AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 70

1. SUBJECT CLASSIFICATION

A. PRIMARY: Food production and nutrition — AF00-0100-G190

B. SECONDARY: Plant production--Cereals--West Africa

2. TITLE AND SUBTITLE
An analysis and forecast of cereals availability in the Sahelian Entente states of West Africa

3. AUTHOR(S)
Becker, J.A.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1974	191p.	ARC AFR338.1731.B395

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Becker

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(Final rpt.)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAE-504

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Cereals
Forecasting
Food supply
Niger
Project planning
Sahel?
Sector analysis
Upper Volta

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/CM/afr-C-73-20 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

AFR
338.1731
B395

AID Library
AID/CM/afr-c-73-20

AN ANALYSIS AND FORECAST OF CEREALS AVAILABILITY IN THE SAHELIAN ENTENTE STATES OF WEST AFRICA

by

John A. Becker

Reference Center

Final Report
Contract No. AID/CM/afr-c-73-20

JAN 1974

PREFACE

The recurring drought situation confronting six sahelian countries in Francophone West Africa has received much attention in recent months. A number of multi and bi-lateral development organizations including the United States Agency for International Development (USAID), have reacted in a generous manner; providing both food and non-food drought relief. With regard to the former, USAID during the past year has led others with over 256 thousand metric tonnes of foodgrains. However, USAID food aid in this area has been more than a simple response to the past year's drought. The United States has been a major supplier of foodgrains in Upper Volta since 1967 and more recently, 1971, in Niger. This report stems from a concern of this longer term involvement of food aid and is not a consideration of short term drought relief. More specifically, the purpose of this contract was that of providing USAID a perspective of cereals availability in the two aforementioned countries. A perspective which describes the past, assesses the future and considers alternative USAID assistance efforts in alleviating future food crises.

In describing the past, the traditional cereals production and distribution systems were reviewed. As a result, the temporal and spacial dimensions of cereals supply and demand which in turn determine general and specific availability were clarified. Specific availability here refers to cereals available to specific segments of the population as opposed to a measure of general availability which is simply an average. In all cases the descriptive criteria applied to variables were simple average or normal levels, amounts of variation and trends.

Assessing the future cereals availability situation was largely a result of examining major changes in technical, economic and institutional factors affecting cereals production and consumption. Three major factors were identified as being of sufficient magnitude that cereals availability in the future could be impaired. These factors have negative impacts on the major inputs into cereals production. They are climatic change affecting available water, urbanization affecting labor supply and simple population growth affecting the average quality of land.

The consideration of USAID assistance alternatives was made in the context of efforts to increase cereals supply, efforts to decrease cereals demand and efforts to distribute cereals in a manner such that the negative impacts of eventual shortages can be minimized. In each case, projects and programs which seemingly have some merit in terms of short term success were recommended. Projects and programs which also are not duplicating other efforts and where the U.S. has a comparative advantage.

The report is presented in two parts to facilitate the objectives of two types of reader/users. Those mainly after a broad perspective of the project and its major findings and recommendations may wish to review Part 1 only. Part 1 is comprised of three secions including in order, an introduction, a discussion of major results, and lastly a section providing implications and recommendations. Part 2, is for those who wish a more thorough review of the manner in which the contract objectives were carried out. It too is comprised of three sections including a discussion of the major hypothesis concerning food production in the sahel, a brief section on data constraints and analytical techniques used and finally the specific analytical results that were found.

At the end of the report are the appendices and a list of references. The appendices include in tabular form raw data and some analytical results not deemed important enough to be included in the text but perhaps interesting to other researchers. The references cited are mainly listings of data sources and economic surveys of one type or another. This list however, is not to be construed as exhaustive. Such a listing of available information pertinent to the food problem in the Sahel would require a substantial effort.

The report is the final report under USAID Contract No. AID/CM/afr-c-73-20. The contract objectives were carried out by both field study in West Africa and analysis of data in the United States. During both period, the contractor has made use of valuable discussion with others knowledgeable in the food problem facing the sahel. Their insight into the very complex problems were of great assistance. However, any errors or oversights in this report are the responsibility of the contractor.

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PART 1

OVERVIEW AND SUMMARY

1 INTRODUCTION

1.1 The Food Provision Dilemma

All governments, regardless of their eco/political characteristics, or the relative position on the development continuum of the nation they represent, are ultimately concerned with two aspects of domestic food provision. Adequacy and cost. Food adequacy for any particular nation is dependent on the varying sets of tastes and preferences of the groups within the population. It is therefore an ambiguous term and one which is necessarily defined differently, from one nation to the other. However, as a minimum, a test of adequacy which can be applied would be a level of food sufficient to insure health for all segments of the particular nation's population. Cost on the other hand, is a straight forward concept. It is defined as the total value of domestic resources, directly or indirectly used to provide food. Thus, for every country and every level of food adequacy, however defined, there is a particular resource cost.

A primary role of government is to insure that for any given time frame, a level of food adequacy is maintained. The consequences of failure being numerous. At best, food shortages result in higher consumer prices; the political consequences of which can be disastrous. At worst, food shortages result in malnutrition, increased disease and in the severest of instances, death by starvation. Simultaneously, it is the role of government to minimize the resource cost required to provide the level of adequacy. To do otherwise would result in sub -optimum economic growth. A consequence which is particularly distressing to those countries which are on the lower end of the development continuum. While this general consideration of basic food provision faces all governments, it becomes a dilemma to many of the developing nations.

In many developing countries, the successful implementation of disease intervention programs have curbed both infant mortality and simple death rates such that much larger populations have resulted. Unfortunately, while the readily adopted health technology has resulted in greater demands for food, no similar success in the transfer of agricultural technology to meet this steadily increasing demand has yet been achieved. (While the benefits of the "green revolution" are undeniable, they were quickly absorbed.) Thus, the traditional production systems in these countries largely remain the sole source of domestic supplies.

Concurrenc with population increases in many developing countries are rapid rates of urbanization. This structural shift in the population has a dual negative impact on domestic food provision. First with regard to the traditional production schema, subsistence food crops are usually increased via extension of the area planted. Given that technology is largely fixed, this extension of the area planted is constrained by available labor. Sustained transfers of people out of the rural sector to urban areas reduces available labor but not the demand for food. Second, with regard to the traditional distribution system, little cash marketing of basic foods is conducted. Subsistence food crops are not usually considered as income earning crops. However, increased urbanization places greater demands on these limited cash marketings resulting in consumer prices which fluctuate widely and increase steadily.

In some developing countries, traditional food production is further restrained by a shifting of inputs within agriculture. Governments, desirous of foreign exchange to speed the development process look towards the agriculture sector as an important and crucial source of foreign exchange via the production of export crops. Crops where price levels are tied not to domestic markets but world markets. World markets reflecting much higher purchasing power than is available domestically no matter what the domestic consequences might be.

Not surprisingly, the attention of many bi-lateral and multi-lateral aid agencies are focused on countries with these basic food problems. They recognize for humanitarian and other reasons that developing countries facing such situations need external assistance if

they are to overcome this most basic of development constraints. Thus, when famine threatens, relief in the form of external food is usually available. However, continual dependence on external supplies may do more harm then good. Imports may perpetuate a situation until a day of reckoning occurs when external food supplies can not be made available in sufficient quantities. In this vein, the recent situation in world food and feed grains supply and demand can be regarded as an ominous warning. Therefore, in assisting developing nations facing food crises, it is imperative to accurately identify the dimensions of the food problem and their root causes. Only then, can adequate recommendations towards the implementation of programs and projects which will alleviate the problems be accomplished.

1.2 The Sahelian Food Situation

The study reported herein stems from a concern of the increasing requirements for external food supplies to Sahelian West African countries. In these countries, two cereal crops (sorghum and millet) provide the bulk of the diet. Until the mid-sixties, the sahelian countries were generally held to be self-sufficient in cereals. That is, a large rural sedentary population produced not only enough food for their own consumption requirements but also enough for barter and sale to a substantial nomadic population and the small urban population. Since then however, indigenous cereals production has been deemed inadequate in light of skyrocketing consumer prices and in increased reliance on imports to insure minimumly adequate cereals for consumption. In fact, during the most recent market year, 1972/73, external supplies were required at such high levels that large scale famine and death would have prevailed had they been denied.

Several reasons have been offered as factors contributing to this bleak food situation in the sahel. The most obvious is the recurring drought which is unparalled in recent history. But other reasons have been offered also. In a 1970 study commissioned by USAID entitled "Food Grain Production and Marketing in West Africa" the Checchi team suggested that primitive farming methods and inadequate foodgrain markets

characterizing the traditional foodgrain production and distribution system were no longer sufficient to keep abreast with population growth. This situation coupled with inappropriate national agricultural policies and a lack of adequate extension financing prohibits the modernization of foodgrains production by stifling price incentives and constraining information on new techniques. The price incentive is suppressed because of governmental support in export crops which in turn are a source of governmental income via their monopoly market positions. This governmental support of export crops also tends to bid away resources from traditional food production.

A later study done by Kansas State University's Food and Feed Grain Institute entitled "A Study and Plan for Regional Grain Stabilization in West Africa" was less concerned with the causes of the situation. However, they suggested that much of the problem stemmed from inefficient use of the land and a lack of adopting new technology because of illiteracy, lack of extension efforts and poor market infrastructure. They also point out that disease prevalence (river blindness) in some countries constrains available land.[2]

In short, both studies saw the traditional production and distribution system of cereals in the sahelian area as no longer adequate; citing general increases in imports and consumer prices as proof of this inadequacy. Both studies accepted the premise that agricultural technology was available and if implemented would correct the food situation. Support of this position stemmed from reports from experimental stations plus the presence of dualism[3] in the agricultural sector. Thus, both studies saw the root causes of the food problem as simple but numerous constraints to the adoption and use of available new technology. Unfortunately, some evidence plus recent events suggest that little if any new technology is available to be adopted and used in the widespread production of food crops.

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[1]Checchi report, pps. 19-34.

[2]KSU study pps. ii-v, 54, 119 and 120.

[3]Dualism here refers to the modern export crop production in the same time and space frame as a traditional food crops production.

New agricultural technology to be adopted must reduce per unit costs of output. The western technologies being extended in the sahel by and large are the cost increasing output increasing types; mainly inorganic fertilizers and mechanization. Results in experimental trials have proven that the application of these inputs do in fact increase output levels. However, it has not been proven that these same results will be obtained under the conditions of uncertainty that face the subsistence producer.[1] Thus, the purely technical aspects of the technology being extended needs to be resolved. Assuming some of the technologies are technically feasible, their impact on increasing cereals production remains a question of their economically feasibility.

The adoption of a new technological input into foodgrains production will result only if favorable factor-product price ratios exist. At this point in time, such favorable ratios do not generally exist for the high cost technologies being extended. (As a result, increased efforts in extension may be akin to futile attempts at pushing a string.) On the factor side, investments in infrastructure may reduce the prices of these inputs to farmers. However, these same inputs are directly linked to world supply and demand conditions and recent events indicate that any gains in lowering prices to farmers via input marketing efficiency will be eroded. On the product price side of the ratio, prices paid to farmers will undoubtedly increase as supplies become increasingly short. The extent that the factor-product price ratios favor adoption thus becomes a matter of relative price moves. Price moves which on the input side will be largely uncontrollable for any government. Assuming the factor-product price ratios do favor adoption of technically feasible new inputs into cereals production, the actual allocation to cereal crops of these inputs will occur only if relative product prices favor cereal crops.

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[1]Vollrath in a study in Upper Volta looks at the new technology in mechanization and concludes much more adoptive research is required before much of the technology being offered is technically feasible.

Inputs are allocated according to their marginal value productivities. In the past food crops have come off second best when compared to the export crops of groundnuts and cotton. The Checchi team pointed out that net returns per hectare were comparable for millets and groundnuts if product prices were approximately equal.[1] Unfortunately, prices received by farmers for millets normally are about one half of those received for groundnuts. Increasing domestic scarcity of cereals should narrow that margin if groundnut prices were to remain stable. However, export crop prices are tied to world demand and supply and again recent events suggest that these prices will increase. In light of this situation, governments would be reducing areas under export crops at a time when foreign exchange earnings could be substantially increased. Thus, the basic food provision dilemma faces the sahelian countries in the context of inadequate food versus reduced earnings of foreign exchange.

Several important points regarding assistance opportunities and payoffs in the sahel area become apparent. First, a reliance on new modern agricultural technology as a counter to inadequate sahelian cereals production in anything but the long run is not justified on both technical and economic grounds. Second, efforts to shift inputs from export crops to food crops in light of rising returns will meet with substantial political and economic rebuff. Third, a continued dependency on external supplies to offset shortfalls in production is a tenuous position with almost certain negative consequences. Fourth, assistance efforts in the sahel must look towards projects and programs which have short run payoffs and are not dependent on food aid.

1.3 The Purpose of This Study

The general purpose of the contract as specified in Article I of the contract schedule was that of " . . . ascertaining the dimensions of the food problem and in developing insights which will lead to

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[1] Checchi study, p. 32.

subsequent project proposals". The particular food problem under consideration is the cereals situation in the sahelian states of the Entente group; Niger and Upper Volta. In these states as in the remainder of the sahelian area, the food problem is essentially one of inadequacy over the decade of the seventies. During this period, it is unlikely that the benefits which will eventually accrue from the adoption and use of new agricultural technology will be realized. Yet, it is highly likely that further shortfalls in indigenous production will be encountered. When encountered, USAID as well as other donor agencies will again be faced with requests for external assistance. Recognition of this situation suggest that an effort should be made to obtain a perspective of the food situation in these two countries which will provide a basis for preemptive actions in countering the eventual shortfalls.

The focus of the study is food adequacy. The cost of achieving and maintaining a level of food adequacy during this period is of course important and will be considered briefly. However, to treat the topic of costs correctly requires an analysis of other sectors of the economy as well as trade opportunities. Topics beyond the scope of this contract. Insofar as, food adequacy is the major concern, a definition of it is in order. Therefore, food adequacy is defined as, a level of available food insuring each consuming group in all areas of the countries in all time periods their normal consumption. A definition as such, requires further elaboration and specification.

Food availability is a wide topic and requires a more concise delineation when analyzed. In this report, food explicitly means cereals and even more specifically the major cereals, sorghum and millets only. Other cereal crops are grown but amount to less than one percent and less than seven percent of the total cereals cropped areas in 1970 in Niger and Upper Volta respectively. Also, in this report, food availability is measured in gross quantities of cereals available for human consumption. No consideration is made of milling margins and other losses incurred in the preparation of grain to actual food unless specifically noted.

The consuming groups in this study were held to three major segments of the population. They are the rural sedentary producer/consumer, the rural nomadic and semi-nomadic consumers and the urban consumers. Each group has a significantly different consumption pattern for cereals and each is affected differently by shortfalls of production given the traditional production and distribution system that prevails in the sahel.

The remaining two dimensions in the definition of food adequacy are time and space. The temporal dimension as usual is based on a single year. Thus, the analysis included both an examination of annual variation as well as annual trends. However, the intra-year or seasonal variation in cereals availability is important in the sahel, particularly with regard to some groups, so it too was considered.

The spacial dimension ideally should be based on agro-climatic regional differences. However, data as well as time constraints were a limiting factor in examining this dimension. Therefore, political entities were used. In general the national boundaries themselves were used in the bulk of the analysis. In some cases, the next step of political disaggregation was used. In Niger, this was the department and in Upper Volta it was the ORD (an aggregation of the cercles). Also, on occasion where political disaggregates could be loosely grouped to differentiate certain aspects and indicate a point, they were.

With this clarification of the term food adequacy, the following three general objectives were pursued.

1. Describe the adequacy of cereals available for consumption over the past decade.
2. Project the most likely cereals availability situation which will prevail over the immediate decade.
3. Review and recommend alternative USAID projects which will alter the negative aspects of the cereals situation over the next decade.

1.3.1 Objective Number 1 and Analytical Procedure

The first objective was that of determining the amount of seasonal variation, annual variation and trends in cereals available for consumption to the specified segments of the population and or regional groupings

when appropriate. To achieve this perspective, the general availability of cereals for consumption for each year in the past decade was determined. This precedure required that the variation and trends of various elements of aggregate supply and demand to be assessed. Namely, current production, exports and imports, changes in stocks and the factors affecting domestic consumption (population growth, prices and incomes). Given the magnitudes of the aggregate availability equation, the traditional distribution system was examined; thereby allowing estimates of the impact of changes in general aggregate supply and demand elements to be assessed on the cereals availability of the specified groups.

In Niger, the data was sufficient such that adequate time series on some of the variables were available to allow the use of basic statistical procedures in estimating variation and trends. In Upper Volta, the data were not sufficient and alternative less sophisticated but logically consistent procedures were used. Because of the similarity in the two countries in many respects, the results in the Niger analysis provided insight and support for the Upper Volta analysis.

1.3.2 Objective Number 2 and Analytical Procedure

The second objective was essentially an attempt to determine the likely cereals availability to the specified groups over the decade of the seventies. To achieve this perspective an analysis of factors affecting the elements of supply and demand was conducted. Particular emphasis was placed on likely changes in indigeneous traditional production as a result of technical, economic and institutional changes which are currently occuring and will likely continue.

In Niger, adequate productivity and area cropped time series data was available for regression techniques to be used. The data in Upper Volta was unsatisfactory. However, climatic data was very good in both countries and because of its importance in determining annual productivity, short run shifts in production as well as long term production levels, it was extensively examined using time series regression techniques.

1.3.3 Objective Number 3 and Analytical Procedure

The third and final objective was the consideration of alternative efforts which can be implemented in a manner which would tend to offset the negative consequences of the specific problems as identified in the second objective. The procedure used, was that of evaluating efforts which affect production, affect demands and affect the distribution of limited supplies to fixed demands. After reviewing these alternative courses of action, those which appear to be most appropriate to USAID were recommended.

1.4 The Study Area

The sahel of West Africa, in a geo-climatic context, is defined as a belt like region separating the Sahara and the tropical savannah. More than 3000 kilometres in length and encompassing some six countries, the sahel can only be described as an arid land where rainfall stems from the Inter-Tropical Divergence (ITD) and ranges between 200 mm. (approx. 8 in.) in the north and 800 mm. (approx. 32 in.) in the south. As such, moisture is adequate for only the most extensive of agricultural systems; livestock grazing and the sparse cultivation of crops.

In socio/economic terms, the sahel can be described as a juncture of divergent people and professions. It is the home of nomads, sedentary agriculturalists and urban dwellers, all producing differing outputs and all interdependent. Traditionally, nomadic people of the northern extremity have provided animal proteins via meats and dairy products as well as organic fertilizers for crop production as they graze their herds south on new grass and on field stubble upon returning north. The sedentary agriculturalists, throughout the region, produce the basic cereal crops that all groups need for consumption as well as livestock feed for the dry season carry over. Lastly, the artisans and other town dwellers provide basic non-food required goods and services in exchange for food directly via barter or the cash markets. Each group providing a necessary input to the others long run livelihood and in turn dependent on them for their own. It is in this sahelian zone that the study areas lie.

1.4.1 Niger -- Country Review

Niger is one of the six sahelian countries in West Africa. Its position in the sahelian zone is that of lying in the eastern half with Chad to the east of it and Mali and Upper Volta to the west. The northern three fourths of the country is sahara while the remaining one fourth is sahelian. It is a large country with over 125 million hectares of surface area. Unfortunately, as aforementioned the bulk is unsuitable for agricultural purposes (76 percent of the area receives less than 200 mm. of rainfall annually). Of the remaining 30 million hectares, approximately one half is suitable for extensive grazing and one half for extensive cultivation. Dryland cultivation prevails with two thirds of the cultivatable area fallowed each year. Of the remaining one third it is estimated that only 2.7 million hectares are cropped annually. The others are areas covered by forests or used for miscellaneous purposes.

Because of the low rainfall, the area is limited with respect to the crops which can be grown. (Irrigation is minor and can be generally regarded as having a negligible impact on the aggregate cropping pattern). Cereals are the major crop, with one crop, millet dominating the cropping pattern. From Table 1, it is observed that the official estimate of the millet area planted was 2.3 million hectares in 1970. This dominance in the cropping pattern holds throughout each department. Sorghum is next in importance for the country as a whole and is relatively more important in the departments having greater levels of rainfall. Other cereal crops are negligible except in the department of Niamey where rice is grown abundantly along the river. But even there, other cereals amount to less than two percent of the area cropped under millet and sorghum.

