# Analysis of Constraints to Agricultural Production in the Sudano Savanna Zone of Cameroon and Implication for Research Priority Setting

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## Summary

*A participatory rural appraisal (PRA) survey approach was used to identify the major constraints to agricultural production and to describe the major production systems in the sudano savanna and sudano sahelian zone of northern Cameroon. Relative emphasis was placed on the household level characterization to have a better understanding of the land use system, farmers' constraints to production and opportunities, so as to better target agricultural technologies and interventions in this vast agro-ecological zone. It was noted that, large variations exist in agriculture management practices between agro-ecological zones, among villages and households in terms of access to resources, such as labour, fertilizers, livestock, farm equipment, and land. Intensive and extensive farming practices might co-exist within the same village and households. The mains sources of vulnerability were identified. Results are used to set research priorities which will be directed towards the need of the majority of area's population; the improvement of sustainable food and feed crop production.*

## Résumé

**Analyse des contraintes à la production agricole dans les zones de savane soudanienne du Cameroun et l'implication pour la prioritisation des thèmes de recherche**

*Une approche de diagnostic participative a été utilisée pour identifier les principales contraintes à la production agricole et caractériser les principaux systèmes de production dans les zones de savane soudanienne et sahélienne du nord Cameroun. L'accent a été mis sur la caractérisation au niveau du ménage pour mieux comprendre les systèmes d'utilisation des terres, les contraintes et les possibilités des paysans afin de mieux cibler les technologies et les interventions pour cette vaste zone agro-écologique. On a observé des grandes variations dans les pratiques de gestion agricole entre les zones agro-écologiques, les villages et les exploitants en terme d'accès aux ressources comme la main-d'œuvre, les engrais, le bétail, les équipements agricoles. Des pratiques de culture intensives et extensives peuvent co-exister au sein d'un même village et ménage. Les principales faiblesses ont été identifiées. Les résultats ont été utilisés pour prioritiser les thèmes de recherche qui devront répondre au besoin de la majorité des populations des zones concernées: une amélioration durable de la production agricole.*

## Introduction

Cameroon is situated on the west coast of Africa between latitudes $2^0$ and $13^0$ N and between longitude $8^0$ and $16^0$ E. It is characterized by a great climatic diversity ranging from the humid tropics near the coast where annual rainfall exceeds 3000 mm to the sahelian zone with 600-900 mm of precipitations, and a dry season of 9 to 10 months. Mountains and plateau areas affect both rainfall and temperature, breaking the regular succession of climatic zones from south to north. The potential for agricultural production is large and opportunities for increased agricultural development exist in the four main agro-ecological zones, each with its unique characteristics.

The Sudano-Savanna zone alone extends between latitude $7^0$ 30' and $13^0$ N and longitude $9^0$ to $15^0$ and is characterized by a large eco-climatic diversity in terms of biophysical (climate, soils, hydrology,) and socio-economic (land, labors, resources, marketing and tenure practices) conditions. There are more than 60 ethnic groups in this region. The climate is of the type AW/BS in the Köppen classification (tropical humid with dry winter/semi-arid) (16). The rainfall pattern is unimodal with the peak in August. The rainy season lasts four months from June to September with two intermediate months of unreliable rainfall in May and October. Mean total annual rainfall is approximately

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750 mm and the length of the growing periods is 120 to 150 days with infrequent droughts. Annual temperatures range between 29 $^0$C and 39 $^0$C. The lowest mean temperatures occur between December and January, with the cold dusty harmattan winds. The major rainfed cereals are sorghum and millet; maize, groundnuts, cowpea, vegetables and rice are additional staple food crop; cotton is the predominant cash crop.

Cropping systems are based on sorghum and millet; but with increasing population densities and fertilizer prices, the quest for alternative, yet productive and sustainable production systems becomes more important. The key factor of production in any agricultural system is labor. It is the human investment, which transforms land and capital assets into consumable output. Different societies have fashioned different patterns of labor organization at different stages of their development. In northern Cameroon, the coexistence of Moslem and non-Moslem ethnic groups allows an analysis of several different patterns of organization. The land use systems and production strategies adopted by farmers depend on the interaction between biophysical and socio-economic resources available to them. A better understanding of environment in which these farmers operate and their constraints would help in sharpening the focus of research through adequate planning and characterization of agriculture environments and land uses; this will lead to the concentration of efforts on key commodities and promising areas of agricultural potentials.

