Elemo *et al.,* 1990)

(ii) mixtures result in more efficient utilization of environmental resources (light, water, nutrients) by plants of different height, canopy structure, nutrient requirements and maturity (Elemo *et al.,* 1990)

(iii) in addition diseases and pests may not spread as rapidly in mixtures because of differential susceptibility to the pests and pathogens (Elemo *et al.,* 1990).

(iv) mixed cropping provides insurance against crop failure because if component crop fails, the other may not (Elemo *et al.,* 1990)

(v) effective coverage is provided for the soil by crop mixtures while erosion and exposure of soil to solar radiation are minimized (Elemo *et al.,* 1990).

(vi) Farmers prefer mixed cropping because it also provide a steady supply of a range of products for the family and help spread cost of labour more evenly throughout the cropping season (Elemo, *et al.,* 1990)

(vii) Mixed cropping may be used to suppres weeds, thereby reducing the cost of weed control and improving the quality of products (Elemo *et al.,* 1990)

2.3.2 Disadvantages of mixed cropping

As advantageous as a mixed cropping system, it is not devoid of shortcomings.

(i) mechanization of planting, harvesting and other productivity-enhancing practices are more difficult if not impossible, with mixed cropping than with sole cropping (Elemo, *et al.,* 1990).

(ii) the nutrients in the soil of mixed-crop farm are depleted yearly and given that smallholder farmers are extremely resource-poor, there is no hope of using inorganic fertilizers and adopting improved conservation methods to replenish the poor soil (Elemo *et al.,* 1990)

(iii) also, it is difficult to determine the exact quantities and modes of application of improve inputs and practices such as fertilizers, herbicides and spacing (Elemo *et al.,* 1990).

2.4 Production functions in Agriculture

A production function is defined as the physical relationship between the output and the inputs used in the production of the product (Olukosi and Ogungbile, 1989). Numerous algebraic forms can be used to derive production functions. The most widely used are:

(i) The linear production

The linear production function is given by:

$Y = a + cX$

Where:

Y = output

a = intercept

c = gradient of the slope

(ii) The Spillman – Mitscherlich polynomial function

Spillman – Mitscherlich suggested an exponential function in the form of:

$Y = M - AR^X$

Where:

Y = total output

X = total input

M = maximum total output possible because of using variable input

A = total increase in output

R = constant

M-A = output level defined by fixed resources when the variable input is at zero level

(iii) The Cobb-Douglas production function

The Cobb-Douglas function is a power function and is given by:

$Y = aX^b$

The function is easy to fit and the co-efficient represent direct elasticities of inputs.

Where:

Y = output

a = constant

b = elasticity of production

When linearised it is expressed as:

$\text{Log}Y = \log a + b_i \log X$

When the elasticities of production (as represented by b coefficients) are summed up, the nature of the returns to scale can be determined.

If $\sum_{i=j}^{n} bi$;

= 1, we have constant returns to scale.

= < 1, we have decreasing returns to scale.

= >1, we have increasing returns to scale.

These features make computation easy and convenient. However, there are some limitations to the use of the model. The model does not allow for increasing, decreasing and constant marginal productivity. It can also be used for data with both positive and negative marginal product. It commonly exhibits a non-linear relationship and does not give a definite maximum response at all inputs levels, thus restricting its usefulness (Olayide and Heady, 1982).

(iv) The Quadratic function

$Y = a + bX - cX^2$

Where;

Y = output

X = variable input

b and c = coefficients

a = constant

The coefficient of c for the X^2 must have a negative sign.

The function denotes diminishing marginal returns, a constraint which does not occur in the case of a production function such as Cobb-Douglas or the Spillman equation. Unlike in the Cobb-Douglas function, the elasticity is not constant, but declines by a constant amount (Olukosi and Ogungbile, 1989).

(v) The Square root function

The function is given by;

$$Y = a + bX + cX^{0.5}$$

It allows diminishing total product like the quadratic function but instead of the constant decline in marginal products it declines at a diminishing rate (Olukosi and Ogungbile, 1989). This type of function is true under biological conditions when the marginal product is high at low levels of input decline at a slower pace at high levels of the variable input utilization. The elasticity also declines at high levels of input and output.

(vi) The 1.5 power function

$$Y = a + bX + cX^{1.5}$$

Where the variable input is raised to the power of 0.5 instead of 2 as in the case of the simple quadratic. This function has similar characteristics as the quadratic form (Olukosi and Ogungbile, 1989).

Among the various functional forms, the most appropriate form to use depends on the type of production being examined. It must be recognized that any specific form of equation automatically imposes certain constraints on the relationship involved and the quantity of resources. One should use the function that best suits the data at hand. For example, the Spillman-Mitscherlich polynomial function is not suitable for data where diminishing total products are encountered. Moreover, researchers prefer functional forms that are easier to work with. For most agricultural productions, the Cobb-

Douglas, Quadratic and Square Root functions are more widely used while the polynomial forms which are difficult to work with are rarely used (Olukosi and Ogungbile, 1989).

2.5 Concept of resource use efficiency

Agricultural productivity may be defined as the ratio of the value of total farm output to the value of total inputs used in farm production (Olayide and Heady, 1982). Since one of the chief objectives of any society is the attainment of an optimally high living with a given amount of effort, any increases in the productivity of resources employed in farm production amount to progress. Increase in agricultural productivity will contribute to the well-being of the economy as a whole. Aggregate measures of productivity in production economics analyses will add to the sum of our knowledge by (a) serving as barometres of economic progress, (b) serving as guide to adjustment of resources, (c) providing a framework for formulating and evaluating policy and (d) indicating problem areas that needed further research. The final objective of our interest in productivity should be to find ways of increasing output per unit of input, and of attaining desirable inter-firm, intra-firm, and inter-sector transfers of production resources, thereby providing the means for raising our economic level of living (Olayide and Heady, 1982).

The input-output process of farm production, we should recollect, is important in at least four major problem areas (Olayide and Heady, 1982). These are the distribution of income, the allocation of resource, the relation between stocks and flows, and the measurement of efficiency or productivity. In the productivity concept, a meaningful assessment will depend upon a clear and precise definition of input and output in such a

way that their movements over time are not equal (Olayide and Heady, 1982). We should also seek to determine which inputs and outputs are consistent with the particular productivity concept in question. Thus, we are faced with separate and distinct conditions when we direct our efforts to, say, measurement of labour or capital, or land, or water or management productivity. In other words, resource productivity is definable in terms of individual resource inputs or in terms of a combination of them. Thus we shall define labour productivity as the ratio of total output to labour inputs. Similarly, land, capital, water and management productivities can each be defined as the ratio of total output to inputs of land, capital, water and management respectively. Using this definition as a bench-mark, change in productivity over time will depend upon changes in both the "included" and "excluded" components and maximum possible output from the minimum possible set of input. In this context, optimal productivity of resources implies an efficient utilization of resources in the production process. This means that productivity and efficiency are synonymous in this context.

An increase in output will result from one of the three forces (Olayide and Heady, 1982). First it will result from an increase quantity of input, with no change in output per unit input. Second it will result from increased productivity of inputs with no change or decrease in quantity of inputs. Thirdly, it will result from a combination of changes in inputs and productivity. This situation makes the concept of efficiency a central issue in production economics.

Several attempts have been made to define economic efficiency and to measure it in an empirical sense. Most of these definitions have floundered in one way or another (Olayide and Heady, 1982). However, Farrel (1957) has defined economic efficiency in

an admirably accepted form, but his definition defies precise measurement. His definition of efficiency is couched in three related terms. First, he defines "technical" efficiency as the measure of a firms' success in producing maximum output from a given set of inputs. It indicates all those undisputed gains that can be obtained by simply gingering up the management. Second, he defines "price" efficiency as the measure of a firms' success in choosing an optimal set of inputs. This is an indication of the gains that can be obtained by varying the input ratios on certain assumptions about the future price structure. Third, he defines "overall" efficiency as the simple product of the technical and the price efficiencies.

Elegant as these definitions are, they cannot be measured easily since precise measurement rests on the assumption of an efficient isoquant. Efficiency measure as the average productivity of say labour, capital, land, water etc can only be meaningful index of technical efficiency if any one of the resources is limiting in the production process (Olayide and Heady, 1982). Index of efficiency, measured as the weighted average of all inputs compared with output is replete with index number problems and hence is not a dependably meaningful measure of technical efficiency. The use of cost comparisons in the production process as an index of technical efficiency has limited applicability where all firms or plants do not face the same factor prices. In a situation where all firms or plants face the same factor prices, cost comparisons constitute a much better criterion than productivity, and are therefore equivalent to the best "efficiency index"(Olayide and Heady, 1982).

If we cannot obtain a universally acceptable yardstick for measuring technical efficiency, which is of interest in resource productivity, we can at least specify certain

necessary conditions for the attainment of technical efficiency. Heady (1952) specifies eight technical conditions for the attainment of economic efficiency. These are:

(i) the marginal rate at which factor is transformed into product must be the same for any pair of farms using the same factors and producing the same product

(ii) the marginal rate of substitution between any pair of factor must be the same for any two farms using both factors to produce the same product

(iii) the marginal rate of substitution between two factors must be the same for every product in which they are used

(iv) the marginal rate of substitution between any two products must be the same for any two farms producing both products

(v) the marginal rate at which two crops substitute as products on one farm must be equal to the marginal rate at which they substitute as factors on another or the same farm

(vi) the marginal rate of substitution must be equal between (a) the income and direct utility (leisure) of a resource, in production, and (b) the income and direct utility (leisure) of a resource, in consumption for any single resource owner and between resource owners

(vii) marginal rate of substitution of products in time or resources in time must be equal for all farms which produce or use both

(viii) price ratios must equal substitution and transformation rates in all cases such that (a) the factor-product price ratios equal the marginal rate at which factor is transformed into product , (b) the product-product price ratios is equal to the marginal rate of substitution of any two commodities, (c) the factor-factor price ratios is equal to the marginal rate of substitution between any

pair of factor, (d) the discounted price ratio is equal to the substitution ratio for one product produced at two points in time, and (e) the compounded price ratio is equal to the substitution ratio for two resources extending into time.

Attainment of maximum efficiency is only possible if the eight conditions outlined above are simultaneously satisfied. A simultaneous attainment of these physical conditions will allow a maximum product from a given stock of resources or conversely, a minimum input of resources for a given output of product.

The eight conditions outlined above are necessary but not sufficient conditions for efficiency in resource use to be attained. This is due to the fact that the eight conditions do not guarantee that a maximum product is forthcoming from a stock of resources or otherwise, that a given output is being produced with a minimum of factor services. Maximum efficiency will be guaranteed if single products are produced under conditions of decreasing returns (or increasing costs) and if commodities produced in combination are never produced within ranges of complementary and supplementary relationships. In other words, the factor-product and the production possibility curves must be concave to the origin in the relevant area of equilibrium for each producing unit. Unless the eight necessary conditions and the sufficient conditions are all attained simultaneously, resources are not efficiently used, and this implies that they can always be arranged to allow (with given and limited resources) greater total output of the product desired by the consuming society.