Major cash crops grown in Niger are peanuts and cotton with the vast majority being peanuts. For the country as a whole, the cereals - cash crops ratio is approximately 7.7 to 1. This ratio varies however by department. The ratio being greatest in Niamey and least in Maradi and Zinder. In these latter heavier rainfall departments, which are also Hausa areas, the cereals - cash crop ratio drops to 2.5 to 1 and 3.3 to 1, respectively.

Other crops are grown in Niger but can be generally considered as minor, that is except for Niebe. Niebe, is a major crop with nearly one million hectares begin grown. It has not been included in Table 1

TABLE 1.1

AREA BY CROP AND CROP CATEGORY IN NIGER
IN 1970 BY DEPARTMENT[1]
(000 ha.)

	Crop Category				
Department	Millet	Sorghum	Other[2] Cereals	Major[3] Cash Crops	Total
Niamey	971.7	113.6	15.9	1.9	1103.1
Dosso	415.5	70.6	1.2	37.3	524.6
Tahoua	244.0	129.5	.7	28.5	402.7
Maradi	264.5	138.4	..5	159.3	562.7
Zinder	354.7	135.9	.4	149.9	640.9
Diffa	59.5	5.2	.5	1.2	66.4
Niger	2309.9	593.2	19.2	378.1	3300.4

Source: Director of Agriculture, Republic of Niger

[1]Agadez not included

[2]rice and maize only

[3]peanuts and cotton only

because it is generally grown in association with other crops and would tend to cloud the first indication of crop estimation problems present. Disregarding all other minor crops (many of these are also grown in association) and Niebe, and summing only cereal and cash crop areas, the total cropped area for Niger is about 3.3 million hectares. This total is about 22 percent higher than the estimate of 2.7 million hectares cropped annually. Our first indication that substantial over estimation in the area planted may exist in Niger.

The population of Niger for 1970 was officially estimated to be 4,016,000 and is currently increasing at a rate of 2.73 percent annually. Of this population, 75 percent were rural sedentary, 20.7 percent nomads and semi-nomads and 4.3 urban dwellers in four major cities. Each year 160,000 men are estimated to leave the country for seasonal work in other countries on the coast. Per capita GNP estimated by UNCTAD for 1970 was 82 US dollars. UNCTAD also estimated that for 1970, 93 percent of the labor force was employed in agriculture but only 58 percent of the gross domestic product stemmed from the agricultural sector.

This brief overview of Niger leaves much to be desired. However, for the purpose at hand it will suffice. It is clear that Niger can only be described as a poor newly emerging nation where a subsistence agriculture dominates. An agriculture because of climatic factors has few options except the production of basic dry land cereals.

1.4.2 Upper Volta -- Country Review

Upper Volta borders Niger to the east, Mali to the north and west and the Ivory Coast, Ghana, Togo and Dahomey to the south. About one half of Upper Volta lies in the sahelian zone with the remaining half being more of the tropical savannah. It is a much smaller country than Niger in simple spacial dimensions, with about 27.4 million hectares of land surface. But whereas Niger has a large proportion of area receiving less than 200 mm. of rainfall, Upper Volta normally receives no less than 400 mm. in its northernmost extreme and 1400 mm. in the south. Thus, a much higher proportion is suitable for cultivation. Official 1959-64 figures place the proportion cultivatable at about 31 percent or 8.6 million hectares. Of this amount, the largest amount is fallowed; 78 percent. The remainder is largely planted to annual crops. Aside

from the cultivatable land, the 1959-64 figures indicate another 50 percent suitable for grazing. The remaining 19 percent of land surface is non-agricultural (forests, etc.). More recent official land classification data is weak and generally given by ORD unit. However, the KSU team indicated that the percentage suitable for livestock grazing is only 31.5 percent.

The 1959-64 official estimated percent of total surface under annual crops was 6.35 percent. The KSU study team offered a figure of "less than 8 percent" for total cultivated area. Table 2, which includes only cereals and major cash crops, gives a 1970 total area planted of 2.3 million hectares or 8.44 percent of total land, area. This figure because of the omission of minor crops is an underestimate but because of intercropping, the underestimate may not be large. In any event, given the differences in the time of the estimates the annual increase the total cultivated area appears to be increasing in the range of 3-4 percent per year. An increase which is a little on the high side assuming a fixed technology and a population growth rate of about 2.5 percent.

In Upper Volta, the increased level of rainfall results in two contrasts to Niger. First, sorghum is planted more than millets where the ratio is about 1.25 to 1. Second, other cereals are more important and comprise about six percent of the 1970 total cereals planted. However, from Table 2 it can be observed that within Upper Volta that variation in these regards does exist. In two ORD's (Est and Sahel) millets outnumber sorghums. Also, in Sud-Ouest, other cereals are approximately of the same level importance as sorghum and millets. In general though, Upper Volta remains predominantly a sorghum and millet growing area.

The ratio of cereals to cash crops in Upper Volta is very similar to that found in Niger. For 1970, this ratio was 7.6 to 1. Also, as in Niger, a wide range exist. In three ORD's Yatenga, Koudougou and Ouagadougou, the ratio was very high; about 15 to 1. In two ORD's, Sahel and Bobo-Dioulasso, the ratio was quite low; about 3.5 to 1. The former three ORD's are densely populated areas and food demands are very large.

The official population estimate for 1970 was 5,308,000 and increasing at a rate of 1.9 percent annually. The 1970 urban population estimate (towns 5,000 or greater) was 590,000 or about 11.1 percent.

TABLE 1.2

AREA BY CROP AND CROP CATEGORY IN
UPPER VOLTA IN 1970 BY ORD
(000 ha.)

ORD	Crop Category				
	Millet	Sorghum[1]	Other[2] Cereals	Major[3] Cash Crops	Total
Bobo-Dioulasso	34.4	67.1	11.5	31.2	144.2
Bougouriba	66.5	63.0	14.0	19.7	163.2
Centre Est	28.0	60.3	15.1	19.2	122.6
Est	82.2	64.2	18.8	23.3	188.5
Koudougou	144.0	176.0	4.4	22.4	346.8
Ouagadougou	163.8	200.2	10.2	24.0	398.2
Plateau Mossi	85.0	140.0	10.5	39.0	274.5
Sahel	73.3	49.1	10.2	42.5	175.1
Sud-Ouest	19.0	24.0	22.1	8.9	74.0
Volta Noire	77.0	108.0	9.1	28.0	222.1
Yatenga	77.0	115.5	.6	10.5	203.6
Upper Volta	850.2	1067.4	126.5	268.7	2312.8

Source: Director of Agricultural Services

[1] includes red sorghum

[2] rice and maize only

[3] cotton and peanuts only

However, a large proportion of urban dwellers are employed in agricultural activities. The official estimate of the urban population for 1970 which were non-agricultural oriented was 225,000 or about 4.2 per cent of the total population. No estimate of rural nomadic and semi-nomadic peoples was available but the KSU study team indicated that 12 percent of the population was made up of Peulhs and Tauregs. This sugests for 1970 the approximate number of nomads and semi-nomads would have been about 637,000 people. In 1970 it was estimated that 181,000 or about 3.4 percent of the population seasonally migrate to coastal West African countries for work. UNCTAD estimates GNP per capita in Upper Volta at about 60 US dollars. UNCTAD also estimates 87 percent of the work force is in agriculture while agricultures share of gross domestic product was only 49 percent.

1.5 The Data Base

The data in both countries is weak. This is by no means an uncommon situation in developing nations and does not suggest that they are inadequate for policy purposes. However, it does suggest that the data must be scrutinized for biases and logical inconsistencies and if necessary and possible, adjustments made in the results. Also, it means that the analytical techniques used be appropriate to the data quality. The general data situation and procedures used with regard to the countries is described next.

In Niger the official data on production, area and yield of cereal crops is biased due to the estimation procedures used. This bias has been estimated by two separate study groups from France and the results have been considered. The bias, however, is assumed to be a consistent one such that an adequate time series of production is available. Therefore, levels were estimated by adjusted averages, variation was measured with coefficient of variations (standard deviation as a percent of the mean) and a technique referred to as proportioning the variation in a statistical identity. Trends were estimated using regression analysis.

Other supply and demand data via a cursory review was found to be weak. Data on trade was confined to public account with one estimate by SEDES on private trade in the early sixties. Data on stocks were generally unavailable. Stocks on public account have been unusually low

because of the drought and no data on privately held stocks is available. With respect to consumer demand little or no information was found. Some price information was available, including a consumer price index for Niamey and a series of sorghum and millet retail prices. Population data is held by many to be highly inaccurate. For the purposes of this contract it was sufficient and did not seem as inaccurate as had been indicated. Data on rainfall was good. Gaps in some stations disallowed their inclusion in the analysis but sufficient stations were available to provide adequate time series for regression and the other statistical techniques aforementioned.

The production, area and yield data for Upper Volta was found to be inadequate for time series analysis. Not only are biases present in the data, but data collection precedures have had several major changes implemented and the biases keep changing. Also, no data on production since 1970 is available. In short, the data situation on aggregate cereal crops in Upper Volta is poor. To estimate levels, a single year which was deemed average was used. Variation estimates stem from a visual review of the data provided and adjusted to known errors and overestimates. Trends were estimated by selecting two years and deriving a simple growth rate over the period. This precedure requires selection of two years where normality in general prevailed or else the trend shows changes in biases not cereals output.

The other supply and demand data in general was found to be a similar situation as that of Niger. Some information stronger and some weaker. Population data was adequate but also suffers from weaknesses. Rainfall data is excellent. This in part, stems from the ASECNA being regionally located in Ouagadougou.

2. MAJOR RESULTS AND IMPLICATIONS

2.1 Past Cereals Availability Situation - Niger

The past cereals availability situation in Niger over the period 1960 to 1971 has been examined in depth. First, actual annual production, the largest and most important determinant of cereals availability was reviewed. (See Part II, subsection 6.1.1 and section 6.3.) Estimates of the bias in levels, the extent of variation and the average trend that prevailed over the period were all made. Also, to determine the adequacy of actual production and specify the type of crop years that prevailed during the period, normal required levels of output were estimated and compared to the actual levels of output. Next, other elements of supply and demand were considered in a manner which allowed general availability over the period to be determined. Again, estimates of levels, variation and trends were made. Lastly, the traditional distribution system was considered, thus providing a perspective of specific cereals availability over the past decade to each of the three segments of the population.

2.1.1 Past Production - Niger

The production, area and yield information for sorghum, millet and combined sorghum and millet were obtained from Annual Reports from the Director of Agriculture. These official estimates are provided in Appendix Table 1 and served as the basic data source for the analysis. However, a bias in their estimation is said to exist. SEDES studied this problem in the early sixties. They reported on their own findings and those of an INSEE study done on the same problem. As a result, various estimates of the bias were extended with regard to an overestimate of both the area cropped and the yields. After substantial review, the SEDES estimate of the bias in the area planted only was accepted. They found that the official estimates of the area planted were overestimated by a factor of 20.88 percent. Granting that the bias is present, it was found to be a consistent bias overtime. Thus, the data actually used in the analysis were a set of indices based on the year 1960. This procedure eliminates working with large biased numbers but retains the essential variation and trend aspects. These indices are provided in Appendix Table 2.

The annual variation of actual cereals production in Niger was quite large. Figure 2.1 is a visual presentation of the indexed official production data for sorghum, millet and combined sorghum and millet. Changes in sorghum and millet output from one year to the next approximate each other on a relative basis. Changes in both can be characterized as successive increases early in the period followed by wider swings from 1964 to 1971. The largest negative changes occured in 1968. That year, sorghum output dropped an abrubt 37 percent from the previous years output level. Millet output dropped less with a negative 27 percent, but it too must be considered as severe.

From Figure 2.1 it appears that movements in combined output can be approximated by changes in either sorghum or millet. That is, both move in the same directions and in similar relative magnitudes. However, a more refined technique is available to determine if one crop or the other is adding a disproportionate amount of variation to the total. It is based on the fact that annual variation in combined production of sorghum and millets can be proportioned into the relative contributions each makes to total variation and the variation which results from their interaction. Using this technique called "proportioning the variation in a statistical identity" the following results were obtained. Variation in combined output due to variation in millet was 59.9 percent. Variation due to sorghum was 8.2 percent and variation due to the combined interaction was 31.9 percent. The interaction was positive. This means that if millet output is down, sorghum output is also down and vice versa. Actually the simple correlation coefficient between sorghum output and millet output was found to be .72. Assuming, the interaction proportion of variation can be evenly split; the variation in the combined output explained by millet equals 75.8 percent. Sorghum variation similarly explains 24.2 percent. These results are very close to the relative make up of average output level of 76 percent and 24 percent for millet and sorghum respectively. This suggests that both crops contribute to variation in combined output approximately the same magnitude as their weights in making up the total.

Using the coefficient of variation (standard deviations as a per cent of the means) the magnitudes of actual variation in each crop can

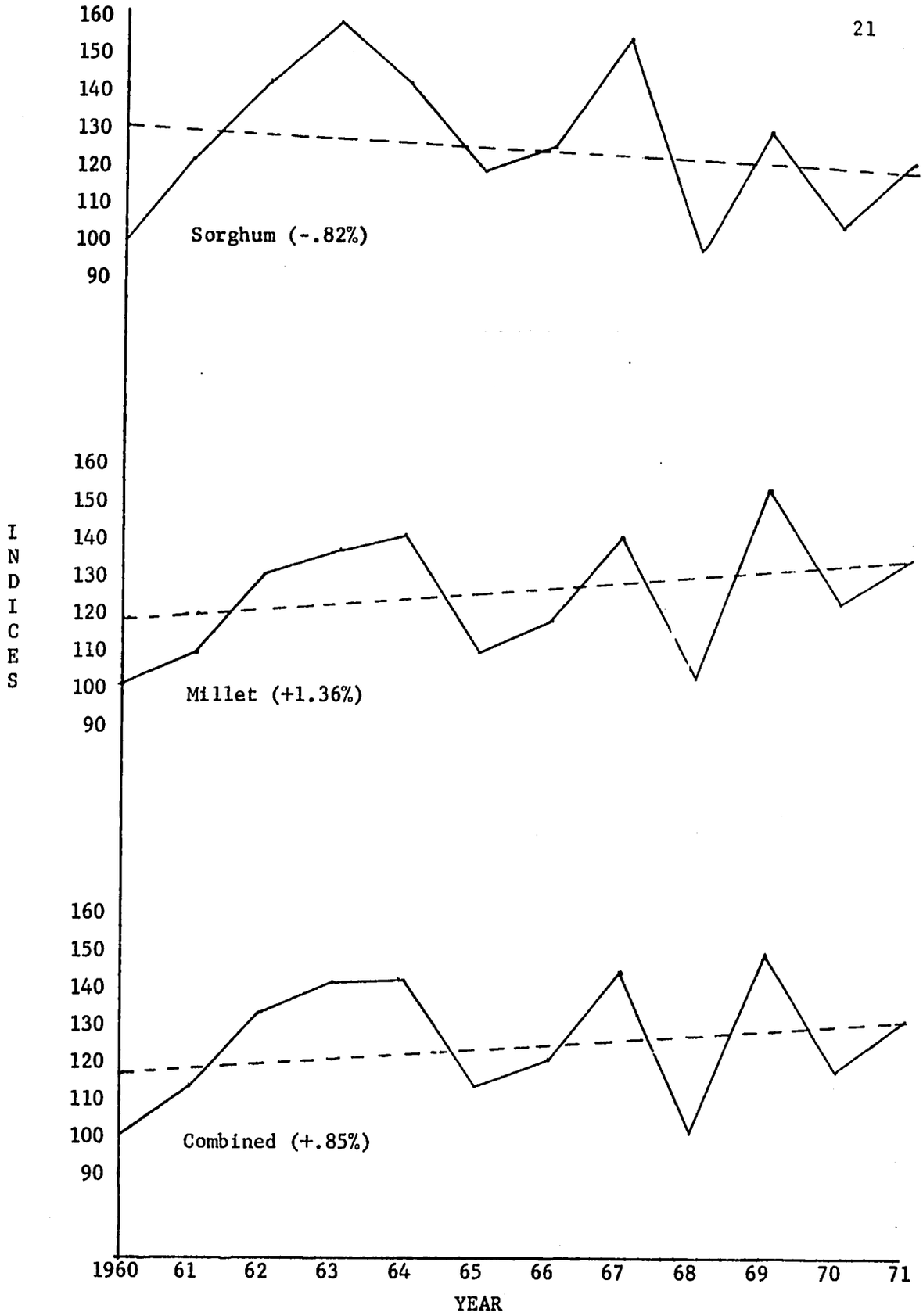

Figure 2.1 Niger - Indices of Annual Production and Estimated Trends for Sorghum, Millet and Combined Sorghum and Millet (base year - 1960)

be approximated and compared.[1] Here it was found that sorghum production varied over the period slightly greater than millet. The coefficient of variation for sorghum was 16.0 percent; for millet, 13.6 percent. The higher value for sorghum probably results from the fact that farmers are more flexible in sorghum plantings and that sorghums are more responsive to rainfall.

The trends in output can be estimated in many different ways. The method used here to estimate the simple relationship between output and time was that of a semi-log linear regression. This procedure provides a compounded growth estimate and a test of statistical significance. Thus, over the period 1960-71 the estimates of trends obtained were:

1) combined production, + .85 percent,
2) millet production, +1.36 percent and
3) sorghum production, - .82 percent.

In all three cases, time was found to be not significant. This simply means that the variation in production overtime has been too large and too erratic to place any confidence in change due to time alone. The above estimates can then only be viewed as net average changes over the time period. These estimated trends have been included in Figure 2.1 for visual interpretation.

The rote presentation of variation and trends of actual output mean little in and of themselves. To be meaningful they must be compared and contrasted to other measures or variables describing the situation. One simple comparison which is important in describing the adequacy of indigenous production is that of comparing the actual output trends with the trend of normal required output. This latter trend is defined simply as the rate of population growth. Thus, if output levels were to have increased annually over the period at a rate of 2.7 percent general per capita availability of cereals would have been maintained. Unfortunately, the average trend in actual production of cereals was .85 percent annually. Therefore, per capita general availability of cereals over the entire period decreased on the average of 1.8 percent annually.

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[1] In the case of production this is acceptable because average time trends were low and not significantly different from zero growth rates.

Unfortunately, a comparison of trends as above has its limitations. Going back to Figure 2.1, it is obvious that during early part of period, actual output was increasing at a rate greater than population expansion and vice versa during the later part of the period. This suggests that indigenous production was adequate during the early period and inadequate during the more recent past. A better way of describing this is to determine the type crop year each year was during the period. This procedure entailed the specification of a "normal" output level for a given year and then compounding by the population growth rate. This series was then compared to actual output levels and percent deviations for each year were characterized as normal or abnormal using the estimated coefficient of variation as a criterion of normality. The estimates of normal required output levels of combined cereals (sorghum and millet) for the period 1960-71 are as follows. (Note: these estimates are not biased and any comparisons to official data requires inflating these estimates or deflating actual official data.)

Year	000 m.t.	Year	000 m.t.
1960	848.0	1966	995.0
61	870.9	67	1021.9
62	894.4	68	1049.4
63	918.6	69	1077.8
64	943.4	70	1106.9
65	968.8	71	1136.8

This series of sliding normal output levels was obtained by simply compounding the original 1960 SEDES estimate of normal output by 2.7 percent annually. The original SEDES estimate for 1960 of 848,00 m.t. was the result of a normal productivity level of 468.4 kgs/ha from a cropped area of 1,810,315 ha. To check this estimate of normal output the simple averages of actual production, area and yield were compared. The assumption is that a 12 year average should approximate normality.

The average actual official productivity of combined sorghum and millet over the period was 483 kgs/ha which is about a 3.1 percent increase over the SEDES estimate. The average actual area planted during the period using official data and deflating by -20.88 percent was 2,015,225 ha. Compounding the SEDES estimate to the same point in time results in an area planted of 2,096,187 ha or about a 4 percent larger area than the average. Insofar as the 4 percent underestimate via the

area average is partially offset by the 3.1 percent overestimate via the productivity average, the two resulting normal production estimates are very close. Average production using deflated official data was about 971 thousand m.t. while the SEDES estimate at the mean would be 981 thousand m.t. (about 1 percent deviation). Thus, the 1960 SEDES normal production figure was accepted as a base. No effort was made to calculate or check annual normal levels of the crops individually over the period.[1]

The normal year to year variation of combined sorghum and millet output as indicated by the coefficient of variation for the twelve year period was 13.4 percent. This suggests that combined output of sorghum and millet can be expected to fluctuate two years out of three ±13.4 percent from a sliding normal level of output. One year in six will be abnormally high with output ranging between +13.4 percent to +26.8 per cent. Conversely, one year in six will be abnormally low with the relative range a -13.4 percent to -26.8 percent from a sliding normal. Applying this criterion to the percent deviations of the above sliding normal levels from the deflated official estimates of combined production, the individual crop years can be described in the following manner with respect to cereals production.