The main objectives of this study were to identify constraints to production in the sudano savanna and sahelian zone of northern Cameroon and subsequently prioritize research and development themes.

## Materials and methods

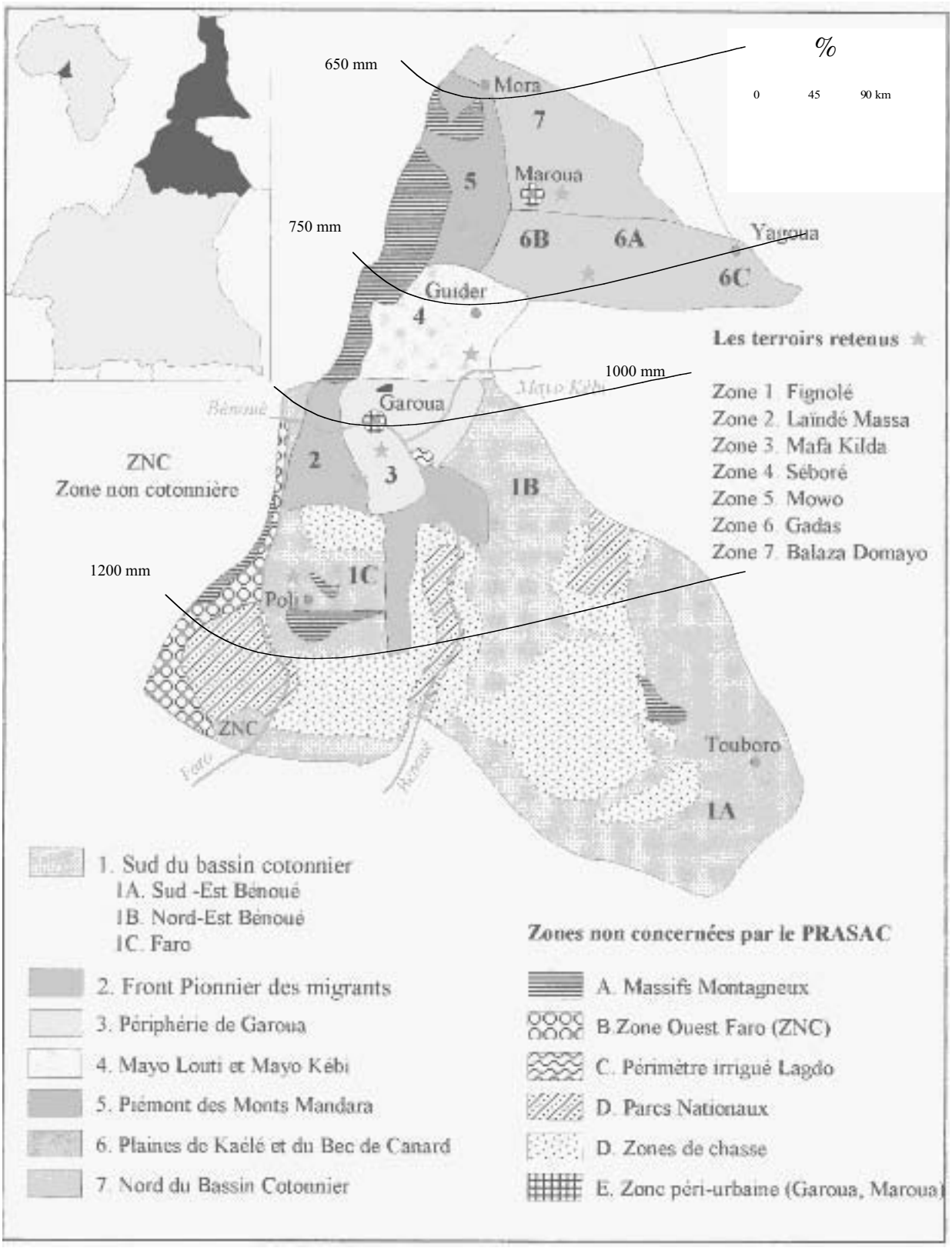
A research team of the Institute of Agricultural Research for Development (IRAD) conducted the research jointly with the Extension service of the Ministry of agriculture. The study area covered a total of seven villages selected from two distinct agro-ecological zones in the northern Cameroon. Four of the selected villages (Fignolé, Laindé, Mafa kilda, Séboré) were from the north province administrative region, representing the sudano savanna agro-ecological zone, and three villages (Mowo, Gadas, Balaza Domayo) from extreme-north province administrative region (Figure 1) representing the sudano sahelian zone. These villages were chosen to represent the agro-climatic and socio-economic diversity of the region.