If the goals of efficiency are specifically the reorganization of resources and the maximization of farm income, then it is necessary to isolate the cause of inefficiency in

farm production process. Inefficiency may be due to endogenous and/or exogenous factors (Olayide and Heady, 1982). These factors fall into three main categories. First, there are factors explaining why the resources of an individual farm are not organized to maximize the value of the product. Second, there are those which explain why the return on resources differs between agricultural areas. Third, there are those which seek to explain why the value of the product of agricultural resources is low relative to that of certain other occupations, and/or less than the maximum for the resources employed in the industry. These three categories when analyzed in detail lead to an isolation of the specific causes of inefficiencies. These causes are:

(i) lack of knowledge of alternative techniques and resource organizations

(ii) uncertainty and capital limitations coupled with net product of labour in relation to capital

(iii) the hypotheses that resource returns in primary or extractive industries, such as agriculture are continually pressing below those of secondary industries, such as manufacturers

(iv) institutions serving as adjustment base may precipitate inefficiency, e.g. the slave economy of Kontheastern U. S. with sudden conversion to small-scale farms, creation of homesteads and pre-emption units in the southern Nigeria, the feudal structure in the northern Nigeria etc

(v) the low income structure of family farms and the complexities of rural life and farm-household complex

(vi) the labour supply function in agriculture in relation to non-agriculture, and the level of investment in the human agent, coupled with tribal restraints as well as problems of migration

(vii) the degree of competitiveness or otherwise for goods, services and products

(viii) the structure of costs and returns to society, due to regional differences in resource productivity, as well as the allusive structure of an efficient agriculture.

A thorough understanding of the implications and ramifications of these specific causes of inefficiency will take us farther afield than what this introductory text cover. Each of these specific causes constitutes broad areas of research and the discussion topics on modernizing peasant agriculture to enhance productivity. It is, however, necessary to outline some positive steps in reducing inefficiency in resource utilization in the production process. These steps will, among others, include the following:

(i) the minimization of risks and uncertainty in farming enterprises

(ii) useful education directed at increasing productivity and adoption of new techniques on small income farms

(iii) provision of credit for acquisition of capital and expansion of farm size

(iv) provision of employment outlook services, coupled with job training and transfer assistance

(v) introduce steps that will try to successfully eliminate differences in costs and returns for the individual and the community

(vi) integration of agriculture and industry in agribusiness framework and introduction of corporate and part-time farming

(vii) Costs and returns analysis is the basis for the measurement of profitability of farm enterprises. The procedure involves itemizing the various costs of inputs and returns from production and using these to calculate the measures of profitability (Iheanacho, 2000). Gross margin and net farm income analyses are tool used to measure profitability of farming.

2.6.1 Gross margin analysis

The gross margin analysis involves evaluating the efficiency of an individual enterprise (or farm plan) so that comparison can be made between enterprises or different farm plans. It is a very useful planning tool in situations where fixed capital is a negligible portion of the farming enterprise as is the case in subsistence agriculture (Olukosi and Erhabor, 2008).

Gross Margin (GM) is the difference between the gross farm income (GI) and the total variable cost (TVC), that is GM = GI - TVC.

Where:

GM = Gross margin (₦ /hectare)

GI = Gross Income (₦ /hectare)

TVC= Total Variable Cost (₦/hectare)

2.6.2 Net farm income analysis

The net farm income (NFI) is determined by subtracting the total fixed cost (TFC) from the total gross margin (TGM) of the whole farm or all the enterprises (Olukosi and Erhabor, 2008). The formula for net farm income is:

NFI = TGM - FC

Where:

NFI = Net farm Income (₦ /hectare)

TGM= Total Gross Margin (₦/hectare)

FC = Fixed Cost (₦ /hectare)

2.7 Constraints associated with Agricultural production in West Africa

Some of the constraints associated with agricultural production in West Africa are (Okigbo, 1994).

2.7.1 Biological constraints

(i) low productivity and adaptation potentialities in a large number of genetically unimproved crops and livestock

(ii) susceptibility of crops and livestock to pests and diseases

(iii) rapid losses of biodiversity in indigenous food crops and land races

(iv) presence of several endemic parasitic diseases of livestock and man

(v) problems of parasitic weeds such as *Striga* in maize and cowpeas

(vi) problems of weeds and water-borne diseases in irrigated areas

(vii) environmental stresses and changes brought about by human developmental activities and over grazing. which upset the dynamic ecological balance in the prevailing ecosystem

(viii) parasitic diseases of ruminants such as East Coast fever and trypanosomiasis

(ix) unimproved forage of low nutritive value and low productivity.

2.7.2 Technological constraints

(i) inadequate human resources development and institutional capacity in R and D

(ii) lack of knowledge of, and neglect of traditional technologies as a basis for designing and testing new ones

(iii) technological weakness of NARS rendering them incapable of generating technologies or adapting, utilizing and fine-tuning technologies developed at the IARCs to their location specific conditions

(iv) inappropriate technology not sustainable in agriculture in the regions

(v) limitations of basic knowledge about the environments necessary to ensure rapid progress in sustainable management of research and information required in R and D

(vi) ineffective use and integration of tradition and existing/emerging technologies

(vii) farming systems and technologies more adapted to uplands than to lowlands.

2.7.3 Socio-economic constraints

(i) rapid population growth and increasing pressure on land

(ii) unfavourable land tenure systems

(iii) limited access to land especially in areas with European settlements

(iv) shortage of labour at peak periods of production

(v) lack of credit

(vi) high level of illiteracy and superstition

(vii) low income of farmers and the resultant lack of money to purchase inputs

(viii) poor rural infrastructures including roads and transportation facilities

(ix) inadequate prices and poor marketing services

(x) poor extension services

(xi) political instability

(xii) inadequate policies for creating a favourable environment for R and D

(xiii) low allocation of funds to research and development in agriculture

(xiv) high debt burdens and problems associated with SAP decline in commodity prices for over a decade.

CHAPTER 3

METHODOLOGY

3.1 Description of the study area

The study was carried out in Katsina state. It lies between latitude 11^{o} 07' and 13^{o} 22' N and longitude 6^{o} 52' and 9^{o} 22' E of Greenwich and occupies a total land area of about 25938 square kilometres. The study areas lie between latitudes12^{o} 40'and 12^{o} 43'N of the equator and longitudes 7^{o} 43'and 7^{o}50'E of the Greenwich meridian (figure 3.1), with a land area of 24,192 Km^{2} (9,341 square kilometres) and a total projected population of 6,483,429 people (NPC, 2009).

The rainy season in the study areas starts from late June to September, with a mean annual rainfall of 650 mm per annum. The temperature is high for the greater part of the year with a range of 24-35^{o}C. The relative humidity is about 49 per-cent and evaporation of 200 mm per year (KTARDA, 2009). The soil types in the study area comprise entisols, inceptisol and alfisols. The first two are young and immature soils, well-drained and derived from recent aeolian deposits while third are form of parent materials rich in Quartz, crystalline rocks of basement complex, and on sedimentary deposits (Ogungbile *et al.,* 1999). A common feature of these soils is low organic matter content, cation exchange capacity (CEC) and low nutrients content, especially nitrogen and phosphorus (Ogungbile *et al.,* 1999).

The people in the study areas are predominantly farmers. They grow crops such as millet, sorghum, maize, rice, cotton, cowpea and groundnut. They also rear animals such as cattle, goats, sheep and fowls.

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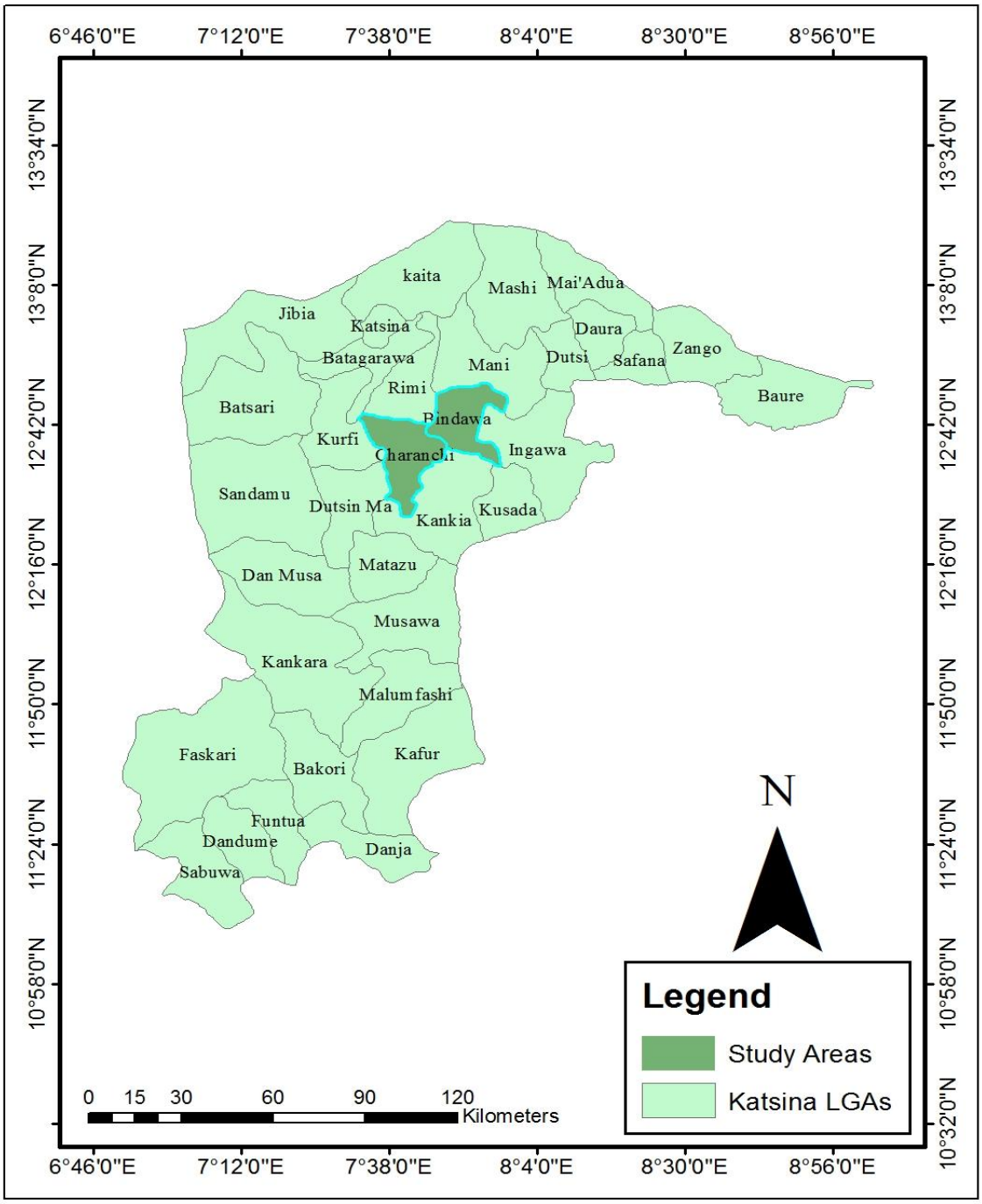


Figure: 3.1 Katsina state showing study areas

Source: Modified from administrative map of Katsina state

3.2 Sampling procedure and sample size

A multi-stage sampling procedure was used in this study for the selection of respondents. The first stage involved purposive selection of three villages from each of the two local government areas, based on the predominance of millet-based cropping systems. The villages selected were Doro, Shibdawa and Tama in Bindawa LGA and Banye, Charanchi and Radda in Charanchi LGA. A reconnaissance survey was conducted with village extension agents from Katsina State Agricultural and Rural Development Authority (KTARDA) to identify the farmers who practised millet-based cropping systems in the selected villages. The farmers were then grouped into five strata as follows:

(i) millet/sorghum

(ii) millet/sorghum/groundnut/cowpea

(iii) millet/sorghum/groundnut

(iv) millet/sorghum/cowpea

(v) sole millet.