1960	normal	(8.3% deficit)
61	normal	(.3% excess)
62	abnormal	(15.5% excess)
63	abnormal	(19.8% excess)
64	abnormal	(16.5% excess)
65	normal	(9.9% deficit)
66	normal	(7.0% deficit)
67	normal	(8.7% excess)
68	abnormal	(25.3% deficit)
69	normal	(6.3% excess)
70	abnormal	(17.7% deficit)
71	normal	(10.8% deficit)
72	normal	(13.3% deficit) (tentative)[2]

[1] A simple bit of calculation can yield what the 1973 sorghum and millets production should be however, using the average percentages and inflating to approximate official estimates, a level of normal millet production would be approximately 911 thousand m.t. and sorghum approximately 288 thousand m.t.

[2] 1972 normal should be about 1,167,500 m.t. The deflated official tentative estimate was 1,011,740 m.t.

The severity of the recent drought period is clear from the above description of crop years. Four out of the last five years have been deficit years with 1968 and 1970 being particularly poor production years. The excess in 1969 was small and was little consolation in comparisons with the deficits that were encountered during this period. The early part of the period can be only characterized as a period of abundance. Three successive excess years (1962, 63 and 64) all of which were abnormally high. This situation in cereals production undoubtedly glutted markets and provided a false sense of security in cereals production to the newly independent government of Niger. Therefore, when the government's agricultural policy emphasized the production of cash crops it could hardly have been considered inappropriate in light of the circumstances.

2.1.2 Past General Availability - Niger

The aggregate cereals available for human consumption for a particular time and space frame is described by the following equation.

$$\text{AGG AVAIL}_{st} = \text{N PROD}_{st} - \text{N XPTS}_{st} - \Delta\,\text{STKS}_{st},$$

Where: AGG AVAIL = aggregate cereals availability,

N PROD = current production of cereals net of feed, seed and a loss factor,

N XPTS = exports minus imports,

Δ STKS = change in stock levels,

s = space frame (Niger) and

t = time frame (1 year).

Per capita availability of cereals is determined by simply dividing the aggregate availability by the population for that particular time and space frame. While both aggregate and per capita availability are easily defined, the estimation was thwarted by data limitations.

The production data for the time period has been previously discussed; official estimates deflated to offset the obvious overestimates were used. But this data series requires further adjustments to achieve production available for human consumption. The non-food uses of feed and seed plus losses must be considered. The adjustment can be accomplished in several ways. The most accurate, would of course be the

measurement each year of these quantities and the corresponding reductions made to gross output. This procedure is not practicle for obvious reasons and a very simple adjustment was used instead. Annual gross production was reduced 16 percent each year. This figure was the SEDES estimate for millet. The sorghum figure was 15 percent but because the millet to sorghum ratio is nearly four to one, the former higher value was used. This adjustment procedure was opted for not only because of simplicity but also because the conflict in other estimates. Normal seeding rates vary greatly, from one source to another. Cereals for feed are held by many to be very high proportion while others say little is used for feed. Loss factor estimates are also quite variable. Thus, a simple average approximation, which resulted from the SEDES inquiry was utilized. However, it must be recognized that because of changes in product value the proportion to non-food uses is understated in good output years and overstated in bad output years.[1]

Data on imports and exports can be best described as scant. Currently, because of the drought, data of imports on public account are available. However, this data doesn't fit the necessary time frame. Some export and import data on sorghum and millets was available for the mid-sixties from the Niger government and was reported in the Weitz -Hettelsater study. It is assumed this data is for public account. The author or authors of the Capital Assistance paper No. AID-DLc/P-1039 cited that external cereals assistance to Niger was to small to enumerate. Perhaps the most thorough review and estimate of the cereals trade balance stems from the report of the SEDES group. They estimated that in 1960 (a deficit year) net imports were a positive 10,000 m.t. This was both on private and public account.

Hard and accurate data on stocks are nil. No estimates of private holdings were available. This same situation prevailed with regard to public stocks, although some may be available for the more recent years from the OPVN.

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[1]When abundant, cereals fed to livestock will undoubtedly relatively increase and vice versa. This may account for some of the variation in estimates of cereals fed to livestock.

Population data was available from two sources. The first source was the U.N. Demographic series. This data was held to be out of date. The second source was the official Niger government data. This data was used and included growth rates, population distributions (spacial and categorical) and a revised 1970 estimate of the total population.

While this general poor quality and lack of data is an obvious problem, it is not insurmountable. Actually, if a more thorough effort had been made, more data would certainly have been identified. Time prevented this. However, for future work and policy making it is clear that more and better data would be of great assistance. Particularly, an effort to approximate the extent of stocks on private account, including both grain dealers and producers. Nonetheless using logic and some assumptions, estimates of normal availability level, the magnitude of variation and the past trends were approximated.

normal levels of availability

The normal per capita availability of sorghum and millet for human consumption estimated over the twelve year period was 229 kgs/year. This estimate was derived by taking the twelve year deflated official average output of 970,591 m.t. (gross average output) and reducing it by 16 percent to obtain 815,296 m.t. of net average output. This figure was adjusted by a neglible average net import figure of -156 m.t. Under the assumption, that stock changes are 0 in a normal year, the lack of data does not affect this calculation because it is not required. Thus, the aggregate average sorghum and millet availability over the period was 815,140 m.t. This figure was finally divided by the mean population estimate for the period of 3,560,602 to obtain the per capita estimate of normal availability of cereals.

The estimate of 229 kgs. of cereals must certainly be regarded as high. Therefore, an alternative estimate using the results of consumer surveys was made. This estimate was 191 kgs of cereals per capita. It was obtained by weighting three separate group consumption estimates by their proportions in the total Niger population. The consumption estimates and proportion in the total population were as follows.

	% Population	Consumption
Rural Sedentary	75.0	212.8 kgs/year/capita
Rural Nomadic	20.7	120.0 kgs/year/capita
Urban	4.3	146.0 kgs/year/capita

The population percentages were the official proportions as reported in the 1971 Annual Report. However, similar proportions were reported in the early sixties and thus these can only be construed as rough approximations. The consumption estimates were obtained from the SEDES report of 1963 and a recent paper by the Rural Economic Ministry which reported on a SEDES study of 1963-64. In this latter instance, two estimates were given. One for Tauregs and one for Peuhls. They were arbitrarily averaged for simplification to the figure above for rural nomadic.

One can conclude from the available estimates that per capita consumption of cereals in Niger is high. Using the 229 kgs figure and converting to ounces per day results in 22 oz/day. The lower figure of 191 kgs results in approximately 18.3 oz/day. Either one is high when compared to other developing regions. India, for example in a good year may average only 16 oz/day/capita. However high, it is not unbelievable insofar as the people of West Africa are noted for their high cereals intake. One can also conclude from the wide divergence of the two estimates that more work needs to be done to rectify this important difference in estimates.[1]

variation in general availability

The variation in general availability of cereals for consumption year to year is less than the variation in production. Shortfalls in production as well as excesses in production are offset in a given year

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[1]One possible explanation of this high estimate of per capita availability is that a continual overplanting of cereals is characteristic in subsistence agricultural area and will result in excess production. Thus, the derivation of average per capita availability from the supply side will reflect this excess production above normal consumption. This phenomenom is discussed in Part 2, subsection 4.2.3.

by net temporal and spacial transfers. In deficit production years, stocks are decreased and net imports are positive in an attempt to maintain consumption. In excess production years, stock levels are built up to desired levels and net imports become negative (net exports). Therefore, given these net spacial and temporal flows for a particular year, the general availability of cereals could be determined. If a sufficient number of years were determined an estimate of normal variation could be derived. Unfortunately, these data requirements are to severe for Niger. Little information is available on imports and exports for the period. No information is available on levels of stocks on private account. Thus, to determine an approximation of the likely variation in general availability, a number of simplifying assumptions were made. While the following can only be extended as an approximation, it is a sufficiently adequate approximation to characterize the past situation in annual changes in availability of cereals in Niger.

The per capita availability of cereals for each of the past thirteen years was obtained by first determining the level of desired aggregate availability which would provide an average consumption rate of 229 kgs per capita each year. Next, the deflated official net production estimates for each year were determined. Beginning only, with 1960, it was assumed that a level of stocks were held on private account to the extent of 13.4 percent of required aggregate availability. To determine per capita availability, the particular year's level of production was combined with the beginning level of stocks for that year. If the two combined were sufficient to meet the aggregate desired level, it was assumed that normal availability prevailed. Any excess above the desired aggregate availability was then assumed as a stock carryover to the next year with a maximum carryover of 13.4 percent of the next years desired aggregate availability. Excesses above desired aggregate availability to maintain consumption and achieve a 13.4 percent stock carry over were assumed to be siphoned off via net exports. In years, of deficit production and insufficient carryovers of stocks, per capita normal availability decreased, stocks carryovers were reduced to zero and net imports would prevail. Granting the inherent limitations of this procedures it does provide insight into the past problems. Thus, the percent variation from a normal per capita availability of 229 kgs per

capita and the percent excess domestic availability (excess above normal consumption and stock supply as a percent of normal consumption and stock supply) for the past thirteen years are as follows.

Market Year	Per Capita Availability	Percent Excess Supply
1960/61	normal	- 4.5
61/62	normal	- 1.2
62/63	normal +	+13.9
63/64	normal +	+17.3
64/65	normal +	+15.3
65/66	normal	- 6.5
66/67	normal	-10.2
67/68	normal	+ 1.9
68/69	deficit -9.4 percent	-25.2
69/70	normal	- 2.8
70/71	deficit -4.6 percent	-18.9
71/72	deficit -7.5 percent	-22.6
72/73	deficit -10.1 percent	-26.1

The above schedule, again, has some inherent limitations. Net spacial transfers have been treated as a residual. That is, net exports are positive only after domestic consumption and stock demands have been filled. This, however may not be far from the truth for two reasons. First, spacial transfers reflect sales for income. In a subsistence economy where cash requirements are small, it seems unlikely that inadequate consumption would be traded for cash. (This arguement discounts the idea of distress sales as being a relevant consideration in the sahel.) Second, in times of deficit supply, the price for export becomes too high for any export demanders during the past period. Another limitation in the above, is that stocks would be reduced in any year to zero. It is doubtful, that this would occur except after series of deficit production years as in the later part of the period. A third limitation is that imports have been ignored in the calculations. These, however would only have affected the last two years to any marked extent. (Net imports of 30,000 m.t. would have reduced the excess supply to a -18.0 percent in 1972/73 instead of a -26.1 percent.)

Granting the limitations, several pertinent aspects of past variation in domestic availability come to light. Assuming that private stocks were held to the extent indicated, they would have been sufficient to maintain domestic consumption at the average level until successive deficit years reduced carryovers to zero. If the normal desired stock

levels were less, the availability in some years may have been reduced, but not much. The cogent point is that, if a determination of availability is to be made for a given year, it is imperative that the level of privately held stocks be known.

With respect to the actual cereals availability in light of the recent drought, the above schedule points out that as a problem it has been present since 1968/69. Granting that 1969/70 availability returned to normal it did so only because of the large production in 1969 and even then excess domestic supply was negative. The problem in short, is the evolution during the past five years of consumption relying on current production and imports.

A third point that can be derived from the above schedule is that price levels do not reflect general availability for consumption. Assume that:

PRICE = -f (EX DOM SUP)

Where: PRICE = the May-July cereals price[1] and
EX DOM SUP = AGG DOM SUP minus AGG DOM DEM.

And Where: AGG DOM SUP = DOM SUP plus STK SUP and
AGG DOM DEM = N PROD plus STK DEM.

Then if the combined demand for consumption and stocks exceeds combined production and stocks supplies, prices will increase (negative excess supply) and vice versa. The above percent excess column in the schedule is an approximation of what the excess supply (inverse of excess demand) was over the period. While, price levels were not statistically regressed on this excess supply they were graphically presented in Figure 2.2.

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[1]The May-July cereals price is at the height of the soudure season and the availability of the past year crop is well known but no expectations of the next year's crop are available as the season has not progressed sufficiently. It was chosen for these reasons. The actual May-July series as well as the other three market quarter series for the years 1960/61 - 1969/70 are available in Appendix Table 3.

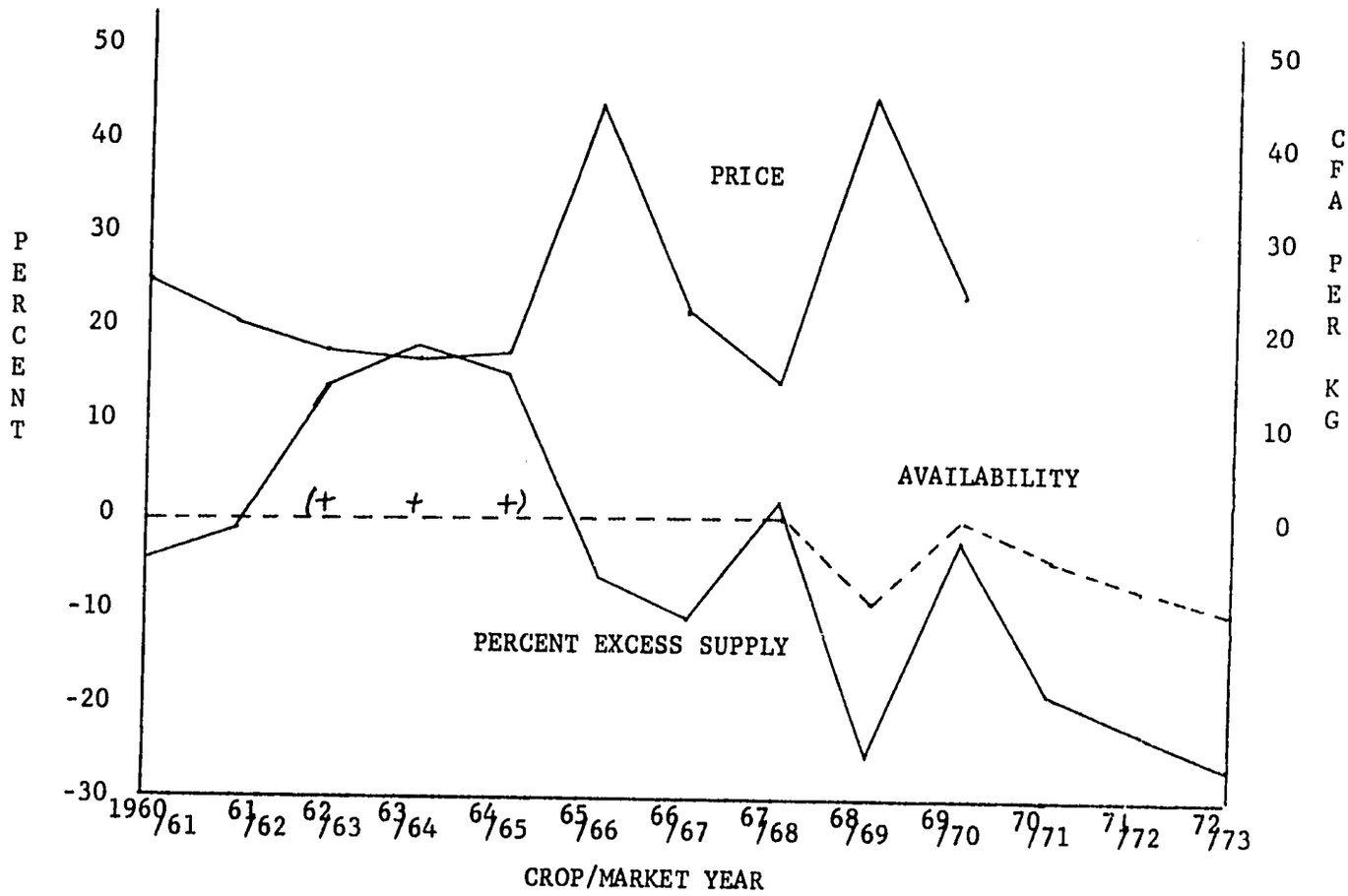

Figure 2.2 Niger - Approximate Relationship Between Relative Excess Supply and Soudure Retail Price Level With Estimated Variation from Normal Per Capita General Availability

Figure 2.2 illustrates that the soudure price level of cereals in Niger was a mirror image of excess supply. During the early sixties when large excess domestic supplies were encountered, prices were low. When the 1965 production fell abrubtly and excess domestic supply became negative, prices skyrocketed. Yet, domestic consumption was maintained. Prices, increased abrubtly again in the 1968/69 soudure season from a previous soudure level of 15 CFA/kg to 45 CFA/kg; a 300 percent increase yet consumption availability decreased 9.4 percent. The most recent prices were not available; however they have been at all time highs. Excess supply has been at continual high negative levels.

trend in general availability

While the normal level of per capita availability can be regarded as high and the variation low granting the assumption of privately held stocks, the trend in recent years is not encouraging. As mentioned earlier, the average trend over the period for general per capita availability was a negative 1.8 percent annual change. However, from Figure 2.2 the falacy of an average trend over the period is clear. Actually, the decrease didn't begin until the 1968/69 market year. The following year it rebounded and has decreased in a sustained manner only since the 1970/71 market year. Unfortunately, in the latter three years the decrease has been more in magnitude of a -3 percent annually. If one included external assistance in the calculation with production, the trend would be reduced slightly. But the point is undeniable even granting possible errors in population growth rates and production trends; per capita availability in recent years has decreased in Niger. The availability with regard to particular segments have been more severely affected and are discussed next.

2.1.3 Past Specific Availability -- Niger

General availability is an often used criterion variable in the pursuit to achieve food adequacy. That is, if the normal level of general availability is achieved it usually assumed that all is well with regard to specific consuming groups. Unfortunately, such an assumption may not be justified because the distribution mechanisms may have

unequitable allocative impacts. Therefore, it is imperative in any evaluation of food adequacy to understand the prevailing distribution system and the implications to specific consuming groups.

To more fully understand the traditional distribution system it has been divided into two levels. The first level of distribution is the producer/consumer distribution where auto-consumption, stocks and sales are considered. The second level of distribution is the commercial distribution of cereals which is dependent on the sales portion of the producer/consumer distribution for its supply. In the discussion of the first level of distribution, the past specific availability of cereals for rural producer/consumer consumption is discussed while the specific cereals availability for rural nomadic and urban consumers is discussed when describing the commercial sector.

producer/consumer allocation

The first point of output distribution is at the producer level. It is at this point, that the vast majority of production is allocated to ultimate consumption and is therefore important that it be understood. For the sake of simplification only current output net of feed, seed and waste will be discussed. It is noted though, that these product allocations are also determined by producers and will vary from year to year.

At the producer level, three allocative categories can be identified. The largest is auto-consumption. The other two, are the categories of private producer stocks and sales. Sales includes both cash and barter trades but are treated as one at this point. Stocks in reality, are one but for explanatory purposes here, they are discussed in the context of safety stocks and buffer stocks. As a result, four categories of use are specified where the producer allocates net product during the year. Figure 2.3 describes the impact of various type crop years on the levels of these categories.[1]

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[1]Assume for this schema that the preceeding crop year was average. In actuality, the allocations are dependent on the exact position the producer/consumer finds himself in as the year begins. Thus, if stocks are less than desired levels at the beginning and a normal excess year occurs he will certainly increase them to desired levels. However, if they are at desired levels no further allocation is warranted.

CROP YEAR TYPE	STOCKS		AUTO-CONSUMPTION	SALES
	Safety	Buffer		
Average	0 Change	0 Change	Normal (84%)	Normal (16%)
Normal Deficit	0 Change	Reduced	Normal Maintained	Reduced Slightly
Normal Excess	0 Change	0 Change	Normal Maintained	Increased
Abnormal Deficit	Reduced	Reduced to 0	Reduced	Reduced Severely
Abnormal Excess	0 Change	Increased Slightly	Increased Slightly	Increased Substantially

Figure 2.3 Crop Year Type Impact on Cereals Allocation by Producer/Consumer

Figure 2.3 indicates that, in an average year, the net output is allocated to auto-consumption to about 84 percent. The remaining 16 percent is sold and traded. SEDES estimated a range of auto-consumption as 70 to 80 percent but given the earlier discussed consumer survey estimates of consumption by rural sedentary, nomads and urban dwellers, the percent of total output consumed by rural sedentary because of higher consumption was 84 percent. Also, in reviewing the 1970 official commercialization data for Niger, it was found that the percent of commercialization in combined sorghum and millet was 15.6 percent of production. A level very close to the 16 percent estimate via consumer surveys. Also in an average year, net flows to stocks are zero. Production is sufficient to provide adequate availability without using buffer stocks and of course, no need of safety stocks is present in an average year. Such is not the case in other years.