Figure 1 provides the location of the selected villages and Table 1 the biophysical details. Others factors used in selection were the accessibility, annual rainfall and representations of main production systems. A total of 100 households were selected in the seven villages. Areas where dry season commercial gardening activities are known to be highly developed were avoided. Table 2 describes the basic characteristics of the two zones and each village. To collect information from the local farmer, several different methods were used sequentially. The study was initiated by conducting a Participatory Rural Appraisal (PRA) from October to December 2000. Activities of households were monitored. The second step was collection of information by means of single and group interviews to verify the information previously collected. Additional interviews with the household heads were held to determine their farming practices and resource endowments. In order to optimize the process, a series of pre-coded questionnaires was developed, modified from the Food and Agricultural Organization's Farm management data collection and Analysis computer package (5). The use of questionnaires provides a systematic, ordering way of obtaining precise statistical data from respondents. Information required included:

- Inventory of household members and livestock assets;
- Livestock management and utilization of range lands;
- Field characteristics and enumeration of area cropped per field;

**Table 1**
**Location and selected biophysical details of the seven villages in northern Cameroon**

| Province | Ecological zone | Villages name | Village coordinates | | Main soil type | Rainfall range (mm) |
|---|---|---|---|---|---|---|
| North | Sudano savanna | Fignolé | 8°30' | 13°10' | Lixisols/sandy Lixisols | 1000-1500 |
| | | Laïndé | 9°20' | 13°19' | Sandy clay | 1000-1200 |
| | | Mafa- Kilda | 9°15' | 13°28' | Lixisols Hydromorphic | 900-1000 |
| | | Séboré | 9°35' | 13°60' | Lixisols Vertisols | 800-1000 1000 |
| Extreme north | Sudano sahelian | Mowo | 10°10' | 14°10' | Hydromorphic Vertisols | 700-800 |
| | | Gadas | 10°15' | 14°25' | Sandy clay Vertisols | 600-700 |
| | | Balaza – Domayo | 10°45' | 14°35' | Sandy clay | |




*Source: IRAD/PRASAC Méthodologie du diagnostic global au Cameroun (2000).*

Figure 1: Location of the studied village in the northern Cameroon.

- Intercropping patterns and crop rotations;
- Land use practices and tenancy arrangement.

Farmers were also asked to provide information on: break down of labour stock, labour profile and utilization, animal traction used and fertilizer quantities distributed per field.

Information was collected not only from the head of the household but, also from each family member who cultivated his or her own field.

**Table 2**
**Selected characteristics of the seven villages in the sudano savanna and sahelian zone of Cameroon**

| Agro-ecological zone | sudano savanna | | | | sudano sahelian | | |
|---|---|---|---|---|---|---|---|
| Region | Cotton belt | Pioneer | Garoua zone | Mayo louti and mayo kebi | Piedmont of mandara mountain | Plain of Kaélé, Bec de canard | Plains of diamaré, Mora zone |
| Villages | Fignolé | Laïndé | Mafa kilda | Séboré | Mowo | Gadas | Balaza Domayo |
| Population | 800 | 680 | 900 | 1000 | 1350 | 1570 | 200 |
| Density (Hab./km$^2$) | 5-10 | 10-30 | 20-60 | 30-70 | 50-180 | 30-180 | 30-180 |
| Total Household | 160 | 150 | 170 | 170 | 180 | 240 | 45 |
| Household selected | 15 | 10 | 15 | 15 | 15 | 20 | 10 |
| Working members/family | 4 | 4 | 4 | 4 | 5 | 7 | 4 |
| Farm size (ha) | 2.5 | 2.9 | 3.1 | 4.0 | 2.5 | 1.6 | 2.2 |
| Animal traction | 8 POC | 10 POC | 55 POC | 3 POC | 40 POC | 40 POC | 3 POC |
| Fallow (years) | 2 to 3 | 1 | 2 | 2 to 3 | None | none | none |
| NPK (on crop) | Cotton, maize | Cotton, maize | Cotto, maize | Cotton, maize | Cotton | Cotton | Cotton |
| Manure (kg ha$^{-1}$) | none | none | none | 120 | 396 | 520 | 650 |
| Cattle | 130 | | 140 | 400 | 300 | 300 | 200 |
| Goat/sheep | 560 | | 400 | 300 | 1000 | - | 300 |
| Donkey | 13 | 11 | 10 | - | 100 | 15 | 20 |
| Animal husbandry | Mbororo Transhumance Semi-sedentary | Mbororo Transhumance Semi-sedentary | Sedentary Transhumance | Sedentary Transhumance | Semi–sedentary | Sedentary | Semi-sedentary Transhumance |