From the population of farmers for each of the cropping systems in each selected village, ten per cent (10%) of the farmers were randomly selected to give a sample size of one hundred and sixty respondents (Table 3.1).

Table 3.1: Distribution of farmers for each of the cropping systems in the study areas

LGA	Village	Sample population*					Total	Sample selected (10%)					Total
Bindawa		**MS**	**MSCG**	**MSG**	**MSSC**	**SM**		**MS**	**MSCG**	**MSG**	**MSSC**	**SM**	
	Doro	80	50	60	20	50	260	8	5	6	2	5	26
	Shibdawa	70	20	70	30	15	205	7	2	7	3	2	21
	Tama	60	10	70	45	10	195	6	1	7	5	1	20
Sub-total	**3**	**210**	**80**	**200**	**95**	**75**	**660**	**21**	**8**	**20**	**10**	**8**	**67**
Charanchi	**Charanchi**	100	60	90	60	55	365	10	6	9	6	6	37
	Radda	60	50	60	50	64	284	6	5	6	5	6	28
	Banye	50	66	50	49	58	273	5	7	5	5	6	28
Sub-total	**3**	**210**	**176**	**200**	**159**	**177**	**922**	**21**	**18**	**20**	**16**	**18**	**93**
Grand Total	**6**	**420**	**256**	**400**	**254**	**252**	**1582**	**42**	**26**	**40**	**26**	**26**	**160**

*** = based on pilot survey, 2010. Keys: MSG = millet/sorghum; MSGC = millet/sorghum/groundnut/cowpea; MSG = millet/sorghum/groundnut; MSC = millet/sorghum/cowpea and SM = sole millet.**

3.3 Data collection

Primary data were used for this study and were based on 2010 cropping season. The data was collected with the aid of structured questionnaire administered on the farmers. Information was collected on inputs and outputs of the farmers which included the following:

(i) land area cultivated in hectares for each millet-based cropping system

(ii) Quantity (kg) and cost of seed planted in (₦)

(iii) Quantity (kg) and cost of fertilizer in (₦)

(iv) Labour used for different farm operations (man-hours/day)

(v) Output (kg) realized from component crops in the millet-based cropping system and sale (₦)

(vi) Problems of millet-based cropping systems.

3.4.0 Analytical technique

To achieve the objectives of this study the following analytical tools were used:

(i) descriptive statistics

(ii) production functions analysis

(iii) farm budget technique.

3.4.1 Descriptive statistics

Descriptive statistics was used to achieve objectives i, ii and vi. It involved the use of mean, median, mode, frequency distribution tables and percentages.

3.4.2 Production functions analysis

This was used to achieve objective iii and iv. Production function stipulates the technical relationship between inputs and outputs in any production process (Olayide and Heady, 1982; Olukosi and Ogungbile, 1989). Mathematically, this relationship is assumed to be continuous and differentiable. Its differentiability enables us to establish the rate of return. There are many functional forms which can be used. They include Linear, Spillman, Cobb-Douglas, Semi-log, Quadratic, Square root and power functions. However, for the purpose of this study, Linear, Cobb-Douglas and Semi-log were fitted to the data. The functional form that satisfies the following conditions will be selected:

(i) positive signs of regression co-efficient

(ii) magnitude of co-efficient of multiple determinations (R^2)

(iii) significance of t-values

(iv) Significance of F-values.

3.4.2.1 Specification of the models

(i) Linear production function

The linear production function assumes linear relationship between the inputs and outputs as well as a constant marginal productivity of the resources used. The model is given by:

$Y = a + b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+e$ ..... (1)

Where:

Y = total output (kilogramme grain equivalent).

a = constant

b_1-b_5 = regression co-efficient of X_1-X_5

X_1 = farm size (hectares)

X_2 = seed (kilogramme grain equivalent)

X_3 = labour (man-hour/day)

X_4 = fertilizer (kilogramme)

X_5 = pesticide (litres)

e = error terms

(i) Cobb-Douglas production function

The model is given by:

$Y = aX_1^{b1}X_2^{b2}X_3^{b3}\ X_4^{b4}X_5^{b5}$e…….. (2)

When linearised it is expressed as:

$\log Y = \log a + b_1 logX_1 + b_2 logX_2 + b_3 \log X_3 + b_4 logX_4 + b_5 logX_5 + e$

Where:

Y = total output of millet-based cropping system (kilogramme grain equivalent)

X_1-X_5 = as specified above in the model

a = constant

b_1-b_5= regression coefficients and elasticities of production of factors X_1-X_5

$e = error\ terms$

The function is easy to fit and the co-efficients represent direct elasticities of inputs.

Where:

(i)$\sum_{i=j}^{n} bi$ = 1, we have constant returns to scale

(ii)$\sum_{i=j}^{n} b\,i$ = < 1, we have decreasing returns to scale

(iii)$\sum_{i=j}^{n} bi$ = >1, we have increasing returns to scale

(iii)Semi-log production function

This is found useful in aggregate production function analysis. It is given by:

$Y = a + b_1 \log X_1 + b_2 log X_2 + b_3 log X_3 + b_4 log X_4 + b_5 log X_5 + e$..... (3)

Y = total output of millet-based cropping system (kilogramme grain equivalent)

b_1-b_5= the regression coefficients

X_1-X_5 = as specified in the linear model

$e = error\ terms$

3.4.2.2 Resource use efficiency

Measures of resource use efficiency are achieved by computing the marginal value productivities and marginal factor costs of the resources. The marginal value productivity of a resource (X_i) in the millet-based cropping system will be derived using formula below:

$MVPX_i = b_i \bar{Y}/\bar{X}.P_y$

Where:

$MVPX_i$= marginal value product of input X_i

b_i= the estimated regression coefficient of input X_i

$\bar{Y}$ = mean of Y

$\bar{X}$ = mean of X

P_y = grain equivalent price of output =

$$\frac{Revenue\ for\ a\ millet-based\ crop\ mixture\ (₦/ha)}{total\ grain\ output\ in\ grain\ equivalent\ (kg)}$$

The resource use efficiency will be computed as the ratio of MVP to MFC as follows:

$$r = \frac{MVP}{MFC}$$

Where:

r = resource use efficiency ratio

MVP = marginal value product of input X_i

MFC = marginal fixed cost of input X_i

The MFC of seed for a millet-based crop mixture =

$$\frac{cost\ of seed\ \ for\ the\ crop\ \ mixture\ \ (₦/ha)}{quantity\ \ of seed\ \ in\ grain\ \ equivalent\ \ (kg)}$$

If:

r = 1, it implies that resources are efficiently utilized

r > 1, it implies that resources are under-utilized

r <1, it implies that resources are over-utilized

3.4.3 Farm budget technique

Gross margin analysis was used to achieve objective number v. Gross margin analysis is the difference between the gross farm income and the total variable costs (Raup, 1977; Olukosi and Erhabor, 2008). It is a very useful planning tool in situations where fixed capital is a negligible portion of the farming enterprises as is the case in subsistence agriculture (Olukosi and Erhabor, 2008). It evaluates the profitability of an individual enterprise. It is given by:

GM = GI-TVC

Where:

GM = Gross Margin (₦/ha)

GI= Gross Farm Income (₦/ha)

TVC = Total Variable Cost (₦/ha)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Millet-based cropping systems

The commonest millet-based cropping systems in the study area were: millet/sorghum; millet/sorghum/groundnut/cowpea; millet/sorghum/groundnut; millet/sorghum/cowpea and sole millet (Table 4.2). The three most common cropping systems in Bindawa LGA were millet / sorghum (31%), millet/sorghum/groundnut (30%) and millet / sorghum / cowpea (15%), while in Charanchi LGA, millet / sorghum (23%), millet/sorghum/groundnut (22%) and millet / sorghum / groundnut/cowpea (19%) and sole millet (19%) were the most common. The two most important millet-based cropping systems in both Bindawa and Charanchi LGAs (pooled) were millet / sorghum (26.25%) and millet / sorghum / groundnut (25.00%). These results agree with those of Ogungbile *et al* (1999), who found that: (i) millet followed by sorghum, cowpea and ground nut were the most important crops in the northern part of Katsina state; and (ii) 2-crop and 3-crop mixtures were more prevalent in Zone1than sole and 4-crop mixtures.

Table 4.2: Distribution of farmers based on millet cropping systems in the study areas

Millet-based cropping Systems	**Bindawa**		**Charanchi**		**Pooled**	
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
M/S	21	31.00	21	23.00	42	26.25
M/S/G/C	8	12.00	18	19.00	26	16.25
M/S/G	20	30.00	20	22.00	40	25.00
M/S/C	10	15.00	16	17.00	26	16.25
Sole millet	8	12.00	18	19.00	26	16.25
Total	**67**	**100.00**	**93**	**100.00**	**160**	**100.00**

4.2 Inputs and Output Levels

4.2.1 Inputs used

4.2.1.1 Sizes of farm land allocated to millet-based cropping systems

In Tama village of Bindawa Local Government Area, 46 hectares were cultivated out of the total cultivated hectares of 129.9 for the local government area. About 16 hectares were devoted to millet / sorghum/groundnut (33.70%), 15 hectares to millet/sorghum (32.60%) and 11 hectares to millet / sorghum / cowpea. In Doro village, 13 hectares were devoted to millet / sorghum / groundnut (30%), 12 hectares to millet / sorghum and about 10 hectares to sole millet (20%). In Shibdawa village, about 14 hectares were devoted to millet / sorghum (34.1%), followed by millet/sorghum/groundnut with about 13 hectares (32.1%), (Table 4.3).

Table 4.3: Cropping systems and number of hectares cultivated in Bindawa local government area

Cropping System	Tama		Doro		Shibdawa	
	No of Ha.	Percentage	No of Ha.	Percentage	No of Ha.	Percentage
M/S	15.0	32.60	12.0	28.00	13.6	34.10
M/S/G/C	3.0	6.50	6.5	15.00	6.0	15.03
M/S/G	15.5	33.70	13.0	30.00	12.8	32.10
M/S/C	11.0	23.90	3.0	7.00	5.0	12.50
Sole Millet	1.5	3.30	9.5	20.00	2.5	6.27
Total	**46.0**	**100.00**	**44.0**	**100.00**	**39.9**	**100.00**

Out of the 178.26 hectares cultivated in Charanchi local government area, 76.61 hectares were cultivated in Charanchi village, with 21.05 hectares devoted to millet / sorghum (Table 4.4). This was followed by millet/sorghum/groundnut with 20 hectares (26.11%), and sole millet with 13.5 hectares (17.62%). In Radda village, millet/sorghum/groundnut was allotted the highest number of hectares of about 13 hectares. This was followed by millet / sorghum / groundnut/cowpea with 11.2 hectares, and millet / sorghum / cowpea with 9.25 hectares. In Banye village, the highest number of hectares allocated was to millet / sorghum / groundnut/cowpea (14.5 hectares). This was followed by 10 hectares for millet / sorghum / cowpea, 9.5 hectares for millet / sorghum and about 9 hectares each for millet/sorghum/groundnut and sole millet.