In a normal deficit year, net product flows from buffer stocks to auto-consumption are registered in an effort to maintain normal consumption. Thus, the buffer stock level is reduced. Sales are also reduced in an absolute manner. The degree or extent of both reductions in buffer stocks and sales depends on the extent of the deficit and the particular cash requirements of the individual producer family. In a normal excess

year, and assuming the previous year was average such that the desired stock levels are present, sales are increased. Again the extent of the increase in sales is dependent on the extent of the excess. In short, during crop years of normal variation (two thirds of the time), buffer stocks are essentially used to maintain normal levels of consumption during deficits while increased sales are the outlet for excess production. (Of course, on the average, the decreases in stocks as a result of normal deficits are recouped in normal excess years).

In an abnormal deficit crop year, the reliance on stocks is much greater. But here the purpose of stocks is not to simply maintain auto-consumption but to provide sufficient food to sustain life. Auto -consumption is reduced below normal levels. The situation is further characterized by substantial reductions in products sold or bartered. Under traditional economies, the producer cash requirements are minimal. The case made for forced sales (distress) which result in the producer selling low and being forced to buy high is weak. No doubt it happens, but in the aggregate when deficits are encountered the first area of distribution reduced is sales.

In an abnormal excess year, the level of safety stock is unchanged. The safety stock is for purposes of offsetting abnormal deficits and is not maintained for any other purposes. Buffer stocks however, will increase slightly as a result shear abundancy and lack of other alternative uses. Given that stocks do not absorb the greater quantity, the latter categories must. Auto-consumption will increase but not much. The greatest relative impact is that of sales. In short, a glut on the market during an abnormally high output year.

Again, the above description is only for explanatory purposes. In reality, stocks held for each purpose are indistingishable from each other and there really aren't arbitrary abnormal or normal deficits and excesses, just variations from average. But the essence of the description is true. The major consideration in determing product allocation at this point is the maintainance of auto-consumption. Stocks provide the producer a reservoir to do this when poor output years occur. Sales, on the other hand, provide an outlet for excesses first and a source of income second. This latter point is subject to debate but it must be extended that basic cereal crops, as income earners must rank quite low.

past producer/consumer availability

Using the producer/consumer allocation schema as presented in Figure 2.3 in conjuction with the earlier described crop years of the past period, an improved basis to view availability is provided. The years 1960 and 1961 were normal crop years and normal availability undoubtedly was maintained. The years 1962-64 however, were abnormally excess years. Each years production was in excess of 15 percent of required aggregate requirements. Thus, the level of consumption probably was larger than normal, privately held stocks were at maximum levels and markets were glutted. In fact, three successive abnormal excess years probably resulted in large quantities of grain fed to livestock as well as increased waste above usual levels. The following three years were again normal. In 1965 and 1966 production was off but the deficits were well within the range of being offset by buffer stocks to maintain consumption. Of course, sales were reduced in both periods. In 1967, a normal excess was registered and stock levels were brought back up, normal consumption prevailed and sales increased above the past two years.

The year 1968 was a severe deficit year. Assuming that a normal distribution in output over the years is correct, a deficit such as encountered in 1968 would happen once in 40 years. Stocks were undoubtedly reduced to near zero levels, consumption reduced and sales cut back sharply. The next year, production was a normal excess. Consumption levels were perhaps restricted to some extent to allow a greater retreival in stocks but the pressure on sales substantially reduced.

The following three years were all deficit production years. In 1970, an abnormal deficit production level was encountered. Again, the stock position was drawn down heavily in an attempt to maintain consumption which although less than normal was not exceedingly reduced. Sales were reduced sharply the next two years were again deficit and although normal deficits they bordered on being categorized as abnormal. Consumption availability in these latter years undoubtedly was severely reduced insofar as the stocks were drawn down as a result of the 1970 deficit. Sales of course, during the entire three year period were sharply reduced.

To briefly describe the past situation of cereals available for producer/consumer consumption in general, it can be said that two periods prevailed. From 1960 through the 1967/68 market year, adequacy prevailed

with three years being abundant to the point where consumption increased. Since the 1968/69 market year (results of the 1968 crop year) rural producer/consumer availability of cereals for consumption has been reduced with the cereals availability in the latter three years being substancially restricted.

The past five years have undoubtedly been severe for the rural producer consumer. One aspect which is often suggested in perhaps being of sufficient magnitude to reduce some of the pressure on domestic consumption is the seasonal migration of young rural men out of the country. Each year, large numbers work in the coastal countries during the off season (approximately October through May). Using the estimate of 160,000 young men and assuming annual consumption at 250 kgs per young man (higher than the average because they are the largest consumers) results in 40 thousand metric tonnes. If gone for three fourths of the year net reduction in rural demand would have been about 30 thousand metric tonnes. This amount would have been about 3.9 percent of total rural consumption demand in 1970. A sufficiently high enough level to decrease the pressure on availability somewhat during the recent period of shortages in the rural area.

Within the category of rural producer/consumers the most severely affected have been the younger children. As the reduced availability is reflected in the diet, these children become increasingly susceptible to disease. Thus, while the reductions in available cereals have not been sufficient to cause widespread starvation in the rural area, increased malnutrition and death by disease have resulted.

One aspect of the cereals availability situation in rural areas not yet considered is the simple spacial dimensions. Undoubtedly, some areas have been more or less affected by the shortfalls in production. And as a result the cereals available for consumption reflect this fact. In general, rather than a spotty distribution with in Niger, it is accurate to suggest that those in the northern extreme of the sahel have been more severely affected than those in the southern areas bordering the savannah. Regardless, of this spacial dimension the rural producer/consumer has been affected in general but not as much as the rural nomadic and semi-nomadic and the urban dwellers.

commercial distribution

Domestic commercial availability is defined as that amount of cereals available to the nomads and urban consumers for a given time frame. It is by and large equal to the sales allocation (barter and cash) of the rural producer/consumer. Other supply elements which would effect commercial availability would be imports and stocks. Imports, until recent years, have been a minor element. Stocks privately held by nomads and urban dwellers are important only with regard to intra-year variation and thus would not affect commercial availability year to year. Stocks on the public account are minor as a result of the drought. Therefore, because commercial availability has been dependent on sales from the producer/consumer segment it is discussed as such.

Sales, including both barter and cash, of cereals by the rural producer consumer are comprised of three elements of production. These elements are market oriented production, marketed surplus and marketed excesses. These three elements of cereals production are thoroughly discussed in subsection 4.2.1 of Part 2. Suffice it to say at this point that in total the three make up a sales category which is subject to wide variation from one year to the next and is also unresponsive to prices. Returning briefly to Figure 2.3 it is pointed out that in excess production years, sales are viewed by the producer as his major outlet of production insofar as more consumption of cereals above normal requirements are not preferred to other goods and services which can be traded for, or purchased with cash. In deficit years of production, sales are the first restricted insofar as nothing is as dear as subsistence food and the uncertainty of next year's crop results in discounting current sales above minimum requirements heavily against the maintainance of adequate stocks. Thus, the motive force behind commercial supply is not price and the commercial availability is subject to substantial fluctuation, year to year.

Intra-year variation in sales is also quite large and again results from producer/consumer decisions. It is simplest to divide the marketing year into two distictive phases to characterize this intra-year variation. The first phase is the period November through July. During this period, the rural producer bases his decisions on the relative success of the

harvest, the stock carryover position from previous harvests and family demands for goods and services not produced but which can only be traded for or purchased. Throughout, this period the amounts entering the commercial sector are scaled with the immediate post harvest marketings being the greater. After July a new decision factor is introduced; the anticipated crop as a result of the quality of the early rains. Good rains -- good crop and vice versa. Thus, the period August through October can be characterized by substantial changes in sales based on anticipated, but not known, production.

Intra-year variation in domestic commercial availability however is not as great as the intra-year variation in sales. Again, simple recognition of this situation by nomadic and urban consumer result in their holding stocks which are purchased (bartered) during the post harvest period to offset any shortages in marketings. Also, the spacial considerations facing nomads require their purchasing large quantities during the immediate post harvest period because it is in this time span when they are in the same proximity of the cereals production. This is clarified when the distribution mechanisms are considered.

The actual distribution mechanisms in the commercial sector are varied and cannot be adequately treated here. However, the following general highlights are extended. The trade or barter activity is done both at the individual producer village level and at the local markets. The former is perhaps the most minor but represents the bartering that occurs as the nomads graze cattle on the fields and barter products and manuring for grain. The latter is more prevalent and represents the rural nomads entering the local market areas and trading dates, salt as well as livestock products for grain which the women have brought for sale. The local market area is also the first point of aggregating supplies to the urban areas. The grain destined for urban areas is traded for or purchased by minor traders. They in turn, redistribute the grain supplies to other deficit areas (spacial arbitrage) as well as sell to the larger grain traders who move the product to the urban areas where it is purchased by the urban consumers. With this brief discussion of the commercial distribution system and marketing mechanisms, the specific past availability situations are reviewed for the rural nomads and semi-nomads and the urban consumers.

past commercial availability

The aggregate commercial availability of cereals for a given year is essentially equal to the sales allocations from the rural producer consumer group. Thus per capita commercial availability largely is a result of dividing the aggregate sales for a given year by the total population dependent on commercial supplies. That is, the nomadic group and the urban group. However, the concern here was that of determining the relative per capita availability of the two specific groups separately. Insofar as the two are competitors for the marketed grain it is necessary to determine their relative competitive position in the market.

Clearly, during the early sixties when ample cereals were available both groups fared well. Nomads trading livestock products for grain undoubtedly were in a good position as the terms of trade favored them. This was because, livestock products are higher income elasticity foods and the demand for them increases when incomes are high. Thus, granting low prices for cereals which in turn suppresses the incomes of rural producers of cereals, their income positions as a result pure abundance of supplies were such that their demand for livestock products was high. Similarly, the rural producer demands for other goods and services which require cash were high as a result of abundant cereals. Urban dwellers provided this cash via the markets and they too were amply supplied with cereals.

The first year during the period when sales were restricted was the 1965/66 market year. The 1965 crop dropped off from the previous high levels. The rural producers however with large stocks on hand continued to provide the commercial sector with adequate supplies until March of 1966. By this time the nomads had obtained their supplies and were not particularly affected. Unfortunately, the urban population which had for the previous years been getting adequate supplies through all seasons of the year suddenly faced a drying up of market supplies. Prices rose sharply from the harvest quarter level of 21 CFA/kg to a level of 45 CFA/kg at the height of the soudure. Prices then dropped off sharply to a level of 20 CFA/kg by the next harvest quarter. No doubt some urban consumers faced reduced consumption at this point. However with high incomes and the bevity of the short supply, the reductions in consumption were not severe. The important point of this flare

up of prices was that it indicated the fallacy of an increasing urban population being dependent on the traditional distribution system of cereals.

The next two years (1966/67 and 1967/68) were characterized by ample supplies. Nomads and urban dwellers had no problem obtaining adequate cereals for consumption. Unfortunately, since then, both groups have faced reduced consumption as a result of cereal production deficits and also in the case of the nomads, sharply reduced incomes to purchase grains.

The 1968 crop dropped by about 25 percent of normal requirements. Insofar as the prior year had been an excess year, rural producers had stocks on hand to offset part of the shortfall. Thus, during the distribution period at harvest the magnitude of shortfall was not yet realized. This was good for the nomads who to this point still had large cattle numbers (income). Therefore, while they may have been affected somewhat by the shortfall in production it probably was not severe. It was however severe for the urban consumers. By the first quarter after harvest marketed supplies had already been reduced by producers. Prices shot up to 48 CFA/kg by the Feb-Apr quarter and remained at that level until the 1969 harvest. Even then prices were still quite high. No doubt, urban consumers were severely affected, particularly those without high incomes.

The 1969 crop was the highest level output during the entire period. This has led some to speculate that no problems existed at that time. Unfortunately, problems did exist. Rural producers withheld output from the market to build stocks back up and while greater absolute quantities entered the commercial markets than the previous year, this was little consolation to the nomads who had their incomes reduced by the previous poor year and the terms of trade go against them. Incomes were reduced because of that loss in cattle due to the poor rainfall in 1968. The terms of trade went against them because a shift in producer demand to build stocks rather than enjoy higher income foods. Nomadic consumption decreased somewhat in the 1969/70 market year but again it was not a severe problem. Urban consumption availability in 1969/70 undoubtedly improved relative to the previous year. Prices fell back somewhat during the harvest quarter but this was shortlived.

Since the high level output in 1969, production has been low. Both groups have suffered substantially with the nomads being the hardest hit. The reason for the reduced consumption is simple. The marketed supplies have been reduced each year. The reason the nomads have been more severely affected is because the drought which has reduced cereals output has decimated their source of livelihood, cattle.

2.2 Past Cereals Availability Situation -- Upper Volta

The past cereals availability situation in Upper Volta was examined for the period 1957 to 1970. Unfortunately, the bulk of the inquiry was centered around a single year (1970) because of inadequate time series data. Thus, the analytical procedures applied to Upper Volta were much different than those for Niger and as a consequence much less information concerning annual changes in production and availability of cereals was obtained. Nonetheless, actual annual production levels were reviewed and are presented first. Next, general availability was considered using cross sectional analysis based on ORD's. Lastly, specific cereals availability to the three consuming groups are presented. In all cases, the insight gained from the Niger analysis was drawed upon when data gaps were encountered.

2.2.1 Past Production -- Upper Volta

The production, area and yield data for sorghum, millet crops were obtained from various sources. These data as well as the sources are presented in Appendix Table 4. Again for ease of analysis they were converted to indices using 1961 as a base year. These indices are presented in Appendix Table 5. With regard to the production data in Upper Volta a problem of a consistent bias is not present as in Niger. The problem in Upper Volta is essentially a continual change in the collection and estimation procedures.

Prior to 1962 the procedures used in estimation and collection of production data were techniques which had been used before independence. However, after independence, a move for greater regional autonomy was made and the ORD's were beginning to take form. (Not all ORD's are yet

operative after more then ten years.) Simultaneously, a new five year plan was announced which called for agricultural output to double over the period.[1] Thus, the data was not only difficult to collect as a result of the newly organized ORD's but a definite bias in the data was introduced because of the goal to double production. In 1965 another change was introduced. This change was the central organization shift with the cessation of the "Agricultural Services" branch and the discontinuance of the annual report of production statistics. The production data for 1970 was available in a report from "Agricole Statistics". The 1971 data was not yet available. In short, little credence can be placed on the data between 1961 and 1970 and these years are also suspect. However, they did appear to be sufficient for the purposes of denoting problems in cereals production, particularly when used population data. The actual official estimates of sorghum and millet production are considered next. The data problems become obvious from Figure 2.4 which graphs the data.

Separate output estimates for sorghum and millet prior to 1961 were not available. They were available for the two combined. Thus the period covered in Figure 2.4 is 1957 to 1970 for the two combined and 1961 to 1970 for each separately. From Figure 2.4, the 1962 goal to double output in five years is apparent. Sorghum increased 114 percent in three years and millet 110 percent in four years. This data is obviously erroneous and cannot be used in any time series analysis insofar as it is simply manufactured rather than based on estimates. The most that can be said is that both sorghum and millet output levels must have been good during this period because it would be difficult to offer these estimates if the actual situation had been one of adversity. This point is supported by examining the rainfall data for the period (see Figure 6.12 in Part 2) and also the fact that Niger enjoyed high levels of output during this period.

Sorghum and millet output after 1965 both began to drop until 1967. Then sorghum output stabilized while millet again sharply increased. This increase however, could be the result of crop shifting in light of the

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[1] Rapport Economique, "Production", p. 72.

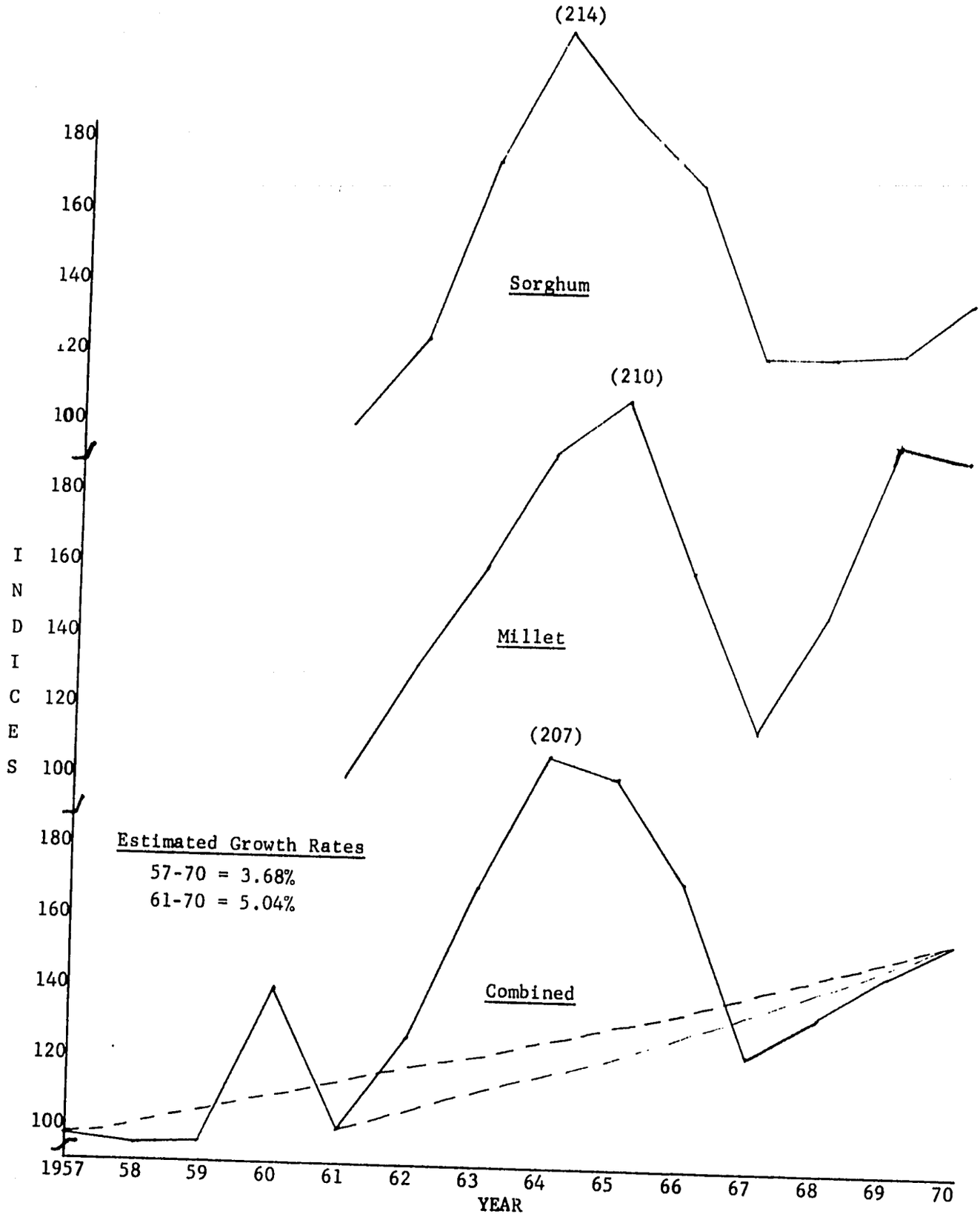

Figure 2.4 Upper Volta - Indices of Annual Production and Estimated Trend for Sorghum, Millet and Combined Sorghum and Millet (base year - 1961)

drought period that began during this time frame. This crop shifting capacity insofar as Upper Volta is comprised the more moist savannah than just sahel is logical. Unfortunately, the data provided in the Wietz-Hettelsater study indicates that area planted to both maize and rice increased during this same period. Thus, no logical explanation is available for the increase unless there was excess capacity in the production process.

Looking at the data plot of the two combined over the longer period reinforces some of the above conjecture. The period 1957 to 1961, aside from 1960, was characterized by very stable output levels. Ther period from 1961 to 1967 again represents the period when data estimations are not viable. From 1967 to 1970, three seccessive increases were registered of about 10 percent per year. Again these must be considered as suspect in providing any indication in the extent output variation.