POC= Pairs of cattle used for plowing and transport

## Results and discussion

*Rainfall*

The sudan-savanna zone of northern Cameroon may be subdivided into three sub-ecological zones. The sahelo-sudanian zone with rainfall less than 700 mm, the sudano-sahelian zone where the rainfall varied from 700 mm to 900 mm and the sudano-guinean zone where rainfall varies from 1000 mm to 1200 mm. The growing periods of the sudano-sahelian zone vary from 100 to 150 days while for the sahelo-sudanian zone it varies from 60 to 100 days. All zones are characterized by large inter-annual variability. Monthly variation is important since rainfall is usually limited to few months, i.e. June to October. Aridity prevails during the rest of the year and is most pronounced from November to April. The rainfall is variable and unreliable. As one moves north, the rains begin progressively later and end earlier. Rainfall variability, especially late starting and early cessation of rain often results in a shortened growing season. Effective moisture for plant growth is reduced by high evapotranspiration and runoff. The drought spells become more and more frequent. At the scale of agro-ecological zone, the mean annual rainfall during 1999 and 2000 cropping season varied between 1100 mm in sudano-savanna zone to 650 mm in the sudano-sahelian zone. According to Nicholson (9), the potential for development of these zones is limited not only by total rainfall, but also by other, less commonly considered characteristics of the area's rainfall such as spatial variability, intensities, infiltration and runoff.

*Soils*

Overtime, the various process of soils formation have given rise to important pedological heterogeneity of this part of Sudan savanna zone (Table 1). Based on a 1:100 000 soil map from ORSTOM (10) and translated to FAO classification, three major soil types maybe distinguished:

Vertisols: they are heavy textured soils having more than 30% clay at least to a depth of 50 cm, wide and deep cracks at some time of the year and a specific morphology characterized by one or more of the following three criteria: gilgai microrelief, intersecting slickensides, and wedge-shaped structural aggregates (2). They have low available water holding capacities because they may hold water and nutrients so tightly that they become unavailable to plants even though they have high total water holding capacities. The most extensive vertisols may be found between

the 600 and 900 mm isohyets. They cover 1 200 000 ha, that represents 12% of north Cameroon's land area and 2,5% of total country (3).
Lixisols: they are reddish brown and show the translocation of clay from the surface horizon to the sub soil horizons. The structure is massive with sandy clay loam texture. A common feature of these soils is low organic matter content; cation exchange capacity (CEC), and low nutrient content, especially N and P.
Hydromorphic soils are found in pockets in all zones in the northern Cameroon. These soils have fluctuating water tables and occur in small valley bottoms and flood plains. They are sandy loam or loamy clay. Farmers recognized these three types of soil.
Others factors that may influence soil physical properties in the region include the very high intensity of rainfall and its erosive power. Rains are very strong and aggressive and cause intense erosion, which lead to significant runoff as well as prolonged condition of superficial soil water logging. Farmers maintain soil fertility through application of inorganic fertilizers, mixed cropping practices and animal manure. The quantities are, however insufficient to meet crop requirements. Land degradation through overgrazing and also degradation through overgrazing and also deforestation is common in most parts of the region.