Table 4.4: Cropping systems and number of hectares cultivated in Charanchi local government area

Cropping systems	**Charanchi**		**Radda**		**Banye**	
	No of Ha.	**Percentage**	**No of Ha.**	**percentage**	**No of Ha.**	**Percentage**
M/S	21.05	27.47	8.25	16.43	9.50	18.46
M/S/G/C	13.00	16.97	11.2	22.31	14.50	28.18
M/S/G	20.00	26.11	12.5	24.90	8.50	16.52
M/S/C	9.06	11.83	9.25	18.43	10.00	19.44
Sole millet	13.50	17.62	9.00	17.93	8.95	17.40
Total	**76.61**	**100.00**	**50.20**	**100.00**	**51.45**	**100.00**

A pooled total of 308.16 hectares of farmland were devoted to the millet-based cropping systems in the two local government areas (Table 4.5). Millet/sorghum/groundnut had the

highest amount of land allocation of 82.3 hectares, representing 26.71 per cent of total land cultivated. This was followed by millet / sorghum with 79.4 hectares (25.77 %) and millet / sorghum / groundnut/cowpea with 54.2 hectares (17.59%). The least number of hectares was allocated to sole millet (44.99 hectares), representing 14.59 per cent of the total land cultivated.

Table 4.5: Cropping systems and number of hectares cultivated in both Bindawa and Charanchi local government areas (pooled)

Cropping Systems	**Bindawa L.G.A.**		**Charanchi L.G.A.**		**Pooled**	
	No. of Ha	**Percentage**	**No. of Ha**	**Percentage**	**No. of Ha**	**Percentage**
M/S	40.60	31.00	38.80	21.77	79.40	25.77
M/S/G/C	15.50	12.00	38.70	21.71	54.20	17.59
M/S/G	41.30	32.00	41.00	23.00	82.30	26.71
M/S/C	19.00	15.00	28.31	15.88	47.31	15.35
Sole millet	13.50	10.00	31.45	17.64	44.95	14.59
Total	**129.90**	**100.00**	**178.26**	**100.00**	**308.16**	**100.00**

4.2.1.2 Seeds used

Table 4.6 shows the quantities of seeds used in the five cropping systems in Bindawa local government area. For millet / sorghum, the amount of millet and sorghum seeds used per hectare was highest in Tama village, compared to Doro and Shibdawa villages. For millet / sorghum / groundnut/cowpea, more millet and sorghum seeds were used in Shibdawa than in Doro and Tama villages, but more groundnut seeds were used in Doro than in shibdawa and Tama villages. For millet/sorghum/groundnut, more sorghum seeds were used in Doro than in Shibdawa and Tama villages but more groundnut seeds were used in Shibdawa than

in Doro and Tama villages. For millet / sorghum / cowpea, more sorghum seeds were used in Doro than in Shibdawa and Tama but more cowpea seeds were used in Tama than in Doro and Shibdawa. For sole millet, more millet seeds were used sown in Doro than in Shibdawa and Tama villages.

Table 4.6: Cropping systems and amount of seed used in kilogramme per hectare in Bindawa local government area

Cropping Systems	Doro				Shibdawa				Tama			
	Millet	**Sorghum**	**Ground't**	**Cowpea**	**Millet**	**Sorghum**	**Ground't**	**Cowpea**	**Millet**	**Sorghum**	**Ground't**	**Cowpea**
M/S	2.5	1.5	--	--	6	2	--	--	7	3	--	--
M/S/G/C	4	2	**7**	1	8	3	3	1	4	2	4	1
M/S/G	7	5	8	--	7	4	10	--	6	4	8	--
M/S/C	4	8	--	3	5	3	--	3	5	4.5	--	3.25
Sole millet	7	--	--	--	5	--	--	--	3	--	--	--

For millet / sorghum in Charanchi local government area (Table 4.7), more millet seeds were used in Charanchi village than in Radda and Banye, but more sorghum seeds were used in Banye than in Charanchi and Radda. For millet / sorghum / groundnut/cowpea, more millet and cowpea seeds were used in Banye than in Charanchi and Radda, but more sorghum and groundnut were used in Charanchi than in Radda and Banye. For millet/sorghum/groundnut, more millet seeds were used in Charanchi, more sorghum in Banye and more groundnuts in Radda. For millet / sorghum / cowpea, more millet seeds were used in Radda and Banye but more sorghum and cowpea seeds in Charanchi than in Radda and Banye. For sole millet, more millet seeds were used in Radda than in Charanchi and Banye villages.

Table 4.7: Cropping systems and amount of seed used in kilogramme per hectare in Charanchi local government area

Cropping Systems	Charanchi				Radda				Banye			
	Millet	Sorghum	Ground't	Cowpea	Millet	Sorghum	Ground't	Cowpea	Millet	Sorghum	Ground't	Cowpea
M/S	4	3	--	--	3	2	--	--	3	4	--	--
M/S/G/C	6.5	5	8	4.5	4	3.5	8	2.5	8.5	4	6	5
M/S/G	10	7	12	--	5	6	14	--	7	8	3	--
M/S/C	6	7	--	5	8	5	--	2	8	3	--	4
Sole Millet	8	--	--	--	9	--	--	--	7	--	--	--

The results for the amount of seeds used for the millet-based cropping systems in Bindawa and Charanchi local government areas (Table 4.8) showed that for millet / sorghum, more millet seeds were used in Bindawa than in Charanchi, but more sorghum seeds were used in Charanchi than in Bindawa. For millet / sorghum / groundnut/cowpea, more millet, sorghum, groundnut and cowpea seeds were used in Charanchi than in Bindawa. For millet/sorghum/groundnut, more millet, sorghum and groundnut seeds were used in Charanchi than in Bindawa. For millet / sorghum / cowpea, more millet and cowpea seeds were used in Charanchi than in Bindawa, but more sorghum seeds were used in Bindawa than in Charanchi. For sole millet, more millet seeds were used in Charanchi than in Bindawa. The pooled results showed that for millet / sorghum, 25.5 kg of millet and 15.5 kg of sorghum were used. For millet / sorghum / groundnut/cowpea, 35 kg of millet, 19.5 kg of sorghum, 36 kg of groundnut and 15 kg of cowpea were used. For millet/sorghum/groundnut, 42 kg of millet, 34 kg of sorghum and 55 kg of groundnut were used. For millet / sorghum / cowpea, 36 kg of millet, 30.5 kg of sorghum and 20.25 kg of cowpea were used. For sole millet, 39 kg was used.

Table 4.8: Cropping systems and amount of seeds used in kilogramme per hectare in both Bindawa and Charanchi local government areas (pooled)

Cropping Systems	Bindawa L.G.A.				Charanchi L.G.A.				Pooled			
	Millet	**Sorghum**	**Ground't**	**Cowpea**	**Millet**	**Sorghum**	**Ground't**	**Cowpea**	**Millet**	**Sorghum**	**Ground't**	**Cowpea**
M/S	15.5	6.5	--	--	10	9	--	--	25.5	15.5	--	--
M/S/G/C	16	7	14	3	19	12.5	22	12	35	19.5	36	15
M/S/G	20	13	26	--	22	21	29	--	42	34	55	--
M/S/C	14	15.5	--	9.26	22	15	--	11	36	30.5	--	20.25
Sole millet	15	--	--	--	24	--	--	--	39	--	--	--

4.2.1.3 Labour used

For millet / sorghum, in Bindawa local government area (Table 4.9), more man-hours of labour were used in Shibdawa village than in Doro and Tama. For millet / sorghum / groundnut/cowpea, more labour was used in Doro than in Shibdawa and Tama. For millet/sorghum/groundnut, more labour was used in Shibdawa than in Doro and Tama. For millet / sorghum / cowpea, more labour was used in Shibdawa than in Doro and Tama. For sole millet, more labour was used in Doro than in Shibdawa and Tama.

Table 4.9: Cropping systems and amount of labour used in man-hours per day in Bindawa local government area

Cropping systems	**Doro**	**Shibdawa**	**Tama**
M/S	139	173	116
M/S/G/C	181	180	144
M/S/G	133	183	128
M/S/C	100	197	160
Sole millet	107	84	96
Total	**660**	**817**	**644**

For Charanchi local government area, millet / sorghum had the highest labour used in Charanchi than in Radda and Banye villages (Table 4.10). For millet / sorghum / groundnut/cowpea, more labour was used in Banye than in Charanchi and Radda. For millet/sorghum/groundnut, more labour was used in Banye than in Charanchi and Radda. For millet / sorghum / cowpea, more labour was used in Radda than in Charanchi and Banye. For sole millet, more labour was used in Charanchi than in Radda and Banye.

Table 4.10: Cropping systems and amount of labour used in man-hours per day in Charanchi local government area

Cropping systems	Charanchi	Radda	Banye
M/S	166	124	138
M/S/G/C	236	171	251
M/S/G	140	136	162
M/S/C	123	179	107
Sole millet	136	118	134
Total	**801**	**728**	**792**

The results of the amount of labour used in the millet-based cropping systems in Bindawa and Charanchi local government areas (Table 4.11) showed that for millet / sorghum, the same amounts of labour (428 man-hours)wereused in both Bindawa and Charanchi local government areas. For millet / sorghum / groundnut/cowpea, more labour was used in Charanchi (658 man-hours) than in Bindawa (505 man-hours). For millet/sorghum/groundnut, more labour was used in Bindawa (444 man-hours) than in Charanchi (438 man-hours). For millet / sorghum / cowpea, more labour was used in Bindawa (457 man-hours) than in Charanchi (409 man-hours). For sole millet, more labour was used in Charanchi (388 man-hours) than in Bindawa (287 man-hours). The pooled results showed that for millet/sorghum, 856 man-hours of labour were used per hectare. For millet / sorghum / groundnut/cowpea, 1163 man-hours of labour were used. According to Iheanacho 2000, the more the number of crops in a mixture, the more the amount of labour required for various activities, since crops mature differently. For millet/sorghum/groundnut, 882 man-hours of labour were used. For M/S/C, 866 man-hours were used. For sole millet, 675 man-hours were used.

Table 4.11: Cropping systems and amount of labour used in man-hours per day in both Bindawa and Charanchi local government areas (pooled)

Cropping systems	Bindawa	Charanchi	Pooled
M/S	428	428	856
M/S/G/C	505	658	1163
M/S/G	444	438	882
M/S/C	457	409	866
Sole millet	287	388	675
Total	**2121**	**2321**	**4442**

4.2.1.4 Fertilizer used

For millet / sorghum, in Bindawa local government area, more fertilizer was used in Shibdawa than in Doro and Tama villages (Table 4.12). For millet / sorghum / groundnut/cowpea, more fertilizer was used in Tama than in Doro and Shibdawa. For millet/sorghum/groundnut, more fertilizer was used in Doro than in Shibdawa and Tama. For millet / sorghum / cowpea, more fertilizer was used in Shibdawa than in Doro and Tama. For sole millet, more fertilizer was used in Shibdawa than in Doro and Tama.