In view of the data quality, no individual trends were calculated for sorghum and millet. Two trends were calculated for the combined sorghum and millet production however. These trends are to be viewed only as indicative of the direction of change and nothing more. The two trend periods were 1957 to 1970 and 1961 to 1970. The procedure used was that of calculating average compounded rate of change over the period from the beginning of the period to the end. Thus, the interim years were ignored. The years that were selected, were those which the data quality was best. Both trends lines are plotted in Figure 2.4.

The average trend for the period 1957 to 1970 was 3.68 percent, while the average trend for the shorter period was 5.04 percent. The difference obviously results from the period of no sustained change between 1957 and 1961. Both are quite high even granting crop shifting and excess capacity arguements. Comparing them to the population growth rate of 1.9 percent during this period results in an average increase in per capita availability of between 1.7 percent to 3.0 percent. However, because of the questionable nature of the data, the only result that can stem from this analysis is that it appears as though cereals output increased in an adequate manner to maintain per capita availability until 1970. After 1970, the data was not available to make an estimate. The review of the rainfall situation as presented in Part 2, suggests that output has undoubtedly deceased since 1970 however.

2.2.2 Past General Availability -- Upper Volta

Obviously, without adequate time series data on cereals production, no direct estimates of general aggregate and or per capita cereals availability could be made for all the particular years over the past decade. However, using indirect means a general perspective of the past cereals situation is provided. The first step of this indirect procedure was that of estimating the general per capita availability of cereals for consumption in the 1970/71 market year.

Total production of sorghum and millets estimated by the government for 1970 was 941,065 m.t. This figure is gross output and must be reduced by the amount for feed, seed and waste. In the case of Niger 16 percent was utilized because of the higher proportion of millets. In Upper Volta, sorghums are in the majority so a figure of 15 percent was arbitrarily used. Thus, net production that year was 797,905 m.t. Again, as in Niger, various estimates of feed, seed and waste are used. In the SEDES study "L'Approvisionnement Des Villes", a figure of 16 percent is used for just seed and waste.

Insofar as Upper Volta has a greater proportion land devoted to other cereals than Niger, they must be included in making up the general availability level. Thus, to the net output of sorghum and millets are added 75,508 net m.t. of rice and maize. Also, during the 1970/71 market year 34,319 m.t. of imported cereals were introduced into the market.[1] Export figures were not available but could be considered nil. Again, no information was available on privately held stocks and at this point are ignored. Thus, total aggregate availability of cereals for the 1970/71 market year were estimated at 907,732 m.t.

The total population of Upper Volta for 1971 was estimated to be 5,421,000. However, not all of this population can be considered as consumers. First, the number must be adjusted by the population which had permanantly migrated. This population estimate was 116,000 and reduces the actual population down to 5,306,000. Next, the population is reduced by the number which seasonally migrate. For 1971, it was estimated

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[1]This includes all food aid and commercial imports of sorghum, millet, maize and rice. Commercial imports of wheat flour were excluded.

186,000 people left the country to work elsewhere. If these migrants are gone three fourths of the year, the net reduction to the consuming population would be 140,000. Therefore, the total consuming population estimated for the 1970/71 market year was 5,166,000

The estimated general per capita availability for that year then becomes about 175.7 kg/year of cereals. This amount is made up of 154.4 kgs of sorghum and millet, 14.6 kgs of other cereals and about 6.6 kgs of imported foodgrains. While the total level is low in comparison with Niger, it is fully within the realm of a feasible level of consumption as it would provide about 17 oz/day of cereals. Also, it must be pointed out that 1970 was a poor crop year as measured by weather quality and the high level of required imports which would suggest reduced consumption. Also, no consideration of privately held stocks was introduced. If stocks were available, they would have been drawn down and thereby increase the level of availability. For example, if privately held stocks were available and drawn down at a level of 5 percent of the 1970 output, an added 10 kgs per capita would have been available. Nonetheless, this estimate for the 1970/71 market year provides a basis to contrast prior years.

Table 2.1 contains a listing of several indicators which reflect elements of cereals supply and demand for the years 1960/61 to 1970/71. First, a qualitative approximation of the rainfall in each of the years is given. These approximations stem from the all Upper Volta rain index which was constructed. A plus indicates the rain index for that particular year was substantially above the 17 year mean. A zero means a value about the mean and a minus a level substantially below. (The actual plotted index is given in Figure 6.12.) The next two columns denote retail price levels of sorghum and millet at two different points in the market year; at harvest and during the soudure. The last two columns consider two aspects of spacial flows. The first is total imports of cereals and the second gives the approximate proportion of imports on commercial account (not food aid).

Assuming that a good level of rainfall is indicative of a good crop, the year 1970 (1970/71 market year) must have been suppressed. Thus, the 169.1 kgs per capita availability from indigenous production only, must have been low. This is further substantiated by looking at

TABLE 2.1

VARIOUS INDICATORS OF THE CEREALS SUPPLY AND DEMAND SITUATION IN UPPER VOLTA FOR THE MARKET YEARS 1960/61 - 1970/71

Year	Rainfall	Retail Price Levels (CFA/kg) Nov-Jan	May-Jul	Cereal Imports (mt)	Percent Commercial
1960/61	0	18	22	NA	NA
61/62	0	19	16	2506	100%
62/63	+	19	29	6155	100%
63/64	+	22	30	4569	100%
64/65	+	22	25	3646	100%
65/66	0	20	29	8908	69%
66/67	-	26	31	28281	30%
67/68	-	24	30	6056	26%
68/69	0	19	34	16469	10%
69/70	0	35	NA	17232	0%
70/71	-	29	NA	34319	0%
71/72	-	NA	NA	NA	NA

Sources: Rainfall index constructed by author. Retail price data from Aid Capital Assistance paper on "West Africa Regional Entente Fund" (see references). Import data from various sources including the previous AID paper, the KSU study and the Wietz-Hettelsater study (again see references).

the retail prices at the harvest period. A level of 29 CFA/kg although not the highest is certainly above the majority. Also, the level of imports that year were high. The highest in fact for the entire period. Thus, to what extent the per capita imports made up for reduced indigeneous output is difficult to say. However, by looking at the previous years level of retail prices at harvest plus the high level of imports it is doubtful that large levels of stocks were available to increase general consumption availability in 1970/71. In short, it appears as though a general per capita availability level of about 176 kgs/year might be low for an average normal level in Upper Volta. However, it is doubtful that normal in Upper Volta is as high as normal or average in Niger.

Using the indicators provided in Table 2.1 does allow the early years to be compared indirectly with the 1970/71 market year. In this context, two separate periods become clear. The first period is from 1960/61 to 1965/66. Rainfall levels were either average or above average during this period. The three plus years are the same as the very good output years in Niger. Harvest period retail prices also were low. They averaged 20 CFA/kg for these six years. Imports during this period were quite low in relation to the next period and the bulk of the imports were on commercial account. No doubt, general cereals availability for consumption was at the normal level during this period as stocks were sufficient to offset any output variations.

The second period, 1966/67 to 1971/72, was a mixed period. Two successive poor rainfalls occured and harvest period retail price levels increased to an average level 25 percent above those of the former period. While retail prices, during the soudure were high, they were not particularly higher than those of the previous period. This can be attributed to the increased level of imports which were largely food aid. Then two normal rainfall years occured, 1968/69 and 1969/70. During the 1968/69 year, harvest period retail prices fell back to early 1960 levels. However, the low price levels were shortlived as the price level during that soudure season shot up to 34 CFA/kg. Imports were then introduced at high levels and again they were predominantly food aid sources. The only rationale explanation for this type of price movement (aside from a

clerical error in the data) is that while Upper Volta may have had a fair rainfall and a fair cereals output in 1968, countries on either side of it did not. Niger, in 1968 suffered a worst drop in cereals output. This probably shifted much of the usual Mali demand from Niger to Upper Volta and thereby put pressures on marketed supplies during the soudure. The situation continued into 1969/70 even though, rainfall was near the mean. Prices were at their highest level during the harvest period and imports continued at a high level. Much less information is available for the last two years but the situation is clear nonetheless. Poor rainfall, high prices, high imports and reduced availability in general.

Thus, using indirect means the general cereals availability situation in Upper Volta appears to be quite similar to that in Niger for the past decade. High levels of consumption until the mid sixties and then reductions as a result of poor weather during crop seasons. Unfortunately, in the case of Upper Volta, the general level of consumption appears to be lower than that in Niger and it has been reduced not only by poor output levels within but also by shifts in demand from Niger.

2.2.3 Past Specific Availability -- Upper Volta

In general, the rural producer consumer group in Upper Volta probably fared quite well throughout the period 1961-1970. Again, this is because they are the initial allocaters of product and it is unlikely that they would reduce auto-consumption of cereals for either higher income elasticity foods or cash when and if shortages occured. Also, the retail price level series in Table 2.1 for the Nov-Jan quarter (harvest period) indicates that prices did not increase to high levels until 1969. Had output levels been reduced to severely affect the rural producer consumer groups consumption earlier during the decade, it would have shown up. It did not. As far as 1969 availability levels were concerned for the rural producer consumer group, stocks on private account were still adequate to insure ample availability. Unfortunately, while the group in general may have fared well, it appears as though some variation does exist from one ORD to another. This becomes clear by comparing the ORDs for the 1970 crop year. Table 2.2 contains several measures of the factors which provide a basis for this comparison.

TABLE 2.2

VARIOUS INDICATORS OF ORD DIFFERENCES WITH RESPECT TO THE UPPER VOLTA AVERAGES FOR 1970

	Rural Pop Density (per Km^2)	Total Cereals Output/Rural Pop (kgs/year)	Rainfall Type	Cereals Area / Rural Pop (ha/person)	Cash Crop Area / Rural Pop (ha/person)	Sorghum & Millet Area / Total Cereals Area (per cent)
Average Upper Volta	17.5	214	-	.425	.056	.938
ORD	Relative Differences					
	(Same)	Per Cent (Deviation)	(Same)	Per Cent (Deviation)	Per Cent (Deviation)	(Same)
Bobo Dioulasso	14.5	14.6	+	-16.8	74.6	.898
Bougouriba	19.0	-19.7	0	- 6.5	- 2.4	.902
Centre Est	30.0	- .5	-	- 8.8	28.8	.854
Est	7.9	22.6	-	43.5	54.0	.886
Koudougou	25.0	4.9	-	6.0	-44.3	.986
Ouagadougou	38.6	6.0	-	6.8	-47.9	.973
Plateau Mossi	27.0	- 3.1	-	4.6	20.1	.955
Sahel	6.4	-18.3	-	18.6	189.2	.923
Sud-Ouest	8.0	- 4.6	0	-27.2	-23.4	.661
Volta Noire	16.5	18.1	-	2.8	6.7	.953
Yatenga	45.5	-24.1	-	-12.7	-63.9	.997

Source: Calculated from official Government sources. Rainfall type from the individual indices constructed.

The second column in Table 2.2 provides the average total cereals output per capita rural population (this excludes urban consumers but includes nomads) in Upper Volta and the percent deviations from this average for each of the ORDs. Three ORDs were markedly below the average. They were Bougouriba, Sahel and Yatenga. Three were also markedly above the average; Bobo-Dioulasso, Est and Volta Noire. The remainder were approximately equal to the average for Upper Volta. With regard to these variations, the remaining indicators in Table 2.2 help to provide some answers as to why they might have occured.

Unfortunately in the case of Bougouriba no explanation appears. Bougouriba incurred almost a 20 percent decrease below the country average in total cereals output per capita rural population. However, while rainfall was generally poor for the country as a whole; it was normal in Bougouriba. While this ORD had a less than proportional area planted to cereals, 6.5 percent below the country average which accounts for some of the reduced cereals output, the bulk of the reduced availability is unexplained. The ORD Sahel on the other hand is easily explained. First, the rural population in this northernmost ORD contains a substantial proportion of the countries 630 thousand plus nomads and semi-nomads. These are not cereal producers but trade for cereals. Thus, their inclusion will decrease the average. Second, the rainfall was severely below average in this ORD which reduced productivity levels. Third, while this ORD is a sparsely populated area with more extensive cultivation practices, a much greater proportion of land is allocated to cash crops per producer than in other areas. In fact, it is the highest per capita rural population. The remaining ORD below the average is Yatenga, the most severely affected. It too is easily explained. First it has the highest density of rural population, 45.5 persons per Km^2. This population pressure has practically reduced fallow land to zero according to official data. The population pressures has led to less than average area planted to cereals per capita rural population and the least cash crop allocation per capita is also found in this ORD; 63.9 percent below the average. Second, the rainfall was below average in 1970. Insofar as nearly 100 percent of the cereals planted are sorghum and millets it appears as though Yatenga is the worst off of all the ORDs.

The apparent reasons for the ORDs to be above average in total cereals output per capita rural population includes above average water in the case of Bobo-Dioulasso and low population pressures with respect to Est and Volta Noire. As sparsely populated areas, the system of fallow is not pressured as in other ORDs. Granting the rainfall was poor in both during 1970, the average levels are higher than the Sahel ORD. Thus, the impact on productivity reduced.

The data in Table 2.2 also points out why the current situation in the central part of the country is relatively worse then other areas. For the ORDs Koudougou, Ouagadougou, Plateau Mossi and Yatenga the heaviest population densities are found. During the 1970 crop, these four ORDs were approximately average or below. The area allocated to cereals were average or below and except for the Plateau Mossi cash crops were all substantially below the country average. Lastly, sorghum and millets have comprised nearly all the total cereals planted. Thus, in recent years as a result of the continuing drought, current output was reduced each year, stocks were depleted, and no crop shifting adjustments were alternatives as very little cash crops or other cereals were being planted to begin with. However the plight of the rural producer consumers in Upper Volta has not been as severe as the nomads and urban dwellers.

Very little information is available with regard to the nomads in Upper Volta. In fact, an estimate of them comprising 12 percent of the population appears high to this author. Nonetheless, many are present in the northern part of the country and as in Niger the situation facing them is bleak. Previously, noted was the fact that the bulk of the nomads are located in the ORD Sahel. An ORD which had less than average per capita cereals output. Given the geography of the country, the nomads facing reduced supplies have probably pushed further south. This has added further pressure on the central region of the country which because of heavy population densities of rural producer consumers were experiencing increasing difficulties. However, this southernly movement of nomads had its worst consequences on the urban consumers located in these areas as they compete for the limited marketed supplies.

The urban consumers as in Niger are dependent on marketed supplies which fluctuate from year to year. Going back to Table 2.1, it can be seen that prices during May-Jul quarter as early as 1963 were increasing

abrubtly from the retail prices at harvest. Also, the level of imports steadily increased as the urban population continued to increase. In short, what appears to have occured in Upper Volta is that over the decade the urban sector continued increase at a rate of about 6 percent annually. This expansion of consumers dependent on marketed grains first showed up with retail price levels increasing during the soudure as indigenous marketed supplies dried up as early as the 1963/64 market year. To hold consumer prices and meet requirements commercial imports steadily increased. This occured throughout the good rainfall years. Then in 1966/67 cereals output drastically fell and marketed supplies were reduced prior to the normal dry up during soudure. Imports (mostly on aid accounts) increased abrubtly. The aid has continued through to the present and amounts to an urban population in Upper Volta almost entirely dependent on exogeneous sources of grain. If in 1970, the 225,000 non-agricultural urban dwellers had received all the imported grain, the per capita consumption would have been about 150 kgs/capita. Disregarding how the imports are distributed, the net balance is that the urban population in Upper Volta is dependent on cereal supplies not produced within.

2.3 Future Cereals Availability

The purpose of this subsection is to provide a perspective of the most likely cereals availability situation which will prevail over the next decade in Niger and Upper Volta. Actually, two perspectives are presented, the short run and the long run. The short run perspective is an attempt to describe the extent of year to year fluctuations in cereals availability that can be anticipated. The long run perspective, considers the trends in cereals availability. In both discussions, the major causal factors are first reviewed. Then the estimates of fluctuations and trends are given. Lastly, implications to specific segments of the populations are considered. The short run perspective is considered first.

2.3.1 Anticipated Fluctuations in Availability

The most urgent problem with cereals availability currently facing the people of the sahel is that of contending with large scale variations in cereals output from one year to the next. Such variation in output is nothing new to this area and several methods of contending with it were available in the past. First, privately held stocks were carried as a buffer to offset lean output years. Second, a reserve of fallowed land was kept which could be brought into production quickly in response to any drawn down of stocks in the prior season. Third, increased labor was potentially available and stemmed from 1) shifting labor from alternative crops 2) decreases in economic leisure and 3) the return of family members which had temporarily migrated to the coast for work. Fourth, livestock numbers were built to high levels as alternative food sources. These, safety valves are no longer available.

As a result of the recent drought years, privately held stocks have been undoubtedly reduced to zero levels. This means current domestic consumption is dependent on the level of current production minus net exports. This latter element of domestic availability has been a large negative and mostly food aid in the form of drought relief.

Excess capacity in sahelian cereals production was also present before the drought began but has since been utilized. In 1969, Niger, as a result of the 1968 shortfall, increased the area planted to cereals about 17 percent. While about one third of the increase was crop shifting from goundnuts to cereals, the remaining two thirds of about 230 thousand hectares was an immediate incorporation of the fallow reserve into the production process. It is deemed a fallow reserve because of the apparent ease in which it was brought into production, that is, it was a one year adjustment of substantial magnitude. However, in light of the continuing deficits that were present in production, the area planted in subsequent years increased only slightly; further suggesting that land had become a constraint. In the case of Upper Volta, the evidence is mixed with regard to remaining excess land capacity. Mixed in the sense that some ORD's (Yatenga, for one) no longer have fallow available to any marked degree, while others, particularly in the southern extreme have large proportions of fallow. Unfortunately, the data does not lend itself to identifying if these large fallowed areas are of the reserve type or areas that require substantial clearing.

Excess capacity as a safety mechanism was also present in the form of labor. Again in 1969, Niger cereal producers incorporated this added input into the production process. From the analysis of aggregate yields in Niger, 1969 aggregate yield intentions jumped 17 percent from those of the previous year. Recognizing that the increased yield intentions of 17 percent during a year when the area planted increased a comparable amount means that the proportional increase in labor had to be greater than that of land. Such an increase, in labor could only result if excess capacity were available. However, once this amount was brought into production it too has been retained but no further increases are apparent. Again, in Upper Volta less information is available with regard to the utilization of available labor. However, one can surmize that little if any excess capacity in labor exists particularly in the Mossi plateau region where the food problem is most severe.

The drought has also taken its toll on livestock numbers. While the estimates vary as to actual losses, the severity of losses can not be denied. These losses have undoubtedly reduced somewhat the extent that livestock can be viewed as a last step alternative to inadequate diets.

In short, one is unable to avoid the conclucion that the traditional safety valves utilized in offsetting fluctuations in cereals output have been effectively wiped out by the successive nature of the drought. The general result is that availability of cereals to sustain life are entirely dependent on current production and food aid and such a situation is likely to continue into the immediate future. With food aid becoming an increasingly scarce commodity as world reserves are drawn down, the immediate future cereals availability situation in the sahel will be largely dependent on annual rainfalls.

The analysis of rainfall (see 6.2 of Part 2) in both countries provided estimates of the normal variation that can be anticipated. In Niger as a whole, rainfall can vary about 14-16 percent from the average any single year and still be considered normal. For Upper Volta as a whole, the variability was substantially less (about 8 percent) because of the offsetting tendencies of rainfall patterns in north and south. Unfortunately, variability in some ORDs was as high as that found in Niger. Such variability in rainfall levels from year to year has direct consequences to cereals availability.

In the analysis of aggregate yields in Niger it was found that the rainfall impact on aggregate intended yields was about 1-1 (see subsection 6.3). A one percent decrease in rainfall means a one percent decrease in yields and therefore a one percent decrease in intended output and vice versa. No analysis of this sort was done for Upper Volta, but one can easily assume that the impact is similar. Thus, for Upper Volta as a whole, much less variability in output fluctuations will result than in Niger because of its diversity in rainfall. In Niger, the entire country will be similarly affected by rainfall variation. In terms of problems with cereals availability for a given year then, Upper Volta will be characterized by regional deficits and surpluses where Niger will be characterized as a general widespread deficit or surplus.