*Land use right and production patterns*
Crop production increases in the region have primarily come from increases in the cultivated area. Land use comprises cereal-based cropping, cotton-based cropping and ruminant-based livestock activities with considerable variability between agro-ecological zones (Table 1). Averaged over ecological zones, farm sizes decreases as one moves from the sudano savanna to sudano sahelian zone. Agricultural land falls into two discrete categories: rainy season fields and dry season fields. In the less crowded villages, farmers' rainy season fields are usually located around the compound. Cotton, the region's primary cash crop, is grown in large blocks subdivided into plots of 0.25 ha. SODECOTON (Société pour le Développement du Coton au Cameroun) the largest industrial force in the region, which organizes all phases of cotton production and marketing has organized the block system in order to standardize plot sizes and facilitate the use of animal traction and chemical inputs. In principle, the sites of the blocks are rotated each year to allow villages to contribute land to common. Very little land if any is left to fallow on a regular basis.
The cultivation of dry season sorghum crop commonly called "Muskwari" is a unique feature of northern Cameroon agricultural systems. Seedlings are taken from their rainy season nursery beds one month after planting and transplanted into vertisol, which are heavy clay soils, known as "Karal" fields. These "Karé" (plural of Karal) are normally completely flooded during the rainy season, and completely unworkable. As the rains taper off, these heavy clay soils are prepared for transplanting of dry season sorghum seedlings. The moisture absorbed by these swollen vertisols from May to September plus the cup of water added at transplanting time will sustain the sorghum (Muskwari) plant for five next months without a single additional drop of water. Dry season sorghum is recognized to be one of the preferred grains for consumption by the majority of the region's population and has grown in importance, particularly because cotton cultivation sometimes competes with sorghum for land and labor during the rainy season. As the demand for dry season sorghum increases, so does the demand for heavy clay soils (Karé). A farmer's field can be much further away from his house. Because of the great competition for vertisols, they figure more prominently in the land rental market, than do rainy season food grain or cotton fields.
In all villages studied, tenure over land is not always secure. All lands belong to the village chief. He distributes control of land to his deputies (Djooros). They in turn oversee the allocation of usufructuary rights to farming families. Land is neither formally rented nor sold, but farmers in need of extra land can borrow field from a neighboring household or from a village chief to use during the growing season. The usufructuary rights to land are effective only during the cropping season. In the dry season, the itinerant livestock herders are free to search for forage and crops residues on all fields that are not enclosed. According to Azarya (1) the 1963 land tenure legislation reinforced the traditional right to land ownership by collective units, even though they are not actually cultivated by those units. This practice is still in force today. Land use is intense and holding are very small. Average cultivated area per household is just about one ha, but more that 50 percent of holdings are smaller than one ha.
Farmers use all their land to grow crops, and there is virtually no grazing land available for livestock during the rainy season. Most fertile lands have already been put under cultivation. To increase or maintain production levels, farmers have extended cultivation into more marginal lands. The growing land constraint in the area of higher population density has caused a breakdown of the traditional fallows system used for maintaining soil fertility. The shortening of fallow cycles without adequate replenishment of soil nutrients through the use of organic and inorganic inputs have caused cereal yields to decline. Increased cultivation on bush fields and the reduction of the fallow period have implications for sustainable long-term production. In addition the growing land constraint in the area of higher population density suggests that extensification of agricultural practices will no longer be feasible solution to increase agricultural production, but that intensification of agricultural production should be sought.

*Cropping systems*
Cropping systems in the two zones are mainly based on sorghum, cotton, and maize (Table 3).

**Table 3**
**Cropping systems in the seven villages in the sudano savanna and sahelian zone of northern Cameroon**

| Agro-ecological zone | sudano savanna zone | | | | sudano sahelian zone | | |
|---|---|---|---|---|---|---|---|
| Villages | Fignolé | Laïndé | Mafa kilda | Séboré | Mowo | Gadas | Balaza domayo |
| Types | | | | | | | |
| *Sole crops* | | | | | | | |
| Sorghum | 3 | 2 | 3 | 4 | 14 | 15 | 12 |
| Cotton | 8 | 9 | 6 | 8 | 10 | 10 | 8 |
| Maize | 10 | 8 | 6 | 6 | 4 | - | 1 |
| Groundnut | 6 | 7 | 9 | 9 | 3 | 4 | 4 |
| Cowpea | 2 | 1 | 1 | 2 | 6 | 5 | 10 |
| Muskwari | 0 | 0 | 0 | 1 | 9 | 10 | 8 |
| Sub-total | 29 | 27 | 25 | 30 | 46 | 44 | 43 |
| *2-Crops mixture* | | | | | | | |
| Sorghum/groundnut | - | - | 6 | 11 | 7 | 5 | 8 |
| Sorghum/cowpea | 0 | - | 1 | - | 5 | 8 | 8 |
| Cotton/groundnut | 12 | 9 | 10 | 10 | 9 | 8 | 7 |
| Millet/cowpea | 0 | 0 | 0 | - | 0 | 2 | 0 |
| Cotton/maize | 12 | 3 | 9 | 14 | - | 0 | 0 |
| Cotton/sorghum | 4 | 5 | 9 | - | 9 | 10 | 12 |
| Cotton/cowpea | 9 | 8 | 6 | 8 | 11 | 9 | 9 |
| Sub-total | 37 | 25 | 41 | 43 | 41 | 42 | 44 |
| *3-crops mixture* | | | | | | | |
| Cotton/maize/grndt | 12 | 12 | 9 | 10 | - | 0 | - |
| Cotton/sorgh/grndt | 7 | 10 | 8 | 4 | 4 | 1 | 2 |
| Cotton/sorgh/veget | - | 6 | 1 | - | 1 | - | - |
| Maize/cotton/veget | 9 | 8 | 9 | 8 | - | - | 0 |
| Sorgh/grndt/cotton | - | 3 | 5 | 4 | 1 | - | 2 |
| Sorgh/cowp/cotton | 2 | 0 | 2 | - | - | - | 1 |
| Sorgh/grndt/cowp | - | 5 | - | - | 1 | - | 2 |
| Sub-total | 30 | 44 | 34 | 26 | 7 | 1 | 7 |
| Others | 3 | 4 | - | 1 | 6 | 13 | 6 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Sorgh= sorghum; Cowp= cowpea; grndt= groundnut; veget= vegetable