Table 4.12: Cropping systems and amount of fertilizer used in kilogramme per hectare in Bindawa local government area

Cropping systems	Doro	Shibdawa	Tama
M/S	34	96	25
M/S/G/C	35	75	100
M/S/G	56	55	43
M/S/C	38	58	33
Sole millet	35	63	25
Total	**198**	**347**	**226**

For Charanchi local government area, millet / sorghum had the highest fertilizer use in Charanchi compared to, Radda and Banye (Table 4.13). For millet / sorghum / groundnut/cowpea, Banye had the highest fertilizer used compared to the amount of fertilizer used in Charanchi and Radda. For millet/sorghum/groundnut, Charanchi had the highest fertilizer used compared to the amount of fertilizer used in Banye and Radda. For millet / sorghum / cowpea, more fertilizer was used in Banye than in Charanchi and Radda. For sole millet, more fertilizer was used in Radda than in Charanchi and Banye.

Table 4.13: Cropping systems and amount of fertilizer used in kilogramme per hectare in Charanchi local government area

Cropping systems	**Charanchi**	**Radda**	**Banye**
M/S	85	16	43
M/S/G/C	47	40	69
M/S/G	57	25	40
M/S/C	21	25	42
Sole millet	30	34	29
Total	**240**	**140**	**223**

The results for the amount of fertilizer used in Bindawa and Charanchi local government areas (Table 4.14) showed that more fertilizer was used for all the cropping systems in Bindawa local government area than in Charanchi local government area. The pooled results showed that for millet / sorghum, 299 kg of fertilizer were used per hectare. For millet / sorghum / groundnut/cowpea, 366 kg of fertilizer were used. For millet/sorghum/groundnut, 276 kg of fertilizer were used. For millet / sorghum / cowpea, 217 kg of fertilizer were used. For sole millet, 216 kg of fertilizer were used.

Table 4.14: Cropping systems and amount of fertilizer used in kilogramme per hectare in both Bindawa and Charanchi localgovernment areas (pooled)

Cropping systems	Bindawa	Charanchi	Pooled
M/S	155	144	299
M/S/G/C	210	156	366
M/S/G	154	122	276
M/S/C	129	88	217
Sole millet	123	93	216
Total	**771**	**603**	**1374**

4.2.1.5 Pesticide used

For millet / sorghum / groundnut/cowpea in Bindawa local government area, more pesticide was used in Doro than in Shibdawa and Tama villages (Table 4.15). For millet / sorghum / cowpea, more pesticide was used in Shibdawa than in Doro and Tama.

Table 4.15: Cropping systems and amount of pesticide used in litre per hectare in Bindawa local government area

Cropping systems	Doro	Shibdawa	Tama
M/S	--	--	--
M/S/G/C	1.4	0.5	0.5
M/S/G	--	--	--
M/S/C	0.5	1.5	1.4
Sole millet	--	--	--
Total	**1.9**	**2.0**	**1.9**

For millet / sorghum / groundnut/cowpea in Charanchi local government area, more pesticide was used in Radda than in Charanchi and Banye villages (Table 4.16). For millet / sorghum / cowpea, more pesticide was used in Charanchi than in Radda and Banye.

Table 4.16: Cropping systems and amount of pesticide used in litre per hectare in Charanchi local government area

Cropping systems	Charanchi	Radda	Banye
M/S	-	-	-
M/S/G/C	1.7	1.8	1.4
M/S/G	-	-	-
M/S/C	1.7	1.5	0.6
Sole millet	-	-	-
Total	**3.4**	**3.3**	**2.0**

The results for the amount of pesticides used in Bindawa and Charanchi local government areas showed that for millet / sorghum / groundnut/cowpea and millet / sorghum / cowpea, more pesticides were used in Charanchi local government than in Bindawa local government area (Table 4.17). The pooled results showed that for millet/sorghum/groundnut / cowpea, 7.3 litres of pesticides were used per hectare. For M/S/C, 7.2 litres of pesticides were used.

Table 4.17: Amount of pesticide used in both Bindawa and Charanchi local government areas (litre)

Cropping systems	Bindawa	Charanchi	Pooled
M/S	0	0	0
M/S/G/C	2.4	4.9	7.3
M/S/G	0	0	0
M/S/C	3.4	3.8	7.2
Sole millet	0	0	0
Total	**5.8**	**8.7**	**14.5**

4.2.2 Output levels

4.2.2.1 Millet in sole and in mixture with other crops in Bindawa local government area

For millet / sorghum, the highest millet and sorghum yields were in Tama. For millet / sorghum / groundnut/cowpea, the highest millet and cowpea yields were in Shibdawa, the highest sorghum yields were in Shibdawa and Tama and the highest groundnut yield was in Shibdawa. For millet/sorghum/groundnut, the highest millet and sorghum yields were in Tama and the highest groundnut yield was in Doro. For millet / sorghum / cowpea, the highest millet yields were in Doro and Shibdawa, the highest sorghum yield was in Tama and the highest cowpea yield was in Tama. For sole millet, the highest millet yield was in Shibdawa (Table 4.18).

Table 4.18: Average yield of millet-based cropping systems in kilogramme per hectare in Bindawa local government area

Cropping Systems	Doro				Shibdawa				Tama			
	Millet	**Sorghum**	**Ground't**	**Cowpea**	**Millet**	**Sorghum**	**Ground't**	**Cowpea**	**Millet**	**Sorghum**	**Ground't**	**Cowpea**
M/S	221.4	124.17	--	--	253	231	--	--	399.24	280.9	--	--
M/S/G/C	177.04	147.55	132.9	92.27	443	280	202	188.3	416.6	280.17	115.54	106
M/S/G	175.32	180.84	572.9	--	235	170	289	--	269.72	193.92	379.64	--
M/S/C	243.02	178.29	--	171.8	243	175	--	193.8	156.23	180.41	--	250.18
Sole Millet	322.87	--	--	--	391	--	--	--	69.43	--	--	--

4.2.2.2 Millet in sole and in mixture with other crops in Charanchi local government area

For millet / sorghum, the highest millet and sorghum yields were in Charanchi. For millet / sorghum / groundnut/cowpea, the highest millet yield was in Banye, the highest sorghum and cowpea yields were in Radda and the highest groundnut yield was in Charanchi. For millet/sorghum/groundnut, the highest millet and groundnut yields were in Radda and the highest sorghum yield was in Charanchi. For millet / sorghum / cowpea, the highest millet and sorghum yields were in Radda and the highest cowpea yield was in Charanchi. For sole millet, the highest millet was in Charanchi (Table 4.19).

Table 4.19: Average yield of millet-based cropping systems in kilogramme per hectare in Charanchi local government area

Cropping Systems	Charanchi				Radda				Banye			
	Millet	**Sorghum**	**Ground't**	**Cowpea**	**Millet**	**Sorghum**	**Ground't**	**Cowpea**	**Millet**	**Sorghum**	**Ground't**	**Cowpea**
M/S	316.10	299.02	--	--	142.40	129.54	--	--	227	185.12	--	--
M/S/G/C	242.15	194.11	387.48	198.23	188.73	290.36	196.42	200.67	313	252.28	361.12	183.76
M/S/G	341.38	248.13	297.61	--	420.9	233.45	412.42	--	295	181.69	127.9	--
M/S/C	116.80	146.19	--	183.7	211.36	246.27	--	158	166	148.75	--	91.84
Sole millet	555.47	--	--	--	308.11	--	--	--	256	--	--	--

The results of the mean yield of millet sole and in mixture with other crops in Bindawa and Charanchi local government areas (Table 4.20) show that for millet / sorghum, the millet and sorghum yields in Bindawa local government areas were greater than those for Charanchi local government area. For millet / sorghum / groundnut/cowpea, the millet yield in Bindawa was higher than that of Charanchi local government area but the sorghum, groundnut and cowpea yields for Charanchi were higher than those for Bindawa local government area. For millet/sorghum/groundnut, the millet and sorghum yields in Charanchi local government area were higher than those for Bindawa local government area but the groundnut yield for Bindawa was higher than that of Charanchi local government area. For millet / sorghum / cowpea, the millet and cowpea yields for Bindawa local government area were higher than those for Charanchi but the sorghum yield was higher for Charanchi local government than for Bindawa local government area. For sole millet, the yield for Charanchi local government area was higher than that for Bindawa local government area. The pooled mean yield for both Bindawa and Charanchi local government areas showed that for millet / sorghum, 1558.69 kg of millet and 1465.38 kg of sorghum were obtained. For millet / sorghum / groundnut/cowpea, 1779.63 kg of millet, 1444.62 kg of sorghum, 1501.68 kg of groundnut and 969.24 kg of cowpea were obtained. For millet / sorghum / groundnut, 1608.12 kg of millet, 1244.22 kg of sorghum and 2079.23 kg of groundnut were obtained. For millet / sorghum / cowpea, 1183.47 kg of millet, 1075.35 kg of sorghum and 1193.13 kg of cowpea were obtained. For sole millet, 1902.3 kg of millet was obtained.

Table 4.20: Pooled mean yield (kg) of millet sole and in mixture of other crops in the study areas

Cropping Systems	Bindawa L.G.A.				Charanchi L.G.A.				Pooled			
	Millet	**Sorghum**	**Ground't**	**Cowpea**	**Millet**	**Sorghum**	**Ground't**	**Cowpea**	**Millet**	**Sorghum**	**Ground't**	**Cowpea**
M/S	873.6	851.70	--	--	685.14	613.68	--	--	1558.69	1465.38	--	--
M/S/G/C	1036.0	707.88	556.65	386.58	743.34	736.74	945.03	582.66	1779.63	1444.62	1501.68	969.24
M/S/G	713.8	544.92	1241.30	--	894.30	699.30	837.93	--	1608.12	1244.22	2079.23	--
M/S/C	642.3	534.15	--	759.57	541.20	541.20	--	433.56	1183.47	1075.35	--	1193.13
Sole millet	782.9	--	--	--	1119.42	--	--	--	1902.30	--	--	--

4.3 Production function analysis

4.3.1 Production function analysis of millet-based cropping systems

The Cobb-Douglas production function was selected to explain the relationship between output and inputs (farm size, seed, labour, fertilizer and pesticide) used in millet-based cropping systems. The choice of Cobb-Douglas function among the three functions tried (semi-log, linear and Cobb-Douglas) was because it gave the best fit to the data (Table 4.21). The outputs of millet-based cropping systems were expressed in grain equivalent weight (GEW) to standardize the component crops of the mixtures as done by Iheanacho (2000).

4.3.1.1 Millet / sorghum mixture

The results revealed that about 68 percent of the variation in output for millet/sorghum mixture was explained by the factor inputs included in the model (Table 4.21). The coefficients of farm size (X_1), seed (X_2) and fertilizer (X_4) were positive and significantly related with output of millet/sorghum. This means that a unit increase in these variables, under static condition of other explanatory variables result in increased output level. The result further confirmed the findings of Shehu, *et al*, (2009) that increases in farm size, seeds and fertilizer imply more output is expected. The coefficient of farm size was significant at 1% and the coefficients of seed and fertilizer were significant at 10% each. The coefficient of labour (X_3) was positive but had no significant effect on the output of millet/sorghum.