Unfortunately, forecasting the weather is a difficult proposition. Some theories are available with regard to cycles but this author does not feel confident in this regard to make any predictions. Therefore, the short run impact on general availability of several types of rainfall years which may occur with equal probabilities are discussed. First, the optimistic position.

Currently, intentions in cereals production are high such that if average or above average rainfall prevailed, intentions would be rewarded by high levels of output. The reason intentions are high is that the subsistence sector is attempting to replenish stocks as well as regain previous levels of consumption. This means that if 1974 rainfall is good to abnormally good, the crisis situation will be over. Intentions however will continue at a high level into 1975 as cereal producers are very conservative and will attempt to get two good years of output before shifting intentions to lower levels. If successful in this respect intentions in 1976 should begin to decrease. When and if this shift to a lower level of intentions occurs, the situation for a crisis will again be present. If the shift to a lower intentions is met with below average rainfall, the actual output will of course be reduced. This means that previously built up stocks will again be reduced and 1977 intentions increased. So far this discussion is largely concerned with general availability. Cereals available to specific segments of the population even under this more optimistic forecast is not encouraging.

The response of cereals producers has been largely a subsistence response. This is because of two reasons. First, the subsistence sector dominates. Second, while market oriented production in 1969 shifted somewhat from cash crops to cereals, in 1970 and 1971 the area planted to groundnuts in Niger was again increasing as a result of increases in producer prices. That is, relative product prices were favoring groundnuts again. Thus, market oriented supplies of cereals will continue to be suppressed as any marketed excesses from subsistence will be retained to build up stocks and market oriented production is being suppressed by unfavorable price ratios. Cereals supplies to both nomads and urban consumers will continue to be inadequate regardless of how good the weather is and prices[1] will be high.

A more pessimistic but equally likely short run position on immediate cereals availability results where rainfall years in 1974, 1975 and 1976 could all very easily be below average. If this were the case, intentions will continue at high levels into 1976 because stocks will not be retrieved by the subsistence sector. If abnormally bad rainfall occurs as it did in 1972, the situation would be disasterous in terms of general availability. Widespread malnutrition and disease would be rampant as nutritional levels would be reduced. Most affected will be the children in rural producer/consumer segment, and the nomads in general. This will result because any imports are easily distributed to urban areas. Urban dwellers would be therefore relatively better off; those at least that can afford the grain at the high prices that will prevail. Nomads must migrate to these areas and some undoubtedly will be reluctant to do so, although the situation in 1973 distributions in Agadez proved that nomads will move to food supplies when destitute. Unfortunately, import distributions to rural sedentary producers is practically nil. While the traditional market is quite well adopted to aggregating grains from a large number of small production units, it is not suited to disaggregating supplies in the reverse manner. Thus, rural sedentary producer

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[1]If high level intentions are met with abnormally high rainfall retail prices at harvest will drop, but they will undoubtedly increase to oppressive levels during soudure.

consumer will be dependent on their own output and when this is reduced it is the children who suffer greatest. Obviously, if imports of food are denied, the consequences would be food rioting and almost certain conflict between nomads and rural sedentary producers of cereals.

2.3.2 Anticipated Trends in Availability

The short run problem facing the sahel is not likely to be improved over the long run as trends in output levels are not conducive to optimism. The future output level of cereal intentions in Niger is anticipated to increase, assuming normal weather, at a rate of 1.9 percent annually. This forecasted increase in intentions stems entirely from increases in the area planted. As this forecasted trend is for a level of intentions, it is important to understand the exact position of the base level in conjunction with requirements. In this context, two estimates are presented. First, a high level of intentions were assumed where compounding at the 1.9 percent growth rate indicates that per capita output levels currently prevailing can be maintained until 1984. After that, even high level intentions will be insufficient to provide current levels of availability under normal rainfall. Assuming, a more conservative estimate of the level of intentions, 1975 is the year in which the traditional production sector will no longer be able to provide adequate output to maintain current per capita output levels.

In the case of Upper Volta, no intentions wer forecasted as the data were insufficient. Instead, simple trends were calculated and adjusted according to several considerations. The major result, assuming the data used to be at least reasonably accurate, was that the trend in cereals output is much higher than Niger, a trend of 3-4 percent. This trend in output also stemmed from both increases in area planted and increases in annual productivity. Conservatively, one can conclude that at least, current general per capita output levels will be maintained as this would require only an increase consistent with population expansion of about 2.2 percent for the next decade. However, this optimistic trend in Upper Volta is not equally distributed throughout the country. Again regions such as the Mossi Plateau area will be unable to maintain per capita output over time.

Thus, as far as trends are concerned it appears as though Niger will find its higher level of consumption being eroded away at some point during this decade. Upper Volta on the other hand, with a lower level per capita cereals availability will be maintaining and possibly slightly increasing per capita output levels for the country as a whole.

The reasons for these unencouraging trends, even assuming normal weather will entail over the long run, are quite simple. The man land ratio is increasing as a result of simple population growth and labor in the traditional subsistence sector is increasing at a less than proportional rate compared to population growth as a result of sustained migrations of people to urban areas. Phenomena consistent with many developing countries. The basic arguement is as follows and Niger will be used as the example.

The population of Niger is estimated to be increaing at a rate of about 2.7 percent annually. It has been doing so for the last 30-40 years verified by the fact that the population since 1937 has doubled. Thus, the process to be described has probably been operative for a long period but as the data is not available for years prior to 1960 this cannot be verified. Since 1960 however, data is available and the argument can be verified. First assume that cereals output is a function of essentially land (capital) and labor. Other forms of capital are used but they can be assumed to be increasing at rates at least consistent with the population growth rate.[1] Also assume that constant returns to scale are characteristic. That is, a one percent increase in each land and labor results in a one percent increase in output. Finally, assume no new technology is present or at least is economically feasible in cereals production. Thus, to maintain per capita availability over the long run requires that output levels increase at a sustained rate comparable to the population increases.

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[1]Simple mechanical capital is usually labor embodied capital and easily reproducible. Biological capital such as organic fertilizers can be expected to increase as man/livestock ratios are maintained. Biological capital as a result of plant residues from the fallow process are assumed decreasing as fallow intensity increases and are treated as land.

If the population increases 2.7 percent, the land and labor inputs must each increase 2.7 percent into the production of cereals to maintain per capita output. Insofar as labor stems from the population, an increase of 2.7 in the labor input is feasible. For the time being, ignore any outmigration in this first arguement and also that labor is fully employed. In this latter instance in Niger, some excess labor was available as a safety mechanism. It however is no longer available. Thus, if population increases at 2.7 percent annually the labor input can increase 2.7 percent but no more.

Land must also increase at a rate of 2.7 percent to maintain output levels. Unfortunately, no new frontiers are available in the sahel for this type of expansion. Land is becoming scarce. As it becomes scarce, its value increases and this change in implicit relative factor prices results in labor substituting for land. This in turn means that per hectare yields will increase and labor productivity per hectare will decrease. (Law of variable proportions.) With respect to total output, less than a 2.7 percent increase results because, labor becomes a constraint. As total output increases proportionately less than the population growth rate, per capita output decreases in a sustained manner over time.

The decrease in labor productivity in the traditional sector combined with the development process itself combine to siphon off labor from the traditional sector. The wage rate in traditional cereals production is the average product of labor, which is low. With the development process being initiated in and around urban areas and jobs becoming available at wage levels greater than tose in traditional cereals production, rapid urbanization not surprisingly results. Because of the absolute dimensions of this type of population change it usually has a meager impact in the initial stages. However, after several years have past and urban populations have risen to say 5-10 percent of the total population it has a significant impact. First, it further constrains the labor input into cereals production which in turn reduces the increases in output over time and secondly, it concentrates a large population totally dependent on marketed supplies from a traditional sector which is itself facing sustained decreases in per capita output.

Thus, in Niger the increase in intended output is about 1.9 percent. The source of this increase is totally due to increases in the area planted. Such a rate of increase is consistent with both increased scarcity of land

as well as reflecting sustained outmigration from the sector. Increases in yields when adjusted to rainfall variation were also found to be increasing at a rate of less than one percent. However, this trend was not statistically different from zero and therefore is assumed as zero. Apparently in Niger, land and labor constraints into cereals production are both operative.

In Upper Volta, the trends are more optimistic and stem from both increases in area and yields. The land increase was about 2 percent which in light of the various estimates of population growth does not suggest land is a constraint. However, review of particular ORD's suggest that it is in some parts. The yield trend for cereals was also higher than might be expected at about 1.5 percent. The data in this case, leads one to doubt this rate of increase and as there was no way to test it statistically, it must be regarded with cautious optimism. However, some increase in yields is expected if land is a constraint.

In the long run then, assuming normal weather, the problem facing both countries will be to increase output per hectare and labor productivity such that per capita output can be maintained and a sufficient level of marketed supplies can flow to the urban area as they will be increasingly affected particularly during the soudure season when marketed supplies dry up. Nomads will also be affected as the long run terms of trade go against them as the traditional sector becomes increasingly more destitute. However, because current rates of consumption are at high levels, even when sustained decreases in per capita output begin to occur the long run problem will not be as severe as the problems facing the people in the short run as a result of rainfall fluctuations.

comment on rainfall

The question of a climatic shift occuring in the sahel is being raised as a result of the successive nature of the current drought. Some meteorologist argue that the climate is shifting and annual levels of rainfall will be reduced in a sustained manner. Others are skeptical of these arguements and point to previous droughts and cite long run analysis of rainfall over the past 30-40 years which indicates no significant decreasing trends. This author neither believes that the climate is shifting nor disbelieves. However, efforts which were made and discussed

in Part 2 of this report, to refute the arguement that the rainfall levels were decreasing failed. (See 4.3.2, 5.2 and 6.2 of Part 2.) Insofar as this would have calamitous implications on long term output levels requires that it be reviewed more throughly.

The rainfall variable was found to have a 1-1 impact on aggregate yields. If rainfall were decreasing on a sustained basis throughout the sahel at a rate 1-2 percent, this would imply that the previously mentioned trends would be effectively reduced to zero or near zero levels. Per capita output and therefore general availability of cereals would be decreasing at a rate consistent with population growth. Unfortunately if true, the problem would be more serious as large parts of the northern fringe of the sahel would no longer be able to technically make a cereal crop. That is, five years of this type of decrease would result in a 5-10 percent reduction in annual rainfall levels which would be too much. People in these area would be forced to migrate. Another consequence might be that those in the southern fringe would be technically restricted from planting groundnuts and would be forced to switch to cereals. This would be good for the cereals situation but obviously bad for a government dependent on the export crop to provide foreign exchange. However, my purpose here is not to speculate on likely consequences of such important questions but simply to draw attention to the question and the fact that it has dire consequences to people and the governments as well.

3 IMPLICATIONS AND RECOMMENDATIONS

Broadly speaking, three types of program directions are available in attacking the sahelian cereals problem. These include first, a comprehensive program to increase the long run supply of cereals and preempt the eventual negative trend in general availability that will undoubtedly occur if not in this decade, at least in the next. Second, a program which attempts to curb long run demand for cereals via population control measures and shifts to alternative food crops. Third, a program effort which is aimed at improving the spacial and temporal distribution of short run cereals supplies in light of relatively fixed demands. While good arguements can be put forth for AID involvement in each, the latter area appears to be USAID's forte.

The remainder of this subsection will attempt to provide the major implications of the problems facing the people of Niger and Upper Volta with regard to cereals availability and also recommend several activities that USAID can undertake such that the eventual problems can be circumvented or at least the negative consequences minimized. In doing so, several considerations were made. First, USAID's "action program" orientation was recognized. Second, an eventual curtailing of PL480 foodgrains as an aid instrument was recognized. Third and perhaps most important, was the recognition that aid efforts initially stem from the transfer of some resource. Thus, in determining avenues of assistance, the use of resources where the United States has a comparative advantage not only to the recipient country but other donors as well, appears to be the most logical direction to pursue. This consideration will become more evident as the discussion progresses, however one point is perhaps best made at this juncture.

Computor technology has been distributed throughout the world as evidenced by the mere presence of computor facilities. Many of these cmputors are underutilized when available because of simple constraints in developing software programs. In French West Africa two are said to exist. One in Abidjan and one in Ouagadougou. More are likely to be present, but no actual identification procedures were conducted to verify this. With regard to their use, it was determined in Upper Volta that the expertise was available to use the computors, but the high cost

of developing programs because of the lack of programmers denied this. The United States has a comparative advantage in this resource. Insofar as the computors can be used in many ways to augment the development efforts, they have been incorporated into some of the recommendations. In my estimation it would be unwise to forego this important contribution. Fears that the computor output are too sophisticated for these countries are not justifiable as they will become increasingly important as time passes.

With this brief digression, the general implications and specific recommendations to USAID are now presented. The first part considers distribution efforts which in light of the results will certainly be the most urgent problem facing the countries. The second and third parts consider the long run problem and discuss supply oriented programs and demand oriented programs respectively.

3.1 Short Run Distribution Efforts

Currently, USAID is involved with grain stabilization programs in both countries. While such programs have important implications to future cereal supplies via the impact of grain stabilization efforts on market prices which in turn affect producer prices, it must be recognized at this point, their major function is that of distributing grain imports and redistributing production such that spacial and temporal differences in available cereals can be smoothed out. Insofar as large fluctuations in current production are anticipated in the near future, this aspect will remain dominant in the grain stabilization effort. Therefore, I recommend that the current grain stabilization efforts be continued and enriched such that the governments have an improved capacity to identify, monitor and offset the almost certain temporal and spacial deficits in cereals availability in the near future. This can be done with following increased USAID inputs.

REC #1 Provide support for the appropriate ministries to more quickly assess deficit areas within the countries. This can be done in the following ways.

a. Improving the speed of weather information collection and analysis. Monitoring this important variable is of crucial importance in

determining likely aggregate cereal yields which will prevail within a given region. Recognizing the availability of computors in the area and the financial limitations to developsoftware, USAID can provide computor programmers to develop systems which will augment current collection and analysis procedures.

b. Improve the speed and accuracy of estimating the area planted to cereals. Previous efforts by AID have identified that the ERTS satellite combined with traditional sampling techniques can certainly improve the current estimation procedures. It is suggested that the effort be made to first identify thoroughly the area planted with a high degree of accuracy followed by subsequent annual sampling procedures which will simply measure changes from one year to the next. With the financial limitations of these governments they cannot be expected to continue using a high cost estimation technique ofter USAID withdraws from this activity.

c. Improve the speed and accuracy of productivity estimates by first developing simple forecasting techniques in light of the improved weather information and secondly by improving or implementing the current sample surveys techniques present.

REC #2 Provide support to the current grain stabilization programs via a perpetual inventory model of grains held in storage and in transit which will be distributed. This inventory model will be a simple computorized accounting system which will provide an immediate comprehensive picture of the spacial dimensions of grain inventories. Insofar as it can be run for any predetermind time period (weekly, monthly, etc.) it will provide the necessary temporal perspective of distribution trends.

REC #3 Develop a grain stabilization policy evaluation system which first estimates aggregate demands of all the various segments of the population (rural sedentary, nomads and urban dwellers) on a quarterly basis for specied regions of the countries and second simulates the likely consequences of the estimated grain supply flows to these demands. The consequences which are identified will be projected per capita availabilities and price levels. In this manner policy makers can assess the likely outcome of grain stabilization efforts prior to the events taking place. Such an effort could also include the likely consequences on the following years crop by changes in relative product prices. This would require supply response models to be constructed and incorporated into the model. Further stipulations of this effort include the following.

a. To be effective, the model must be internalized to the appropriate decision making body. Thus, a primary effort is that of identifying exactly who the decision makers are.

b. To be effective, the model must also be of value to the country. This means that any initial efforts in this regard be designated for a single country and proved by its use that it is of value. Other countries can then be expected to incorporate such systems in their own ministries. The country recommended for the initial development of such a model is Niger.

3.2 Long Run Supply Efforts

The question of a shift in climate has substantial implications for cereals production in the sahel to say nothing of the impact on the entire economy. Given the significance of the question it needs to be resolved. Thus, two recommendations are made. The second (REC #5) is contingent on the findings of the first (REC #4).

REC #4 Initiate a study of the climate of the sahel with the specific purposes of identifying the probabilities that a shift in climate is occuring and the specific magnitudes of the shift.

REC #5 Contingent on the results of the aforementioned study initiate a study which will assess the likely dislocations in peoples and cereals production that might be expected over the long run.

While this question of climate needs to be resolved, other efforts can also be made in increasing cereal supplies in the long run.

Normally the long run supply of cereals can be increased in essentially three ways. First, increase the efficiency of the current production process. Second, increase the inputs into cereals production by shifting inputs from alternative crops. Third, improve technology via the introduction of new inputs. In the sahel, the first alternative is not viable as the production of cereals is characterized by traditional techniques which are normally very efficient. Only when technology is continually changing does inefficient production prevail. The second alternative is a viable approach as large areas of cash crops are produced in both countries which could be used in arresting the cereals trends. What this would require would be to provide competive cereal product prices in areas where cash crops are grown. However, it must be recognized that success in approach will certainly reduce the foreign exchange earning potential of these countries. Thus, the third alternative appears as the most logical insofar as output would be increased without encroaching on the cash crop sector.

To be successful, a new technology or technologies need only increase aggregate output at a rate of 1-2 percent annually. Such increases can be obtained in essentially two ways. The first way, which is also the norm, is to introduce a new technology that provides a large increase in output per hectare. Assuming that it simultaneously, substantially decreases per unit costs per hectare, the technology will be adopted in the early stages by a few (those who can afford it) and in the aggregate, small increases in output will result. As time passes, more and more adopt the technology and larger increases in the aggregate will result. This in turn often leads to "second generation" dislocation problems. However, quite often the adoption rate results in a bidding up of the input costs which decreases the relative product factor price ratio and in turn slows adoption. In either event, this procedure is unequitable amongst producers. Early adopters and those who have capital always benefit.

A second way to increase aggregate output in small increments over time via new technology and circumvent severe dislocation problems, is to introduce a new technology which is easily distributed to all producers and provides small but discernable increases in output. Such a technology would necessarily be of low cost and easily purchased by small producers. Unfortunately, no such technologies are presently available.[1] In fact, no new technologies which are available appear to be practical in the context of solving the problem. Those currently available (new varieties, inorganic fertilizers, water control techniques) obviously do not meet to the test of being practical alternatives else they would be adopted. This suggests basic research in the problem is required. In this vein two efforts are recommended.

REC #6 Identify with the assistance of the Tennessee Valley Authority if time release fertilizers have any potential in the sahel. Currently these fertilizers are being developed in the US as a counter to our pollution problems as they release nutrients as a function of

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[1]Tom Vollrath (see references) discusses a simple improved hoe which appears to meet this criteria. However, because of the intricacies of current production techniques it was not being adopted in Upper Volta.

rainfall and reduce leaching. These same characteristics appear to satisfy many of the problems with inorganic fertilizers on sandy soils in the sahel. Also, as nutrients are released with rainfall, weeds would not become as great a problem as with traditional inorganic fertilizers. At this stage, of development of time release fertilizers, it is not known if they would be technically feasible or economically feasible. Nonetheless, there is but one way to find out and that is to investigate the proposition. Again, this is an area where the US has a distinct advantage.

REC #7 Assess the qualities required of a cereals grain for the newly emerging urban markets. As urbanization has progressed, the traditional varieties developed over long years to fit the traditional subsistence sector have been flowing to the ever increasing commercial market. These grains may possess certain characteristics which are not required for these new markets; particularly in terms of storage characteristics and nutritional quality (urban dwellers have a much wider selection of foodstuffs to balance diets). If so, varieties currently available with increased yield capacity may be ideally suited for these markets and if the correct incentives be introduced into the production process part of the long run problem can be solved. (One way to provide incentives would be premium payments by the grain stabilization offices.)

A final effort in increasing cereal supplies, particularly in the urban areas, and requires no increases in production is that of decreasing milling margins. Recognizing that only certain gains can be made in this area and this contract did not begin to even address the question, it remains a viable alternative. Thus, it is recommended that USAID:

REC #8 Conduct an examination of the likely benefits to accrue from the adoption of simple improved milling techniques.

No further recommendations are made in the area of increasing long run cereals supplies. This is not to suggest that other alternatives are not present but rather that USAID does not have a comparative advantage in these other areas. In this regard, the French and other international consortia do.