On the south-north axis, the importance of maize decreases and that of sorghum increases, while cotton remains the major cash crop regardless of geographical position. A typical rotation involves cotton and sorghum; groundnuts may enter into this succession on lighter soils. Although continuous cultivation of some fields for up to twenty years or more has been reported, fallows last up to three years depending on location and scarcity of land. In the region, major food crops are sorghum, maize, groundnuts and cowpea. Minor crops include sesame, vegetables, Bambara-nuts grown in a variety of intercrop. Sole crops are predominant in the sudano savanna zone were the use of herbicide for weed control is important; but variability in surface cultivated at both provinces and villages is considerable. Small – scale farmers produce the bulk of total output in the region, the size of farm holding varies from 1 to 3 ha (Table 2).

In low rainfall zones that is in the sudano sahelian zone, the most important cropping systems is the two-crop system: cotton/maize; cotton/sorghum; cotton/cowpea; sorghum/groundnut; sorghum/cowpea and millet/cowpea (Table 3) on sandy clay and hydromorphic soils. On heavy textured soils (vertisols), the most frequent cropping system is muskwari/muskwari. Other important enterprises specific to some location include: muskwari/cotton/sorghum and cotton/sorghum/muskwari.

The three-crop system and others patterns are most common in the sudano savanna zone (Table 3) with higher rainfall, more fertile lixisols and low population density; these included: cotton/maize/groundnut or

cotton/sorghum/groundnut; cotton/sorghum/vegetables; maize/cotton/vegetables; sorghum/groundnut/cotton; sorghum/cowpea/cotton; sorghum /groundnut/cowpea. The dry season sorghum (muskwari) where it is being cultivated does not enter in any rotation. Flat plowing of fields is the most common practice of land preparation after field have been cleared and burned.
Farmers were asked about the source of their crop seed and the factors influencing their choice of varieties. It was revealed that farmers stored rainy season sorghum, dry season sorghum (muswkari), maize, and cowpea seeds from their previous harvest or bought seeds on local markets. Groundnut seeds are more commonly bought on the market than those of the other crops. Cottonseeds are provided by the industry (SODECOTON).
The varieties of sorghum, maize and cowpea are chosen for their yield of grain as well as for by-product depending on the specific needs of the farmer. Livestock keeping farmer will chose a variety yielding high amounts of by-product, thereby integrating fodder production with grain production. Other criteria used in the choice are availability of seeds or length of the growing period. In any case, food self-sufficiency and risk avoidance for the farm families are among the principal objectives. A mixture of several sorghum varieties may be planted in the same field to extend the harvesting period and minimize risk of failure. The species, varieties and mixtures of crops grown on particular soils depended on how farmers rate the crop production potentials of the soils. The main source of vulnerability is drought, declining soil fertility, weeds (striga) leading to crop failure.
Because of poor distribution systems and high cost, farmers seldom apply chemical fertilizer on food crops. Farmers look for alternatives to fallow to maintain soil fertility, as extensive techniques of soil fertility maintenance become inadequate to boost crop production. Farmers prepare their manure in the compounds on the basis of droppings from ruminants and crop residues. Because the quantity of manure produced by farmers is usually insufficient to cover the whole farm in any given years, it is only applied to specific spots in the field with each field receiving manure in average every two to three years. However, nutrient transfer from the rangeland to the cropland through farmyard manure application or corralled animals is an important strategy for maintaining soil fertility. To better deal with the scarce manure, farmers take into account the slope of the field to minimize run-off and the risk of “crop burning” on newly manured plot in case of low rainfall in the early growing period. In year of abundant rainfall, spot that has received manure will produce high yield, whereas in years of little or poorly distributed rainfall plots which has received less manure will still produce minimal yields. According to the farmers, the second year of intensively manured spots results in better crop yields without risk of burning. Hence, such difference in soil fertility on one single field would help to reduce risk of crop losses and equalize yield variations. Brouwer et *al*., (4) reported similar use of micro-variability for millet planting as a risk aversion strategy in Niger and argued that farmers aim for reliable but not maximum yields even in years of poor rainfall.