4.3.1.2 Millet/sorghum /groundnut/cowpea mixture

The results of millet / sorghum / groundnut/cowpea mixture showed that about 78 per cent in the variation in output was explained by the inputs included in the model (Table 4.21). The coefficients of farm size (X_1), labour (X_3) and pesticide (X_4) were positive and significant at 1% level. Seed input (X_2) and fertilizer input(X_4) were negative. This means that a unit increase in the level of seed input will result in a decrease in output by -0.17 units. Again, a unit increase in the level of fertilizer input will decrease the output by -0.030 units.

4.3.1.3 Millet / sorghum /groundnut mixture

The Millet / sorghum / groundnut mixture results showed an R^2 value of 41% (Table 4.21). This means that the variable inputs included in the model influenced the output by 41 per cent. Farm size (X_1), labour (X_3) and fertilizer (X_4) were positive and significant. This means that there is direct relationship between these inputs used and the output, that is, the more these inputs are added, the more the output. The coefficient of seed was negative and insignificant.

4.3.1.4 Millet/sorghum/cowpea mixture

The R^2value for millet / sorghum / cowpea was 0.74, meaning that 74% of the variation in output was explained by the input included in the model. All the coefficients of factor inputs used in millet/sorghum/cowpea mixture were positive and significant, except fertilizer (X_4) which was positive but insignificant (Table 4.21). This implies that the quantity of fertilizer applied was not significantly related to output. The positive and

significant coefficients for farm size, labour and fertilizer means that when farm size, labour and quantity of fertilizer are increased, more output will be realized.

4.3.1.5 Sole millet

The results for sole millet revealed an R^2 value of 0.58 (Table 4.21). The positive signs of farm size, seed and labour imply that the output of millet will be greater if farm size, seed and labour are increased. The negative coefficient for fertilizer indicates that the more fertilizer is added, the lesser the output.

Table 4.21: Estimated Cobb-Douglas production function of millet-based cropping systems

	Estimated Parameters							
Cropping System	**Constant**	**Farm size**	**Seed**	**Labour**	**Fertilizer**	**Pesticide**	**R^2**	**F - value**
M/S	5.237	0.798*	0.284***	0.170	0.054***	-	0.68	20.23*
		(3.979)	(1.762)	(-1.081)	(-1.767)			
M/S/G/C	6.261	0.906*	-0.17	0.088*	-0.030	0.105*	0.78	32.79*
		(3.874)	(-4.867)	(2.777)	(-0.690)	(2.926		
M/S/G	5.406	0.965*	-0.356	0.421**	0.100**	-	0.41	6.13*
		(3.048)	(-1.647)	(2.162)	(1.974)			
M/S/C	3.228	0.574**	0.118*	0.425**	0.053	0.273***	0.74	31.14*
		(2.117)	(3.291)	(1.934)	(0.778)	(1.870)		
Sole millet	3.270	0.156	0.770*	0.417	-0.037	-	0.58	7.36
		(0.506)	(3.772)	(1.210)	(-0.516)			

Figure in parenthesis are the t-values, * = significant at 1%, ** = significant at 5%, *** = significant at 10%.

4.3.2 Marginal productivity of inputs

The marginal physical products of inputs ($MPPX_i$) and their corresponding marginal value products (MVPs) were determined (Table 4.22). The MPP is the addition to the total physical product resulting from a unit increase in the use of a variable input, while MVP for each input was calculated by multiplying the MPP of each input by the average price of millet crop mixture output (Py.).

Table 4.22: Estimated marginal physical products and marginal value products of inputs in millet–based cropping systems

Cropping systems	MPP					MVP				
	Farm size	**Seed**	**Labour**	**Fert.**	**Pesti.**	**Farm size**	**Seed**	**Labour**	**Fert.**	**Pesti.**
M/S	5.7	12.36	0.87	-0.33	--	684,000	173.04	348	-26	--
M/S/G/C	9.39	-0.43	2.69	-0.06	57.44	1,032,900	-17.42	107.6	-4.8	3.5
M/S/G	7.96	-0.70	15.74	1.63	--	955,200	-31.5	550.9	122.3	--
M/S/C	1.85	2.05	4.92	0.10	54.02	222,000	41	123	8	8.97
Sole millet	8.8	42.97	0.91	-0.07	--	1,012,000	1547	364	-5.6	--

$$(\text{Py}) = \frac{Total\ value\ of\ output\ \ of\ crop\ mixture\ \ (₦/ha)}{Total\ GEW\ of\ output\ \ of\ a\ crop\ mixture\ \ (kg/ha)}$$

4.3.3 Production elasticity of input

Elasticity of production measures the degree of responsiveness of output to a change in input. The results show that in all the five millet cropping systems, elasticity of production for all inputs was less than unity, that is, a change in the inputs will result in a less than proportionate change in output. The sum of the elasticities indicated increasing returns to scale for millet / sorghum, millet/sorghum/groundnut, millet / sorghum / cowpea and sole millet, but decreasing returns to scale for millet / sorghum / groundnut/cowpea (Table 4.23).

Table 4.23: Elasticity of production for inputs used in millet-based cropping systems

	Elasticity of Production				
Inputs	**M/S**	**M/S/G/C**	**M/S/G**	**M/S/C**	**Sole millet**
Farm size	0.798	0.906	0.965	0.574	0.156
Seed	0.284	-0.177	-0.356	0.118	0.770
Labour	0.170	0.088	0.421	0.425	0.417
Fertilizer	0.054	-0.030	0.100	0.053	0.037
Pesticide	NA	0.105	NA	0.273	NA
Σbi	**1.31**	**0.89**	**1.13**	**1.44**	**1.38**

NA = Not Applicable

4.4 Efficiency of resource use in millet–based cropping systems

The ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC) for each input was determined to show whether resources were efficiently utilized or not in millet-based cropping systems. From the results in Table 4.24, allocative efficiency of farm size was under-utilized for all the millet-based cropping systems. This supports the findings of Oniah *et al,* 2008 and Iheke *et al,* 2008 who reported under-utilization of farm size in swamp rice production and arable crop farmers, respectively. In respect of seed, the

resource use efficiency ratio for millet/sorghum and sole millet indicated under-utilization of the input but over-utilization of the input for millet / sorghum / groundnut/cowpea, millet/sorghum/groundnut and millet / sorghum / cowpea. Under-utilization of seeds was reported by Baiyegunhi *et al,* 2010 in their study on the resource use efficiency in sole sorghum production in three villages in Kaduna state. Seed was under-utilized probably because most of the farmers use local varieties which they saved from previous harvest and some of the farmers buy seeds from market as such they may not be able to buy the required quantity for their farm size. Also improved seed market is not common in the study areas. For labour, there was under-utilization of labour for millet/sorghum/groundnut, but over-utilization of labour for millet / sorghum, millet / sorghum / groundnut/cowpea, millet / sorghum / cowpea and sole millet. For fertilizer, there was under-utilization of it in millet / sorghum / groundnut/cowpea, but over-utilization of it in millet / sorghum, millet / sorghum / groundnut/cowpea, millet / sorghum / cowpea and sole millet. Pesticides were over-utilized in millet / sorghum / groundnut/cowpea and in millet / sorghum / cowpea. Similar case of under-utilization and over-utilization of variable inputs were reported by Olagoke, 1991; Onyeweaku, 1994 and Nwakpu, 2008.

Table 4.24: Resource use efficiency in millet-based cropping systems

Cropping System	MFC (P_x)					MVP/MFC				
	Farm Size	**Seed**	**Labour**	**Fertilizer**	**Pesticide**	**Farm Size**	**Seed**	**Labour**	**Fertilizer**	**Pesticide**
M/S	120,000	43.50	400	80	--	5.7	3.98	0.87	-0.33	--
M/S/G/C	115,000	40.50	400	80	750	8.98	-0.43	0.27	-0.06	0.12
M/S/G	110,000	45	400	80	--	8.68	-0.7	1.38	1.53	--
M/S/C	120,000	46.12	400	80	750	1.85	0.89	0.31	0.10	0.34
Sole millet	120,000	35.65	400	80	--	8.8	43.4	0.91	-0.07	--

$$\text{MFC} = \frac{Cost\ of input\ /hectare\ \ for\ the\ crop\ \ mixtures}{Quantity\ \ of\ \ input\ \ used}$$

4.5 Costs and returns for millet-based cropping systems

Costs and returns results (Table 4.25) indicated that the total variable costs were ₦ 14666.2, ₦ 22817.6, ₦ 16815.5, ₦ 16841.5 and ₦ 12467.5 for millet / sorghum, millet / sorghum / groundnut/cowpea, millet/sorghum/groundnut, millet / sorghum / cowpea and sole millet, respectively. The gross revenues were ₦ 20,380.05, ₦ 211,828, ₦ 59,559.8, ₦ 212,752 and ₦ 14,534.45 for millet / sorghum, millet / sorghum / groundnut/cowpea, millet / sorghum / groundnut, millet / sorghum / cowpea and sole millet, respectively. The gross margins per hectare were therefore, ₦5713.85, ₦189010.4, ₦42744.3, ₦196077.60 and ₦2026.01 for millet / sorghum, millet / sorghum / groundnut/cowpea, millet/sorghum/groundnut, millet / sorghum / cowpea and sole millet, respectively. This result disagreed with the findings of Yusuf *et al,* 2008 who found when studying the profitability of *Egusi* melon production in Okahi local government area of Kogi state under mixed cropping systems that the higher the number of crops in the mixture, the lower the gross margin. The average rates of returns (gross revenues divided by the total variable costs) were 1.39, 9.28, 3.54, 12.63 and1.17 for millet / sorghum, millet / sorghum / groundnut/cowpea, millet/sorghum/groundnut, millet / sorghum / cowpea and sole millet respectively. These showed that the millet-based cropping systems were profitable.