3.3 Long Run Demand Efforts

The other side of the coin, in terms of increasing long run availability of cereals is to decrease long run demands. In particular, decreases in aggregate domestic demand only are considered. Although one element of future export demand, may involve USAID directly. That is, the question of increasing beef production. Currently, beef shortages are present in the coastal cities as general development is increasing incomes. These increases in incomes are quickly transfered into increased demands for beef. This beef must be fed and the traditional procedures of grazing slaughter beef to the coast is being changed. Again, it is not clear if increased demand for fed beef on the coast will directly affect demand for feedgrains (sahelian cereals) or not. It is clear though, that if relative feed costs favored grains over grass, that grain would likely be that already in current short supply in the sahel. No recommendations are given in this area aside from the fact that USAID in their efforts in stimulating beef production be aware of the fact that it may involve increased demands on sahelian cereals.

Domestic aggregate demand for cereals can be reduced by essentially two acceptable means. First, reduce the rate of population growth and second shift tastes.

The populations of these countries are increasing at very rapid rates. In another thirty years, if these rates continue, the populations will again double. This would create undeniable strains on cereals availability. Recognizing that governments may not view population growth as aproblem at this point, and therefore take internal actions to counter the eventual problems. It seems that USAID with a high level of expertise in this area may initiate early stage inquiries. Thus:

REC #9 USAID should begin a small population program in the area which will assess the problems which will likely result if growth rates continue unabated.

The final recommendations concerns the question of alternative foodstuffs. As per capita cereals output in the long run declines, the impact will be most severe in the urban areas, as the marketed supplies will be reduced at a proportionately greater degree. Thus, if the demand for cereals in urban areas could be decreased via a continual shifting to

an alternative and perhaps more nutritional foodstuff, much of the problem would be reduced. This at first may sound unfeasible because such foods would may result only at higher resource costs. This is true. However, these governments when faced with food riots one year and abundance the next may be willing to invest in a high cost food supplement which will be available to consumers with a greater degree of certainty. Therefore, recognizing the very long term impact of this final recommendation (10-20 years) it is extended nonetheless.

REC #10 Evaluate current alternative supplemental foodstuffs that can be produced in the sahel such that the long term reliance of cereals particularly in the cities is reduced.

PART 2

AGGREGATE ANALYSIS OF SAHELIAN CEREAL PRODUCTION

Introduction to Part 2

Any consideration of cereals availability, past or future, necessarily requires that indigenous production be thoroughly understood. Such an understanding, can be obtained by long years of experience. However, given the temporal constraint of this method, an alternative procedure to obtain a degree of understanding was used. The alternative, of course was the scientific method. That is, specification of objectives, formulation of hypothesis and the selection and application of analytical techniques in an attempt to test the hypotheses. In using this technique, it is necessary that the correct questions are initially asked and objectives accordingly specified. Not surprisingly, as a result of doing the analysis, many more questions were raised. However, the results do provide answers to many of the questions currently being asked with regard to the future of cereals production in the sahel.

The major results and implications of the aggregate analysis, have been reported in Part 1. The purpose of Part 2 is to provide those readers who wish, a more thorough review of the analytical procedure and the results. Again, it is recognized that some aspects of this review have more relevance to some reader/users. Thus, Part 2 is comprised of three additional sections to the report; sections 4, 5 and 6.

Section 4 initially reviews the purpose and general objectives of the study of sahelian cereals production. This review is followed by a discussion of the micro-production environment with particular emphasis on output alternatives and input allocation under the traditional setting. Lastly, section 4 lists the major expressed concerns regarding the future of sahelian cereals production. These include the impact of climatic changes, changes induced by simple population growth and structural shifts, and the supply response of cereals in general and with regard to other crops. These concerns are treated as hypotheses which were tested.

Section 5 is a methodogical description of the procedures used in the analysis. It briefly discusses the data base in Niger and Upper Volta and the techniques utilized in building the rainfall indices. The models

which were used in testing hypotheses for Niger are also reviewed. Insofar as section 5 is a methodological one, some readers may wish to skip it. However, in reading the report, one can not help but recognize the preponderance of results for Niger. There are a number of reasons for this and they are discussed in Section 5.

The final section is number 6. It is comprised of four subsections which contain the results and implications of the aggregate production inquiry. Also, included are a number of insights which although not specifically sought in the analysis were deemed worthy enough to be reported. The first subsection includes the results of a simple examination of the area planted and annual productivity of cereals in both countries. Next, the results regarding the quality of rainfall and the past trends in each country are reported. Third, a subsection on the results of the models applied to the data in Niger are presented; accompanied with statements regarding the acceptance or rejection of hypotheses. Fourth and last, is a subsection on projected output levels of cereals in Niger over the next decade. The projection is contrasted to required levels of output such that the temporal aspects of the problem are brought into focus.

4 AGGREGATE PRODUCTION INQUIRY

4.1 Purpose and General Objectives

The past is our window to the future. A solid understanding of what the actual situation of cereals production was and why, provides a much improved perspective of the future. A perspective of not just what trend might prevail with regard to cereals production and its consequent implications to long run cereals availability, but also a perspective of the likely magnitudes in annual variation. Variation that is so very important in determining the short run adequacy of cereals for substantial segments of the sahelian population. To obtain such a perspective, entailed the comparison of three types of cereals output. They were, actual cereals output, required cereals output and aggregate intended cereals output.

Actual cereals output are those estimates of true production provided by the governments. Recognition of the problems in making such estimates and the errors and biases that often enter into them requires that they be scrutinized rather rigorously. However, when certain errors or biases are identified this does not suggest blanket abandonment of the data is warranted. It does suggest that they be adjusted to known biases of possible, and also that the analytical procedures applied to the data be consistent with their quality.

Required output levels are those which are estimated to insure food adequacy. The definition of food adequacy used here again, was a simple quantitative one where the price level was not considered aside from its distributive impact on cereals between segments of the population. Thus, to be adequate, the general level of food output only needed to be maintained on a per capita basis. Any increases in price levels resulting from changes in per capita incomes or a shifting of relative food prices were ignored. These aspects of course are important, but given a cursory review it did not appear as though they were major

factors affecting cereals availability in general. Therefore, a simple approximation of required output was made by first determining a level of normalcy. This level of normalcy was then compounded by the estimated population growth rate.

Intended output levels are those which would occur if normal weather prevailed. Simply stated, intended output levels represent the aggregate producer response. For a given year, this response can change as a result of changes in the area planted or changes in the intended productivity per hectare or both. Insofar as technology is constant in aggregate cereals production in the sahel, the changes in intended output represent changes in the allocations of inputs into production as a result of changes in relative factor product price ratio. By observing the types of changes in intended production -- intensive versus extensive changes with regard to land -- further information becomes available with regard to the nature of constraints facing increased cereals production.

Comparing the actual output levels with the estimated requirements provided a determination of the adequacy of cereals to be made. That is, the nature and the magnitude of the problem was defined by comparing the actual levels for a given year with the required level for that year and tracing out the consequences of a shortage or an excess through the distribution schema. This procedure required some assumptions on stocks but this exercise in itself provided insight into the nature of the problem in maintaining cereals adequacy. The results of this simple analytical procedure have been previously discussed in Part 1 and will not be reiterated here. The purpose of Part 2 is to review the analytical procedure and results obtained by determining intended output levels and the implications that stem from the comparisons with actual output and required output.

Thus, three general objectives were pursued in the inquiry of aggregate cereals production. They were as follows:

(1) Determine the specific levels, short run adjustments and trend of intended aggregate cereals output for the period 1960-1971.

(2) Compare the intended levels of output with the actual levels that prevailed to determine the nature of producer response as well as with required levels to determine the adequacy of producer response.

(3) Review future output level trends and variation in light of future requirements, the uncertainty of rainfall and input constraints.

In light of these objectives, a number of specific hypotheses concerning intended output and its past and future adequacy were formulated. These hypotheses are discussed in subsection 4.3. However, in formulating hypotheses on aggregate cereals production it was necessary to review the traditional micro-production environment. A discussion of that review is provided next.

4.2 Micro-Production Environment

Aggregate cereals output depends on the response and concerted action of thousands of micro-production units. The basis of these production units in the sahel is the extended family and when combined they are referred to as the rural sedentary segment of the population. Each of these units has a resource base composed of land labor and capital which it allocates to various production alternatives. The allocative procedure is the same as in any production enterprise. That is, inputs are allocated on the basis of their expected returns. More specifically, they are allocated to a point where the value of output expected from the addition of one more unit of input is equal to the cost of that input. To more fully understand this process, the nature and value of outputs, the nature and value of inputs and the traditional production function under assumptions of normal and abnormal weather all must be considered.

4.2.1 Outputs and Output Valuation

To begin, each production unit in the sahel has a set of alternative productions activities which can be theoretically distinguished as subsistence oriented production versus market oriented production. As such, the producers respond to different prices in each. In the case of the former, an implicit price of the output which represents the individual producer's supply and demand situation is the motive force. In the case of the latter, two explicit prices prevail. First the market formulates an explicit price which is based on aggregate market

supplies and aggregate market demands. Second, the government can take a monopoly position in a marketed commodity and set an explicit producer price.

Unfortunately, while these two types of production activities are theoretically distinguishable, they are not necessarily distinguishable on a crop basis. Such is the case for sorghum and millet production. In Niger, it is estimated that 84 percent of the sorghum and millet production was consumed by the producers and 16 percent entered the commercial sector in 1970. In Upper Volta, the subsistence percentage of the millet and sorghum combined crop for the region in and around Ouagadougou was 85 percent in 1964.[1] These estimates suggest that both the implicit prices and the market determined prices for these cereals are required to value the output and identify producer response. This point is even clearer when the general differences in the production alternatives are reviewed in Niger on a spacial basis.

Production alternatives facing the production units in the sahel are constrained by the average level of rainfall for the specific location of the family or production unit. Recognizing that this average level of rainfall is actually a continual gradient from south to north, three general production unit types can be approximated. In the north, (northern part of the sahel not the country) the production unit is severely constrained by rainfall and mixed millet crop/livestock operations prevail. (In this particular instance the emphasis is on millets rather than livestock; thus the production units remain in the rural sedentary category. If the emphasis is reversed, then the production unit would be more accurately defined as semi-nomadic.) The department of Tahoua can be appropriately described as including production units mostly in this category. For the year 1970, only 5 percent of sorghum and millet output entered the commercial sector. Sorghum and millet production is definitely a subsistence oriented crop in this area.

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[1]The Niger estimate was calculated from official data, while the Upper Volta estimates was a SEDES estimate reported on p. 74 in "Rapport Economique" (see reference)

In the south, the average level of rainfall is much greater and as a result, mixed cropping operations prevail where the major crops are sorghum and millet versus cash crops, particularly groundnuts. Maradi, fits this category and while a very low percentage of sorghum and millet is commercialized, about three percent, cash crops are produced at a high level. The ratio of combined cereals to cash crops is about 2.5 to 1. Clearly, a large percentage of cereals output would be market oriented, but because of unfavorable relative product prices, they are not produced.

In between these two extremes lies the area where subsistence consumption of cereals may dominate but cereals are also the primary market oriented crop. Moving in a southernly direction from the northern extreme, the increased rainfall favors specialization in cereals production and trading for livestock products. Moving in a northernly direction from the southern extreme of the sahel, average rainfall levels decrease and become a technical constraint to the production of cash crops. Thus, the middle range sahelian production unit is a sorghum /millet producer in terms of both subsistence production activities and market oriented activities as well. In the department of Niamey which approximates this category, 56 percent of the sorghum and millet output was consumed by the producers and the remaining 44 percent entered the commercial sector in 1970. Other cereals (rice) or cash crops produced in this area are meager on a proportional basis. These differences between a subsistence orientation or a commercial orientation of the sorghum and millet crop are important aspects in determining the response of producers.

The allocation procedure requires that the production unit formulates an expected price for the various outputs that it can produce. With regard to the cash crops with announced producer prices, obviously no formulations are required as the government agency in advance of the season sets the price. Any year to year changes in producer prices are determined by the agencies expectations of world prices. Thus, when expectations are in error, there is a change in the excess rents due the government agency not in the producer price. In the case of other purely market oriented crops, price expectations are a function of past levels

and trends. However, in the case of cereals, which in part are marketed, the market price is not representative of the true value of the crop and is therefore not used solely in formulating expected output prices or in allocating factors of production by the production unit.

The value of subsistence cereals is determined by the individual production unit in the following manner. Each production unit implicitly knows the quantity of cereals required to feed the production unit for one year. Each family also knows that the vagaries of weather normally result in actual production being less or greater than intentions. To maintain consumption in an off year it requires a certain level of stocks to be maintained to buffer the low output which will undoubtedly occur. Thus, for a single year, each production unit's demand is comprised of the number of family members times the normal per capita consumption level plus the demand for stocks to carry over. On the supply side, the production unit has both the previous years carryover plus the current years production.

On the average, production should equal normal consumption and no change in stocks levels will occur. Unfortunately, this requires a rather even temporal pattern of deficit and excess production years which cannot be expected. Therefore, when successive excesses occur in production above both consumption and stock demand these amounts are dumped on the market for whatever price prevails. When a deficit occurs, stocks are drawn down and obviously no excess is marketed. In successive deficit years, subsistence consumption is reduced. With regard to the value of subsistence production then, the implicit price is a function of the stock position. It is this implicit price or value of the output which subsistence production unit responds to and it is known to each unit with certainty.

The value of marketed cereals is determined by supplies entering the market and the demand for export and domestic non-producer consumption. On the demand side, the domestic consumption can be expected to be fairly constant from year to year. Export demand is a function of relative price differences and is subject to greater annual variation, however in an absolute context it is too small to drastically move aggregate market demand. Yet, market prices fluctuate greatly. The reason is that marketed supplies fluctuate greatly.

Market oriented production enters the market regardless of the type of crop year. But the level is of course dependent on the crop year. If intentions were three quintals and only two quintals were actually produced then two quintals would enter. If intentions were three and four were actually produced then four would enter. Adding to this normal variation in marketed supplies, are the marketed excesses from subsistence production. In good years, the subsistence excesses are marketed, in deficit years there are no subsistence excesses and as such the marketed supply is comprised of only the reduced market oriented production. (It is reduced because if subsistence output is low due to poor rainfall it is most likely that market oriented output will be low.) A second subsistence excess output can be theoretically described, and enters the market in even normal years. It is the "marketed surplus" and results from a hedging position that the subsistence producer takes on an annual basis to protect against shortfalls. It is described more fully later, but at this point assume that it too is present in normal to good years and absent in deficit years.

In short, market supplies, depending on the type of crop year are comprised of three different elements of production. In a good crop year, market oriented production is high, the market surplus is present and marketed excesses are dumped on the market. Market prices are obviously suppressed. In a normal crop year, the market oriented production is normal and the marketed surplus is present but no marketed excesses. Prices are at their "normal level". In a deficit crop year the only market supply is market oriented production which is reduced because of the poor crop year. Thus, the market supply is subject to wide variation from year to year which is not a result of simply market oriented production. In light of a typical inelastic demand for basic foods, market prices move in a very abrubt manner.

The implications of these output valuations on production intentions are rather straight forward. With respect to producer response for subsistence production he knows the implicit price with certainty and reacts accordingly. With respect to producer response for market oriented production, the only thing known for certain, is that the market prices vary greatly. In formulating expected market prices the producer looks at not only the most recent price but also those over several years in

the past. This average price is usually low and is subject to wide variation. Given announced prices in cash crops which are also high, the producer response is clear. Produce the crop with stable high price rather than a crop with a usual low price and high variability. Production units in the south where this choice is present have done so.

4.2.2 Inputs and Input Valuation

The primary micro-production unit in the sahel is again the extended family. Each family has varying amounts of land, labor and capital which it allocates to its production alternatives. The land factor of production is not held by ownership but rather is an inherited use claim. Thus, no market determined land prices are available. Instead, land values must be considered in the context of their true economic value as measured by their opportunity cost in production. In this respect, two major considerations are noted. First, land available to the family, although abundant in a purely spacial context is not abundant in an economic sense. That is, land has varying qualitities determined by soil types and structure, drainage patterns, simple proximity to the dwelling and etc. These differences result in varying inherent capacities to produce crops and therefore varying implicit prices. Second, much of the land suitable to sorghum and millet production is rotated on a lengthy fallow basis. This procedure allows plant cover to grow when fallowed which in turn is burned off prior to planting therebye providing plant residues as organic fertilizers. Obviously, the productive capacity of the land is a function of its fallow duration and therefore its implicit value or price can be regarded as a function of the length of time under fallow. Thus, land being brought out of fallow early comes at a higher cost.

Labor is a crucial factor of production. Each family has a source of labor in proportion to the size of the family. (Thus a major economic incentive prevails for maximum birth rates and ready adoption of improved health technology to reduce mortality rates.) Labor is utilized primarily for planting (little or no soil preparation is done aside from burning) weeding and harvesting. Weeding is the most crucial use of labor and because of the quick response of all plant growth to moisture in the sahel, labor often becomes a constraint at this point. Therefore the

extent of labor allocated to weeding has substantial implications towards prevailing yields because of the competition between weeds and cereals for available nutrients and moisture.

The price of labor can be viewed as the opportunity cost of labor engaged in other activities including other crop production and or non-agricultural employment. In this respect it would be low because other crops are not particularly viable alternatives in much of the sahel and non-agricultural employment is only an alternative to those who are literate or to young men as unskilled labor. (This essentially is the reason for the large seasonal migration.) Thus, the best measure of the price of labor or wages is the marginal productivity of labor in cereals production.

Capital which is available to each family is both mechanical and biological. The former being simple hand tools and the latter being essentially comprised of animal manures and plant residues. Animal manures are obtained by the families own stock as well as the stock of nomads which graze field stubble. Plant residues again result from burning plant cover on lands which have been left fallow. Thus, the fallowing operation is in actuality an investment in capital but insofar as it is tied spacially to the land it is treated simplest as an element which varies land quality and therefore land values.

The price of mechanical capital is practically nil insofar as they are simple tools which are hand made. Prices for animal manures vary depending on local supply and demand condition. Again, the prices that prevail probably reflect the marginal productivity of fertilizers in production under conditions of normality. In recent years, with demands for organic fertilizers increasing and supplies decreasing both as a result of the drought, the implicit price levels of organic fertilizers have increased. This would be reflected in improved terms of trade to the nomadic herdsmen who bargain grazing patterns for grains. The price of plant residue as been discussed in land values.

4.2.3 Input Allocation and Production Functions

Input allocation decisions in actuality are made on a continual basis. However, two major points of input allocation can be described which fairly accurately provide the gist of the process. The first

point is prior to the beginning of the season when the area to be planted to alternative crops is determined. At this point land, labor and capital are all variable and an assumption on rainfall is made. The second point is after the season as progressed. Then, land and capital allocations have been fixed, labor particularly in weeding operations is still variable, and an improved perspective of the rainfall for the season is available.

At the first point, both the extensive and intensive use of the land is determined, whereas at the second point only the intensive use can be changed. (This assumes that any area planted will be harvested.) Given that the state of the arts is known, the individual production units allocate inputs on the basis of expected prices of outputs and inputs under varying rainfall assumptions using simple budgeting techniques. Budgeting is a simple approximation of equating expected marginal value products to input prices. At the first point, complete budgeting of area planted versus alternative yields is conducted for alternative cropping patterns. At the second point, partial budgeting of labor to various crops planted is conducted to obtain desired yields.

allocations to subsistence cereals

Inasmuch as cereals provide the sustenance of life to each production unit in the sahel, assume that the limited factors of production are allocated to this productive activity first.[1] As the season begins, the producer does very simple budgeting of the land available and the expected normal yields of alternative crops. With regard to subsistence cereals the amount of required output is known; let it equal P_1. To obtain this amount, the producer simply divides the output required by the expected normal yield (Y_1) and the area required for subsistence

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[1]Some arguement can be made for self-consumption production to be second to commercial production. Undoubtedly, this is true for some production units in areas where good cash crops can be grown and cereals supplies can be purchased on the market. However, for the average production unit in the Sahel, a dependence on the market place as a source of cereals grain to even augment their own production is not a viable alternative.

cereals is determined (A_1). This expected normal yield actually results from the short run production function when land is fixed.

Let the expected productivity or output/hectare of cereals be,

$$\text{Exp } Yt = f\ (Lt,\ Ct,\ \text{Nor } Wt),$$

Where: Exp Y = expected yield or output/hectare,
L = labor/hectare,
C = capital/hectare,
Nor W = normal weather and
t = crop year.

Given that the state of the arts is known by the producer, as well as the price of inputs, the implicit price of the output and the assumption of normal weather, the producer will bring into the production process the amounts of labor and capital where their expected marginal value products are equal to their price and thereby determine expected yield. It is an expected yield because weather was assumed normal. However, the producer knows to well the variation in rainfall from year to year and must guard against a shortfall. The unit does so in two manners. First, a private stock is held which has been previously discussed. Second, hedging in production is conducted and is discussed next.