*Labor force*
Labor is the most limiting factor in resource – poor farming systems. The amount of land a family can cultivate is constrained by the amount of labor available to it. Any expansion of production must come either from an increase in the amount of available labor including hired labor or from an increase in labor productivity through technological innovation. The use of animal traction for land preparation is the most common technological advance encouraged by development agencies and adopted by farmers. It is widely practiced in the sudano savanna zone where land availability is important. This practice reduces human labor input and alleviates drudgery. Family members provide the bulk of farms labors. Small-scale agriculture in the sudano sahelian zone is highly labor intensive because farms sizes are smaller and all the farm operations are done manually.
General knowledge holds that there are different patterns of labor organization by ethnicity in northern Cameroon. Thus non-foulbé household rely to a greater extent on family labor and community labor. They do not resort to hired labor. Between the foulbé and non-foulbé, a market exits for hired labor. Generally, labors are hired for cotton and muskwari cultivation and the only outside labor input for rainy season sorghum is hired for harvesting of grain. Labor requirement vary considerably in the course of the year. The agricultural calendar year starts in May with clearing and carry the manure to the fields. The onset of rains and subsequent sowing is between June to early July. During these periods labor use is important.

*Animal husbandry*
Livestock constitutes an important component of agricultural production systems in the region. Serving as a store of wealth and a source of cash for the purchase of seasonal inputs in agricultural activity. That is, pastoralism and mixed-crop livestock farming are at the two ends of a continuum of livestock production systems found in the region (Table 2). The main species are cattle, goat, sheep and donkey. These animals are kept on-farm for ploughing, manure and farm transport. Animals are grazed extensively by family members or entrusted to Mbororo herders. The mixed farmers keep 2 to 5 heads of cattle and 5 to 10 sheep, while Mbororo pastoralists keep 20 to 50 cattle and 20 to 50 sheep and goats. Women tend to keep smaller ruminant such as sheep or goats. In the

highly populated mountains regions, cattle and small ruminants are stall-fed during the rainy season. This labor-intensive activity appears to be an ecologically well-adapted means of raising animals in the face of land scarcity and also complements intensive crop production in the mountains (11).

Livestock production in pastoral systems of sudano savanna zone is based on periodic movements of cattle in search for pastures and water (Table 2). However, pastoralist change their production strategies in accordance with their perception of environmental conditions, which may require occasional movements of short duration or seasonal transhumance lasting several months (6, 15). During the rainy season, the most used practice consists of moving animals into drier areas of the arid zone to take advantage of the flush of high quality forage produced by annual grasses. During the dry season, pastoralists attempt to access enough water, crop residue and forages to maintain the productive capacity of their herds (12). Within each season they take advantage of the patches of pasture that produce more forage either due to higher soil moisture or fertility (14). This traditional transhuman production system appears to be in a state of transition and is becoming increasingly difficult to sustain. The problem is not simply of too many animals relative to available grazing areas. Long periods of below average rainfall, recurrent severe droughts and animal health problems have decreased pastoralists' herds. In addition, in many parts of the region, farmers have taken over the best grazing lands and converted them into cropland. This process has been accompanied by the increasing cultivation of valley bottoms, which has restricted pastoralists movement and prevented them from using these areas as trekking routes or pasture during the dry season. This phenomenon is common in all semi-arid regions of West Africa (17). The net effect has been a reduction in total pasture area and seasonal inaccessibility to remaining pastures due to diminution caused by cropping. Farmers-herders' conflicts increase as access paths to local (transhumance) pastures are obstructed. In densely populated zones such as piedmont of mont mandara, plain of Diamaré and plain of Kaélé, livestock and crop systems have become more integrated and cropping intensity as well as labor input increase with population density. Small ruminant increase whereas cattle decline. Livestock feeding becomes more labor intensive because of the scarcity or complete loss of natural range. Crop residue, cut grass and browse are gathered to feed livestock kept in confinement. The mains source of vulnerability are feed and water availability, especially during the dry season, leading to animal health problems and the distress sale of assets.