Table 4.25: Costs and returns in millet-based cropping systems in the study areas

Variable		**Millet**	**Sorg.**	**Mill.**	**Sorg.**	**G/nut.**	**Cowp**	**Mill.**	**Sorg.**	**G/nut**	**Millet**	**Sorg. cowpea**		**Sole millet**
Seed	Quantity	4.25	2.6	5.8	3.3	6	2.5	7	5.7	9.2	6	5.9	3.4	6.5
	Unit Price/kg	40	35	40	35	120	100	40	35	120	40	35	100	35
	Value ₦/ha	261		1317.5				1583.5			786.5			227.5
Labour	Quantity	29.07		41.84				29.68			32			24
	Unit price/man-day	400		400				400			400			400
	Value ₦ /ha	10174		16736.00				11872.00			12800			9600
Fertilizer	Quantity	52.89		53.27				42			33.00			33.00
	Unit Price/kg	80		80				80			80			80
	Value ₦ /ha	4231.2		4261.6				3360.00			2640.00			2640.00
Pesticide	Quantity	-		0.67				-			0.82			-
	Unit Price/litre	-		750				-			750			-
	Value ₦ /ha	-		502.50				-			615			-
TVC		**14666.2**		**22817.6**				**16815.5**			**16841.5**			**12467.5**
		Millet	**Sorg**	**Mill.**	**Sorg.**	**G/nut.**	**Cowp**	**Mill.**	**Sorg.**	**G/nut**	**Millet**	**Sorg. cowpea**		**Sole millet**
Yield	Quantity	259.8	244.23	296.6	240.8	250.3	161.5	268.02	207.4	346.5	189.5	179.2	198.9	415.27
	Unit price	40	35	40	35	120	100	40	35	120	40	35	100	35
	Total Revenue ₦ /ha	**20,380.05**		**211,828**				**59,559.8**			**212,752**			**14,534.45**
GM ₦ /ha		**5713.85**		**189010.4**				**42744.3**			**196077.61**			**2026.01**
GM/₦ Invested		**1.39**		**9.28**				**3.54**			**12.63**			**1.17**

4.6 Constraints faced by millet-based farmers in the study areas

The results presented in Table 4.26 show the constraints faced by millet-based farmers in the study area. Inadequate fertilizer ranked first for all the cropping systems under consideration. According to Barbier, (1999), average fertilizer use is low in Africa, averaging 18 kilogramme per hectare of cropland. This is attributed to low farm incomes, imports and budget restrictions and high fertilizer prices which have prevented farmers from increasing fertilizer input use. For sole millet, poor market and inadequate storage facilities ranked second and third respectively. According to Ohiagu (1996), lack of storage facilities limits the steady availability of produce and stable market of food prices, prevents farmers and producers from selling their produce at times when they can get best prices; increases losses in quality and quantity and prevent healthy seeds from being made available for planting in the next cropping season. In the case of millet / sorghum / cowpea, lack of storage facilities and problem of pests and diseases ranked second and third, respectively. It is estimated that worldwide up to 30% of agricultural production is lost to animal pests, weeds and diseases each year with losses in tropical regions higher than in temperate areas (Kiss and Meerman, 1991). For millet / sorghum / groundnut, inadequate capital and lack of storage facilities both ranked second and problem of pests and diseases ranked third. According to Saito *et al.* (1994), lack of capital prevents farmers from acquiring inputs in a timely way, prevents farmers from financing technologies and capital improvements for raising productivity and also prevents farmers from taking advantage of market opportunities. For millet / sorghum / groundnut / cowpea and millet / sorghum, the problem of pests and diseases was the second important problem reported by the farmers after the problem of inadequate fertilizer. Inadequate capital was one of the problems faced by farmers in millet / sorghum and millet / sorghum / groundnut / cowpea and this ranked

third in millet / sorghum and fifth in millet / sorghum / groundnut / cowpea. For all the cropping systems, except millet / sorghum / groundnut, inadequate land was one of the constraints faced by the farmers and ranked third in millet / sorghum / groundnut / cowpea and fourth in millet / sorghum. According to Baanante *et al*. (1989), there is a consensus that arable land area available for expansion of agriculture is severely limited in developing countries. For example, though there are potentials for expanding the area of cultivated land in Africa, the soils are often poor in quality and expanded cultivation may endanger ecologically fragile areas.

Table 4.26: Distribution of farmers based on the constraints to millet production

Problems	**sole millet**	**M/S/C**	**M/S/G**	**M/S/G/C**	**M/S**
Inadequate capital	-	-	8 (20) 2nd	2 (7.7) 6th	6 (14.29) 3rd
Inadequate land	2 (7.7) 5th	2 (7.7) 6th	-	4 (15.38) 5th	5 (11.90) 4th
Inadequate fertilizer	13 (50) 1st	9 (34.62) 1st	14 (35) 1st	9 (34.62) 1st	15 (35.71) 1st
Poor market	5 (19.23) 2nd	3 (11.54) 5th	3 (7.5) 4th	2 (7.7) 6th	5 (11.90) 4th
Problem. of pests and diseases	2 (7.9) 4th	5 (19.23) 3rd	7 (17.5) 3rd	6 (23.08) 2nd	8 (19.05) 2nd
Lack of storage facility	4 (15.38) 3rd	7 (26. 92) 2nd	8 (20) 2nd	3 (11.54) 4th	3 (7.14) 6th
Total	**26 (100)**	**26 (100)**	**40 (100)**	**26 (100)**	**42 (100)**

Note: figure in parentheses are percentages

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study examined the economics of millet-based cropping systems in Bindawa and Charanchi local government areas of Katsina state. The specific objectives were to identify and describe the millet-based cropping systems; determine the inputs and output levels for the millet-based cropping systems; determine the production functions for the millet-based cropping systems; determine the resource use efficiencies for the millet-based cropping systems; determine the costs and returns for millet-based cropping systems; and identify and describe the constraints associated with the millet-based cropping systems.

Primary data were collected for the study, based on the 2010 cropping season using structured questionnaire and interview schedules administered on 160 millet-based farmers from a sample frame of 1582 millet farmers. The analytical tools employed were the simple descriptive statistics, production function analysis and farm budget technique.

The results of the study showed that the two commonest millet cropping systems in the study areas were millet / sorghum (26.25%) and millet / sorghum / groundnut (25.00%). For inputs used in the millet cropping systems, millet / sorghum / groundnut had the highest amount of land allocation of 82.3 hectares (26.71%) and sole millet had the least land allocation of 44.99 hectares (14.59%). For seed, the results showed that for millet / sorghum, 25.5 kg of millet and 15.5 kg of sorghum were used. For millet / sorghum / groundnut / cowpea, 35 kg of millet, 19.5 kg of sorghum, 36 kg of groundnut and 15 kg of cowpea were used. For millet / sorghum / groundnut, 42 kg of millet, 34 kg of sorghum and 55 kg of groundnut were used. For millet /

sorghum/cowpea, 36 kg of millet, 30.5 kg of sorghum and 20.25 kg of cowpea were used and for sole millet, 39 kg was used. For labour, the results showed that for millet / sorghum, 856 man-hours of labour were used. For millet / sorghum / groundnut/cowpea, 1163 man-hours of labour were used. For millet / sorghum / groundnut, 882 man-hours were used. For millet / sorghum / cowpea, 866 man-hours were used and for sole millet, 675 man-hours were used. For fertilizer, the results showed that for millet / sorghum, 299 kg of fertilizer were used per hectare. For millet / sorghum / groundnut/cowpea, 366 kg of fertilizer were used. For millet / sorghum / groundnut, 276 kg of fertilizer were used. For millet / sorghum / cowpea, 217 kg of fertilizer were used and for sole millet, 216 kg of fertilizer were used. For pesticide, the results showed that for millet / sorghum / groundnut / cowpea, 7.3 litres of pesticides were used per hectare and for millet / sorghum / cowpea, 7.2 litres of pesticides were used.

The results for mean yield of millet cropping systems showed that for millet / sorghum, 1558.69 kg of millet and 1465.38 kg of sorghum were obtained. For millet / sorghum / groundnut / cowpea, 1779.63 kg of millet, 1444.62 kg of sorghum, 1501.68 kg of groundnut and 969.24 kg of cowpea were obtained. For millet / sorghum / groundnut, 1608.12 kg of millet, 1244.22 kg of sorghum and 2079.23 kg of groundnut were obtained. For millet / sorghum / cowpea, 1183.47 kg of millet, 1075.35 kg of sorghum and 1193.13 kg of cowpea were obtained and for sole millet, 1902.3 kg of millet was obtained.

The results of the production function analysis showed that for millet / sorghum, the coefficients of farm size (X_1, $P \leq 0.05$), seed (X_2, $P \leq 0.1$) and fertilizer (X_4, $P \leq 0.1$) were positively and significantly with output. For millet / sorghum /groundnut/ cowpea, the coefficients of farm size (X_1, $P \leq 0.1$), labour (X_3, $P \leq 0.1$) and pesticide (X_5, $P \leq 0.1$) were positive and significant, but seed

(X_2) and fertilizer (X_4) were negative and insignificant. For M/S/G, farm size (X_1, $P \leq 0.1$), labour (X_3, $P \leq 0.05$) and fertilizer (X_4, $P \leq 0.1$) were positive and significant, but seed was negative and insignificant. For M/S/C, farm size (X_1), seed (X_2), labour (X_3) and pesticide(X_5) were positive and significant ($P \leq 0.05$ for farm size, $P \leq 0.01$ for seed, $P \leq 0.05$ for labour and$P \leq 0.1$ for pesticide)but fertilizer (X_4) was positive but insignificant. For sole millet, only seed (X_2)was positive and significant ($P \leq 0.01$). Farm size (X_1), and labour (X_3) were positive but insignificant and fertilizer (X_4) negative and insignificant.

The results of resource use efficiencies for the millet cropping systems showed that for millet/sorghum, farm size and seeds were under-utilized, but labour and fertilizer were over-utilized. For millet / sorghum / groundnut/cowpea, farm size was under-utilized but seeds, labour, fertilizer and pesticide were over-utilized. For millet / sorghum / groundnut, farm size, labour and fertilizer were under-utilised, but seed was over-utilised. For millet / sorghum / cowpea, farm size was under-utilized but seed, labour and fertilizer were over-utilized. For sole millet, farm size and seed were under-utilized but labour and fertilizer were over-utilized.

The results of costs and returns analysis showed that the gross margins per hectare for millet / sorghum, millet / sorghum / groundnut/cowpea, millet / sorghum / groundnut, millet / sorghum /cowpea and sole millet were ₦5,713.85,₦189,010.40, ₦42744.3, ₦19, 6077.60 and ₦2,026.01, respectively. The average rates of return for rmillet / sorghum, millet / sorghum / groundnut/cowpea, millet / sorghum / groundnut, millet / sorghum / cowpea and sole millet were 1.39, 9.28, 3.54, 12.63 and 1.17, respectively, indicating that the millet cropping systems were profitable.

For the constraints associated with the production of the millet cropping systems, inadequate fertilizer ranked first for all the cropping systems. For sole millet, poor market and inadequate storage facility ranked second and third respectively. In the case of millet / sorghum / cowpea, lack of storage facilities and problem of pests and diseases ranked second and third, respectively. For millet / sorghum / groundnut, inadequate capital ranked second and problem of pests and diseases ranked third. For millet / sorghum / groundnut/cowpea and millet / sorghum, the problem of pests and diseases ranked second after the problem of inadequate fertilizer. Inadequate capital ranked third in millet / sorghum and fifth in millet / sorghum / groundnut/cowpea. Inadequate land ranked third in millet / sorghum / groundnut / cowpea and fourth in millet / sorghum.

5.2 Conclusion

The study showed that millet cropping systems are an important part of the farming systems of the study areas. The identification of the wide range of technical, socio-economic, biological and related problems associated with the production of these cropping systems and providing solutions to them will contribute to the achievement of food security and improved standard of living.

The millet based cropping systems were found to be profitable. This then means that more research should be conducted on these cropping systems with a view to evolving appropriate agricultural innovations that will make them more profitable.

The resource use efficiency for the millet cropping systems indicated the over-utilization and under-utilization of some of the resource inputs used in production. This means some adjustments in resource use to optimal levels are necessary.

5.3 Recommendations

The following recommendations are made based on the findings of the research work.

(i) Farmers should be advised by the extension workers in the areas to take advantage of new crop cultivars developed for their ecological environments, since millet-based cropping systems were widely adopted in the study areas and were found to be profitable.

(ii) Given that some of the inputs (farm size, seeds, fertilizer and labour) were under-utilized and in some cases, over-utilized in the millet-based cropping systems, increasing the levels of inputs that were under-utilized and reducing the levels of those that were over-utilized to optimal level will lead to more output by farmers.

(iii) Farmers should be encouraged to form cooperatives societies and farmers' group so as to access loans more easily from financial institutions. This will help address the problem of inadequate capital in millet-based cropping systems.

(iv) Problem of inadequate fertilizer can be addressed by liberalizing and privatizing fertilizer procurement, distribution and marketing so that the input becomes readily available to the farmers.

(v) Since pests and diseases were found to be problems, crop improvement research should not only aim at increasing yield, but also at improving resistance to pests and diseases and to improvement in processing and storage.

(vi) Since poor storage was a problem, there is need for adequate and efficient storage facilities to save the excess crop produced from deterioration and waste and to ensure steady availability and stable market price for farm produce.

5.4 Contribution to knowledge

(i) The study identified the two most important millet cropping systems in the study area to be millet / sorghum (26.25%) and millet / sorghum / groundnut (25.00%).

(ii) The result of costs and returns analysis showed that the millet cropping systems were profitable. The gross margin per hectare for millet / sorghum, millet / sorghum / groundnut/cowpea, millet / sorghum / groundnut, millet / sorghum /cowpea and sole millet were ₦5,713.85, ₦189,010.40, ₦42744.3, ₦19, 6077.60 and ₦2,026.01, respectively. The average rates of return for millet / sorghum, millet / sorghum / groundnut/cowpea, millet / sorghum / groundnut, millet / sorghum / cowpea and sole millet, were 1.39, 9.28, 3.54, 12.63 and 1.17, respectively.

(iii) For the constraints associated with the millet cropping systems , inadequate fertilizer ranked as the most important constraints for all the millet cropping systems. For sole millet, the two most important constraints were inadequate fertilizer and poor market. lack of storage facilities and problem of pests and diseases were the serious constraints facing the millet-based farmers.

(iv) The fact that the coefficients of farm size (X_1), seed (X_2), fertilizer (X_4) and pesticide (X_5) were positive and significant in most of the enterprises is a good indicator that food insecurity and poverty reduction in the areas can be mitigated by making the inputs available and affordable for increased productivity.

(v) Failure to operate on the least-cost combination of inputs by the farmers in the areas may be due to the use of previous harvest seeds, abundant and chief labour and the care-free use of scarce inorganic inputs (fertilizer and pesticides). These led to some inputs being under-utilized while others over-utilized.

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Appendix I: Grain equivalent weight conversion factors

Crops	GEW* conversion factor
Millet	0.68
Sorghum	0.60
Cowpea	1.12
Groundnut	1.83

* Source: Clack, C. and M. Haswell (1970)

Appendix II: Estimated semi-log production function of millet-based cropping systems

Cropping system	Constant	Farm size	Seed	Labour	Fertilizer	Pesticide	R^2	F-value
M/S	-50.205	3.835 (5.099)	-0.404 (-0.478)	0.804 (0.385)	-0.339 (-1.507)		0.35	25.63
M/S/G/C	374.04	1.202 (3.168)	- 1.219 (-0.752)	1.199 (0.089)	-2.07 (-0.077)	3.923 (0.185)	0.40	2.751
M/S/G	-349.42	2.316 (10.62)	-0.179 (-0.360)	0.739 (0.741)	2.385 (1.178)	-0.224 (-0.187)	0.39	13.54
M/S/C	-153.25	1.260 (1.242)	9.753 (0.103)	7.305 (1.124)	1.281 (0.089)	4.559 (0.770)	0.39	21.545
Sole millet	575.50	3.259 (4.752)	-0.371 (-0.409)	2.689 (0.801)	4.793 (1.107)	-0.323 (-1.734)	0.41	50.14

Figures in parentheses are the t-values

Appendix III: Estimated linear production function of millet-based cropping systems

Cropping system	Constant	Farm size	Seed	Labour	Fertilizer	Pesticide	R^2	F-value
M/S	7.635	-0.682	2.063	0.067	-0.000		0.45	9.345
		(-6.978)	(1.429)	(2.211)	(1.809)			
M/S/G/C	14.135	-0.701	0.041	6.552	1.197	0.213	0.50	29.87
		(0.512)	(1.901)	(6.844)	(4.141)	(-0.103)		
M/S/G	9.832	-0.186	0.086	0.173	-0.142	--	0.39	5.453
		(-1.415)	(0.621)	(1.853)	(-0107)			
M/S/C	10.329	-0.043	0,043	0.005	-1.074	2.210	0.40	6.274
		(-1.714)	(1.544)	(0.053)	(-2.320)	(0.931)		
Sole millet	19.304	3.245	0.905	-0.053	-0.003	-0.246	0.42	17.568
		(1.371)	(7.768)	(-0.164)	(-8.000)	(-8.956		

Figures in parentheses are the t-values

Appendix IV: Questionnaire

Economic Analysis of millet-based cropping systems in Bindawa and Charanchi local government areas Of Katsina State

Farmers' questionnaire

Local government---------- village----------No: ----------

I am a student of Ahmadu Bello University Zaria and undertaking a research work in the above mention topic. Kindly assist by providing answers to the under-listed questions. Your responses will be treadtd with utmost confidentiality.

INFORMATION ON MILLET CROP MIXTURES AND SIZES OF FARMLAND ALLOTED

1. Do you grow millet in your farm(s)? yes/No
2. Do you grow millet sole or in combination with other crops?
   (i) Sole
   (ii) In combination with other crops
3. Indicate the millet-based cropping system(s) in your farm and the size of farmland Allocated to the millet-based crop mixtures and to sole millet

Millet-based cropping system	Size of farmland (hectares)
Millet/sorghum	
Millt/sorghum/groundnut/cowpea	
Millt/sorghum/groundnut	
Millt/sorghum/cowpea	
Sole millet	
Others(specify)	

4. INFORMATION ON SEED INPUT

Field No:	Cropping system	Millet		Sorghum		Groundnut		cowpea		Others (specify)	
		Qty(kg)	Cost(₦/kg)	Qty(kg)	Cost(₦/kg)	Qty(kg)	Cost(₦/kg)	Qty(kg)	Cost(₦/kg)	Qty(kg)	Cost(₦/kg)
	M/S										
	M/S/G/C										
	M/S/G										
	M/S/C										
	Sole millet										
	Others (specify)										

5. INFORMATION ON FERTILIZER INPUT USED AND COST

Field No:	Cropping system	NPK (Kamfa)		Super phosphate (sulfa)		Muriate of potash		Urea.	
		Qty (kg)	Cost (₦/kg)	Qty (kg)	Cost (₦/kg)	Qty (kg)	Cost (₦/kg)	Qty (kg)	Cost (₦/kg)
	M/S								
	M/S/G/C								
	M/S/G								
	M/S/C								
	Sole millet								
	Others								

6. INFORMATION ON MANURE USED

Field No:	Cropping system	poultry		Goat		sheep		cattle	
		Qty (kg)	Cost (₦/kg)	Qty (kg)	Cost (₦/kg)	Qty (kg)	Cost (₦/kg)	Qty (kg)	Cost (₦/kg)
	M/S								
	M/S/G/C								
	M/S/G								
	M/S/C								
	Sole millet								
	others								

7. INFORMATION ON CHEMICALS USED IN LITRES AND COST

Field No:	Cropping system	Pesticide		Herbicide		Others (specify)	
		Qty (ltr)	Cost (₦/ltr)	Qty (ltr)	Cost (₦/ltr)	Qty (ltr)	Cost (₦/ltr)
	M/S						
	M/S/G/C						
	M/S/G						
	M/S/C						
	Sole millet						
	Others (specify)						

8. INFORMATION ON THE TYPES OF LABOUR USED AND COSTS

a. Labour for land clearing

Field No:	Cropping system	Land clearing			
		Method of land clearing	Total family labour (days)	Total hired labour (days)	Total cost of land clearing (₦)
	M/S				
	M/S/G/C				
	M/S/G				
	M/S/C				
	Sole millet				
	Others (specify)				

b. Labour for ridging

Field No:	Cropping system	Labour for ridging		
		Total family labour (days)	Total hired labour (days)	Total cost of ridging (₦)
	M/S			
	M/S/G/C			
	M/S/G			
	M/S/C			
	Sole millet			
	Others (specify)			

c. Labour for planting

Field No:	Cropping system	Labour for planting		
		Total family labour (days)	Total hired labour (days)	Total cost of planting (₦)
	M/S			
	M/S/G/C			
	M/S/G			
	M/S/C			
	Sole millet			
	Others (specify)			

d. Labour for first weeding

Field No:	Cropping system	Weeding		
		Total family labour (days)	Total hired labour (days)	Total cost of weeding (₦)
	M/S			
	M/S/G/C			
	M/S/G			
	M/S/C			
	Sole millet			
	Others (specify)			

e. labour for second weeding

Field No:	Cropping system	Weeding		
		Total family labour (days)	Total hired labour (days)	Total cost of weeding (₦)
	M/S			
	M/S/G/C			
	M/S/G			
	M/S/C			
	Sole millet			
	Others (specify)			

f. Labour for fertilizer application

Field No:	Cropping system	Fertilizer application			
		Number of applications	Total family labour (days)	Total hired labour (days)	Total cost of application (₦)
	M/S				
	M/S/G/C				
	M/S/G				
	M/S/C				
	Sole millet				
	Others (specify)				

g. Labour for spraying of chemicals

Field No:	Cropping system	Spraying			
		Number of application	Total family labour (days)	Total hired labour (days)	Total cost of spraying (₦)
	M/S				
	M/S/G/C				
	M/S/G				
	M/S/C				
	Sole millet				
	Others (specify)				

h. Labour for harvesting

Field No:	Cropping system	Harvesting		
		Total family labour (days)	Total hired labour (days)	Total cost of harvesting (₦)
	M/S			
	M/S/G/C			
	M/S/G			
	M/S/C			
	Sole millet			
	Others (specify)			

i. Labour for threshing

Field No:	Cropping system	Threshing		
		Total family labour (days)	Total hired labour (days)	Total cost of threshing (₦)
	M/S			
	M/S/G/C			
	M/S/G			
	M/S/C			
	Sole millet			
	Others (specify)			

9. INFORMATION ON OUTPUT OF SOLE MILLET AND MILLET MIXTURES

Field No:	Cropping system	Output (Kilogramme)				
		Millet	Groundnut	Sorghum	Cowpea	Others (specify)
	M/S					
	M/S/G/C					
	M/S/G					
	M/S/C					
	Sole millet					
	Others (specify)					

10. INFORMATION ON THE QUANTITY SOLD OF EACH OF THE COMPONENT CROPS

How much was the revenue from the quantities you sold of each of the component crops?

Cropping systems	Millet (₦)	Sorghum (₦)	Groundnut (₦)	Cowpea (₦)	Total revenue (₦)
M/S					
M/S/G/C					
M/S/G					
M/S/C					
Sole millet					
Others (specify)					

11. INFORMATION ON THE CONSTRAINTS TO MILLET PRODUCTION

Millet-based mixtures and sole millet	Constraints
Millet/Sorghum	
Millet/Sorghum/Groundnut/Cowpea	
Millet/Sorghum/Groundnut	
Millet/Sorghum/Cowpea	
Sole millet	
Others (specify)	