Mixed crop-livestock production systems in the sudano sahelian zone are growing in importance as population pressure rises and demand for arable land increases. There is however evidence which indicates that irrespective of the extent of integration of crop and livestock production, many of the direct benefits of closer integration are small (7, 13). The notable benefits in improved soil quality and fertility, as a result of manuring and the use of animal traction may not always result in large increases in crop yields due to low output response of available crop varieties and the inadequate quantities of manure applied. This implies that along with closer crop-livestock interactions, new technology development involving breeding adapted high yielding varieties, increase soil fertility under sustainable input conditions and improvement in feed production are needed to raise overall agricultural productivity.

**Future research need**

Within this ecological zone, crop combinations and rotations vary widely in response to local conditions. The complex cropping strategies of traditional systems contribute to their stability, diversity, as well as their productivity. It is probably not possible to substitute simplistic production packages. Therefore, the objective should be to improve components within the system, which includes better varieties, agronomic practices and develop strategies to maintain high soil fertilities. In the drought prone zone, a key priority will be to reduce the likelihood of crop failure through improved land husbandry and water harvesting; plus utilization of more efficient crop combinations involving drought tolerant cultivars, and early maturing varieties.

The effects of each cropping system on soil productivity and cultural operations such as weed control need to be better understood. Similarly, understanding factors that affect crop-water balance, such as plant type, plant density, soil moisture and soils preparation techniques are essential. The resource-use patterns of sorghum/cotton/leguminous sole and intercropping systems are yet to be adequately studied. Understanding the of cropping patterns on soil fertility and water-use efficiency, particularly those that have an impact on moisture loss due to soil evaporation will be important when developing strategies to improve and stabilize crop productivity in the region. Of equal importance is the development of integrated control methods for *striga* and other weed. In the livestock sub-sector, research on animal productivity should focus on feeding strategies, the utilization of crop residues and by-products, the utilization of locally-adapted breeds and the control of epizootics diseases. Forest regeneration is necessary for sustainable fuel wood supplies.

## Conclusion

This study was carried out in seven villages located in the north and extreme north province of Cameroon using the rural appraisal survey on the basis of the

following aspect: crop and livestock husbandry, land, labor and climatic conditions. It is recognized that all aspect of variability could not be captured, but with this survey, constraints and opportunities were better identified. It may be observed that, in general high population growth and large number of rainfall deficit years have encouraged extensification of arable farming and heightened the competition between grazing and cropping systems. The unpredictability of the rainfall patterns makes the timing of plow-planting absolutely critical. Moreover, the cultivation of marginal lands and changes in farming systems (e.g. no or shorter fallows) have rendered farmers more vulnerable to climatic risk. In this contest, expansion of cultivated areas to marginal and fragile environments may no longer be a feasible solution to increase agricultural production; therefore the intensification of practiced agronomy should be in order. In most areas, land allocation to agricultural production is hindered by lack of exclusive use rights and land tenure insecurity. Common property or access to large land area is desirable in this case, since it can reduce production losses in poor rainfalls years.

It is in light of these developments that technologies are urgently required which fit in with the land-use systems of resource-poor farmers and which do not destroy the natural resource base. Increase in food crop, feed production and quality are needed not only to improve human nutrition and livestock production in the region but also to provide the needed energy for economic growth and poverty alleviation. The integration of grain and forage legumes can serve an important role in sustaining the production of crop and livestock in the region. To this end, mixed crop-livestock systems can be seen as offering a solution to the crisis of pastoralism and extensive cropping in the region specifically and generally in all the semi-arid region of the west Africa (8).

The multiple problems identified will not be solved without stronger and more stable government commitment to research. The National Agricultural Research program and extension services must find ways of increasing adoption where existing technology has shown promise, while developing new models where it has failed. These goals are essential and involve not only direct support, but also policy decision that recognize that technological change is a dynamic process endogenous to the economy, and that successful adoption is not simply a function of research and extension, but is highly correlated with policy and the effective development of the overall institutional framework.

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