Assuming the rainfall would be less than normal, the expected productivity of both labor and capital shifts to lower levels. This downward shift in the production function may or may not shift the marginal productivities in the relevant range. If not, and the price of inputs remain the same and the expected price of the output increases (expected decrease in rainfall implies a decrease in output and increased scarcity), the marginal value productivities will rise in relation to the prices of the inputs, and increased amounts of inputs per hectare would be allocated. This would result in excess capital and labor inputs to cereals production in light of normal output. However, disregarding this aspect and assuming that at least the same levels of labor and capital are used as under the assumption of normal weather, a lower yield is anticipated. That is, the same approximate inputs per hectare are allocated to production but because of expected less than average rainfall, the expected yield is reduced. Thus, when allocating the area planted to cereals in a given year, the desired total production (P_1) is divided

by a less than average productivity (Y_2) and a greater area (A_2) is planted to cereals to insure adequate auto-consumption. But this increased area (A_2) results in excess output when average rainfall occurs and normal productivity (Y_1) prevails. Thus, over the long run, as the producers hedge a bad year in a very rational manner each year by expecting less than average rainfall, an excess of inputs are allocated to subsistence cereals production. It is the output from these hedged inputs which provide the true marketed surplus in subsistence crops.

The hedge against rainfall uncertainty described above is an a priori hedge. That is, it is a conservative rational economic approach to counter the vagaries of weather before the actual crop season begins. Another such a priori counter against rainfall is the simple process of spacially separating the fields. Often times by many kilometers. This hedge has substantial implications on any efforts in land tenure reform, e.g. efforts at land consolidation. Subsistence producers also counter rainfall during the crop season.

Rainfall variation is not anything new to the cereals producer in the sahel. They have lived with it for centuries. Over this time period all the basic temporal dimensions or patterns of rainfall during the crop season have been encountered. This knowledge is handed down from generation to generation and provides the decision making producer a basis to change crop patterns within the year. Also noteworthy, is the fact that it is the elderly who make many of all the decisions. Elderly, who have had many more years of experience in countering rainfall uncertainty.[1] Given this knowledge and the variability in crop duration periods and variation in the two cereal crops themselves, adjustments in cropping patterns can be made during the season itself in the following manner.

The rainfall stems from the ITD moving in a north easterly direction over the sahel. When the rains have reached a certain level of intensity over a few days the decision to plant is made. Planting is usually accomplished in one or two days. If the rains were a false start,

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[1]Dr. Priscilla Reining on an AID contract identified this aspect of decision making in her field study.

much of the crops will die for lack of moisture after germination. At this point in time and dependent on the nature of the early rains, decisions to replant are made. The decisions relate to the replanting of shorter duration varieties or a shift from sorghum to millet. The latter has a quicker response to available moisture than the former. The extent of crop shifting and replanting depends, of course, on the severity of the first planting losses. The end result however, is variations in cropping pattern based on the current years "early" rainfall.

The variation in rainfall from year to year and its impact on output is recognized and countered by the above production hedges to insure adequate subsistence availability. However, production hedges are insufficient alone and the family production units also carry a level of stocks. These stocks are held to offset the shortfalls in production. When drawn down, they of course must be replenished by the next years production. Thus, to our earlier level of P_1, we recognize that the crop year following a short output year, P_1 will expand to include not only the desired normal auto-consumption level but also the amount required to replenish stocks. The procedure used in allocating inputs under this situation is the same as before. Budgeting is done prior to the season to determine the necessary area to be planted under alternative yeild assumption where again the implicit price of output has increased and therefore the marginal value productivities of all inputs have increased. Thus, an increase in the area planted will be made. However, the more important result is with regard to the second point in input allocation.

When a draw down on stocks has occured, the implicit price of subsistence output is undoubtedly increased and the increase is sharp because cereals are a basic necessity. As the season progresses and the rainfall pattern begins to become clear, it is imperative that the intended yields be achieved. This may mean more labor in weeding. The extent labor is allocated is according to its marginal value productivity and the price of labor. When no other competitive crops are planted, the price of labor is low and amounts to a simple trade off for leisure. An economic good that they cannot afford during this crucial period when

cereals stocks are low. When other competitive crops are planted, the price of labor can be viewed as the opportunity cost in these alternative crops which is usually quite high.[1]

Input allocations to subsistence cereals for a year following a good crop year, follows the pattern of a normal allocation. This is because any excess outputs above normal consumption requirements for the family and the level of stock demand are marketed and the returns are treated as a windfall to the family. These windfalls of course are quite low because, when subsistence production is in excess for one family, it is usually in excess for all. Therefore, the market is deluged with grain and prices are low. If successive good years occur the market becomes a less viable alternative. More grain is fed to livestock, levels of waste increase and stocks may build up. The allocation of inputs reflects the abundance. Land remains in fallow, labor in weeding is reduced, and capital (fertilizers) is switched to other crops. Again the economic rationale is simple. The implicit price of subsistence cereals is decreased therefore decreasing the marginal value productivities of all inputs in relation to their costs.

This general description of subsistence oriented production alone has several implications. First, on the average and as a result of hedging uncertain weather, the production units commit an excess of inputs to the production of cereals for their own consumption. The excess output which accrues from this hedging is the market surplus. An amount which enters the market but is not produced as a response to market prices. Second, inputs allocated to the production of subsistence cereals vary from year to year; not as a response to market prices, not as a result of changes in subsistence consumption demand but as a result of changes in stock level positions. Third, the production units have substantial latitude in allocating both land and labor in the production of cereals for subsistence.

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[1]In Upper Volta, it was observed that weeding operations were being conducted in a sorghum field while a nearby rice field was being ignored. When the producers were asked if the rice field would get any attention in weeding, their response was negative because they did not have enough time. It would be obviously lost if not weeded but the decision was clear to the producer. Get the subsistence crop properly attended to first.

In the case of the former, a decrease or increase in fallow periods is the result. In the case of labor, the latitude stems from more or less leisure and more or less output from alternative market oriented crops including cereals.

allocations to market oriented crops

Assuming that the family units total resource base of land, labor and capital is not exhausted by the production of cereals for auto -consumption, the decision of what crops to plant for the market must be made. This decision procedure is based on which alternative crops are technically feasible and also, their expected profitability. Thus, in much of the sahel, normal rainfall prohibits any commercail production except more cereals and as a result the production unit produces cereals for auto-consumption and cereals for market. However, in the southern fringes of the sahel, other crops are viable alternatives particularly groundnuts. Also, in Upper Volta which is to a large extent the more moist savannah, alternative commercial crops also include other cereals, particularly rice and maize, and cotton.

In areas of the sahel where cereals are the only feasible alternative as a marketed crop, the allocation of inputs is the same as that described for subsistence production except for two major differences. First, the price of the output is the expected producer market price not the implicit price. As discussed earlier, this expected market price is formulated on the basis of several past years not the most recent year alone. Second, there is no hedging of rainfall. Thus, the input allocation on the average more truly reflect actual marginal value productivites and costs.

In areas where alternatives to cereals exist for commercial or market oriented production, the production unit budgets the alternative expected yields in conjunction with the remaining inputs. (Actually, in these areas the qualitative differences in land are more pronounced and are reflected in their implicit value such that the production unit may have some land which is too valuable to be planted to cereals for subsistence consumption.) Expected outputs are multiplied by expected prices. Total costs in each alternative are determined and expected relative

profitability results. Insofar as expected prices are the most subject to variation, the key to the allocative procedure between crops from one year to the next is expected relative prices.

In this vein, the production of certain cash crops like peanuts and cotton in areas where technically feasible are attractive alternatives to cereals. Cereal market prices vary substantially from year to year as output varies. The excess in good years is marketed and prices are suppressed. In bad years, prices skyrocket as marketed supplies fall short. This situation in part results from the inelastic nature of domestic demand. Cash crop prices on the other hand, are announced by the government in advance of the season. Variability in prices is much reduced because the government acts as a monopoly buyer and reflects expected world prices minus costs and excess rents. Changes in world prices are reflected in changes in excess rents and not producer prices. In any event, the uncertainty in cereals prices is much greater than that of cash crops.

In may seem somewhat silly to specify market oriented cereals input allocation versus subsistence oriented cereals input allocations when both are conducted by the same producer. However, it is necessary to do so to understand that inefficiencies in the aggregate exist as a result of these differences. Production units in the northern fringe, as a result of hedging bad weather, commit an excess of labor to subsistence cereals production and place excess pressure on the fallow period. Production units in the middle range which could produce more market oriented cereals via increased labor are discouraged to do so because of low cereal prices on the average. Production units in the south, capable of producing more cereals for the market by allocating both land and labor are also discouraged because cereal market prices are low and highly variable when compared with the prices for cash crops.

4.3 Macro Sahelian Cereals Production Hypotheses

The first general objective of the inquiry was the determination of intended cereals output over the past decade. In this exercise, specific levels for each year, the extent and type of short run adjustments and the trend that prevailed were all sought. Also, it was in

this exercise that the major concerns usually expressed as possible constraints to increased cereals output were considered. Those concerns were the impact of climatic change, population growth, shifts in population (urbanization and migration) and short run supply response. These concerns and attendant specific hypotheses are dicussed later in this subsection in depth.

The successful determination of specific levels and the extent of short run adjustments in first objective allow aggregate producer intentions over the period to be compared with both actual and required output levels. This was the second general objective. Comparisons in the first instance (intentions and actual) provide further insight into the overall question of supply response particularly when augmented with available price level data. The general hypothesis addressed in this case and stated in null form is that subsistence producers do not respond to market price incentives. Comparisons in the second instance (intentions and required) provide an improved perspective of the adequacy of producer intentions. Recognizing that actual output levels have been insufficient, it is important to determine what extent, if any, the shortfalls were due to the inadequacy of producer intentions, where the inadequacy of producer intentions can result from technical, economic or institutional constraints in the production process. The general hypothesis in this case and again stated in null form is that the producers intentions were not adequate in light of required levels of output.

The third objective was the review of future output levels under various assumptions concerning adjustments to weather (uncontrollable factor). This objective was also dependent on the results obtained in the determination of aggregate producer intentions, particularly the estimation of the long run trend in aggregate intentions. Usual projections on future output levels are derived from extrapolation of a time trend on previous actual levels of output. Crucial to this procedure is the assumption that weather over the period was normal. Such an assumption is questionable in this study. Therefore, the trends in producer intentions are more appropriate insofar as they are based on weather adjusted actual output levels. Given that some evidence exists with regard to changes in weather, several alternatives estimates of output are reviewed. Also, insight with regard to the future cereals situation

is augmented when these alternative estimates are viewed in conjunction with future requirements to provide an estimate of future adequacy of production. The general null hypotheses is that future production levels will be inadequate in light of required.

Obviously, the bulk of the analysis rests on the determination of intented output levels. A more thorough review of the theoretical procedure in estimation and the specific hypotheses follows.

4.3.1 Estimating Intentions of Aggregate Cereals Output

Intended aggregate output for cereals can be described in the following aggregate production function format.

1) $\text{INTENDED OUTPUT}_{tc} = f\ (\text{LABOR}_{tc}, \text{CAPITAL}_{tc}\ \ \text{EXPECTED WEATHER}_{tc})$[1],

Where t = time frame (year or season) and

c = crop category.

Using this same format, actual output is described as,

2) $\text{ACTUAL OUTPUT}_{tc} = f\ (\text{LABOR}_{tc}, \text{CAPITAL}_{tc}, \text{WEATHER}_{tc})$[2].

If observations on labor and capital specifically devoted to cereals production were available, then estimating intended output would be simplified greatly. First, estimates of the elasticities of labor; capital and weather could be obtained via simple ordinary least squares regression. Given the elasticity estimate of weather, the actual output levels during the observation period could be adjusted to normal weather thereby providing estimates of intended output levels. Short run adjustments in intentions could be directly assessed by observing the annual

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[1]Weather is included in a crop specific manner because the spacial dimensions of the crop may be inconsistent with the spacial dimensions of weather reporting stations. A simple weighting procedure is usually applied to offset this problem.

[2]In this function it assumed that efficiency prevails. That is, given the level of inputs, they are combined in the production process in a manner such that maximum output accrues. Such an assumption in an environment of traditional production is not unlikely because the state of the arts (technology) is well known to all producers and in the situation of marginal subsistance production, little room exists for inefficient use of resources.

changes in labor and capital in conjunction with estimated elasticities. The trend in intended output would be determined by calculating, the average changes in labor and capital in conjuction with their elasticities.

More importantly, however, the inputs into the process and the extent of fluctuations could be directly observed. If labor were a constraint in increasing intentions, it would be obvious immediately with the simple calculation of the labor input. If identified as a constraint, then determining if the constraint was a technical, economic or institutional one would be facilitated by observing the limitations of the production function itself (marginal rates of substitution with other inputs) prices of labor and other information. Similarly, capital as an input could be reviewed where in this instance, the question of land fallow would be considered, as it is essentially a capital input. Unfortunately, such data is not available and requires estimates of intentions to be made in an alternative manner.

The alternative procedure uses available estimates of actual area, actual yields, a rainfall variable which was constructed by an aggregate indexing procedure, a time variable and simple logic. With this procedure, the specific levels, short run adjustments and trends in both intended area and intended yields were estimated. Insofar as

3) $\text{INTENDED OUTPUT}_{tc} = \text{INTENDED AREA}_{tc} \cdot \text{INTENDED YIELD}_{tc}$

these same estimates are specified for output. Also, the major concerns of weather impact, population growth on land pressures, population shifts on labor supply and the general supply response are addressed. The discussion of hypotheses with respect to intentions will proceed on the basis of these major concerns. First, weather impact is considered.

4.3.2 Impact of Rainfall

One variable of crucial importance in determining the actual level of aggregate cereals output for a given season is weather, particularly the rainfall aspect of weather. Variations in world climatic conditions in recent years have left some parts of the world abnormally wet and others abnormally dry. In this latter case, the areas particularly affected have been areas of the world dependent on annual monsoons for rainfall. This includes the sahel and is examplified by the recent drought. USAID as well as other national development and relief organi-

sations have attempted to make up for deficit production in the sahel with temporary food relief. Unfortunately, some meterologist suggest[1] that the drought situation in the sahel may not be a temporary or cyclical fluctuation at all, but rather represent a sustained shift in climate which may or may not have been completed. Such a position has dire consequences for the sahel and will certainly alter USAID program policies. Thus, a substantial part of the inquiry considered this crucial production variable.

Rainfall was considered in the inquiry in essentially two manners. First the variable in and of itself was considered. That is, if the climate in the sahel is changing, the temporal dimension (time trend) of rainfall should be affected. Also, changes in this temporal dimension should be different for different parts of the sahel. Second, rainfall, because of its importance in dictating actual output, was necessarily considered as an explicit variable in determining intended output levels.

hypotheses on rainfall

Not surprisingly, given the ramifications of shifts in climate, controversy does exist concerning the speculation of major climatic change around the world as presented by meteorologists such as Bryson. Much of the discussion and controversy is confusing and entails a rather thorough knowledge of meteorological phenomenom to understand. Even then, controversy exists with regard to cause and effect. In this inquiry, no effort was made to sort out the various arguements. Rather, a singular arguement (Brysons) which has been offered as an explanation for the recent drought in the sahel was opted for. Efforts were made to see if it could be refuted on statistical grounds. The arguement briefly, is as follows.

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[1]Bryson at the Institute for Environmental Studies of the University of Wisconsin is one. See Bryson "World Food Prospects and Climatic Change" testimony before joint meeting of Senate Subcommittee on Foreign Agricultural Policy and Subcommittee on Agricultural Production, Marketing and Stabilization of Prices, October 18, 1973.

Recent volcanic activity, since 1955, coupled with mans own pollution have combined in a manner such that both equator to pole and vertical temperature gradients have been changed. Insofar as temperature changes have direct implications with regard to pressure systems and therefore air movements, rainfall in various parts of the world have been affected. With respect to the sahel the arguement essentially results in a decrease with regard to the distance that ITD (inter tropical divergence) moves over the West African hinterland. As the ITD carries rain into the sahel, a reduction in its movements inland implies that less rain will fall over time for a given geographic location. Also, given that the absolute reduction over the region is equal, the relative changes in northern segments of the sahel should be greater insofar as average totals are less in the north than the south. Thus two specific hypotheses can be tested. They are stated in null form.

Ho: 1. Rainfall over the sahelian region during the past several years has not decreased in a significant manner with time.

Ho: 2. Relative changes in rainfall trends have not been significantly different between the north and south extremes of the sahel.

The exact tests of the hypotheses are discussed in section 5 and the results are reported in subsection 6.2. However, at this juncture, two points should be extended. First, the arguement as presented does not suggest that weather prior to 1955 was changing, only since then. Therefore the time series usually required by meterologists (30 years) is not available as only nineteen years have past since 1955. Including data prior to this period is illogical because the arguement does not suggest any change prior to the recent period. Second, the attempt here was to refute the arguement. The results obtained failed to do so. However, this does not suggest that it should be accepted but only that more rigourous work on this very important consideration needs to be done.

hypotheses on rainfall impact on output

As aforementioned, actual output in given years will vary from intended output largely to the extent that rainfall varies from the anticipated or expected level of rainfall. With regard to the extensive

element of aggregate output then, (actual area planted) this variation is rainfall from expected levels usually has no bearing on intentions. That is,

4) $\text{INTENDED AREA}_{tc} = \text{ACTUAL AREA}_{tc}$.

Returning briefly to the discussion of input allocation by micro-producers, the intended output/hectare was determined and land in turn allocated to the extent necessary to obtain the desired output levels. Changes in rainfall over the entire season thus have no impact on the area planted to the crop.[1]

However, it was suggested that intentions on the area planted to sorghum and millets could be changed by early rainfall patterns. Simple replanting and crop shifting both occur and may well net out in the aggregate as a shift in intentions during the season on the extensive element of output as a result of changes in anticipated rainfall. A poor early rainfall implies a poor rainfall for the season which affects productivity expectations which in turn affect area planted. Such a situation results in the following hypotheses to be tested.

Ho: 3. Early rainfall is not a significant explanatory variable of changes in the actual area under sorghums and millets.

The major impact of rainfall during the season of course is with regard to productivity for the year. Actual productivity will vary from intentions to the extent actual rainfall varies from expected rainfall, again assuming efficient production. While this is generally accepted it also must be tested. Thus, the null hypotheses is:

Ho: 4. Total rainfall is not a significant explanatory variable describing changes in actual productivity in sorghums and millet.

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[1]This had led many economists to use actual area planted as a proxy variable for intended output. This procedure requires that the assumption of constant productivity intentions be made over the period observation. Such an assumption can not be made for the sahel and the procedure accordingly dismissed.

Actually, proving this is not as important as the estimate of the extent changes in rainfall affect the changes in aggregate productivity. This estimate will be provided by the elasticity coefficient. Thus, in making projections of future actual output, the variablility limits from intended future outputs can be placed in an improved perspective.

4.3.3 Impact of Population Growth and Shifts.

Much controversy exists with regard to the true populations and the rates of growth in both Upper Volta and Niger. However, in general two facts are difficult to deny. First, the populations have doubled in the past 35 years and second they are increasing at a rate such that they will double again in about 30 years. A 1937 census of Niger which roughly corresponds to present day bountries, placed the total population at about 1.8 million. The 1970 population is about 4.0 million or more than twice that of the 1937 census. It follows then, that agricultural pressures for cereals production have doubled since the early forties.

These pressures, assuming no increase per capita consumption but simply maintaining a level, would result in a long run growth rate in intended output consistent with the population rate of growth. For the sake of arguement, assume a population growth rate of about 2.5 percent. Going back to the aggregate production function where aggregate output is equal to aggregate inputs of labor and capital, if the population is increasing at 2.5 percent then aggregate labor should be increasing at a rate of about 2.5 percent.[1] Capital on the other hand, does not necessarily have to be increasing at this rate. In the case of simple capital in the form of tools, where the capital is embodied labor, a rate of growth consistent with the population is achievable. Capital in the form of organic fertilizers is also quite achievable if one assumes the man/livestock ratios were constant. In fact, given that the tendency for large numbers of livestock to be a capital investment (as well as a sign of wealth) this capital input may have increased in excess of the population rate. However, the capital as represented by fallow does not necessarily too have been increasing at a sufficient rate.

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[1]This ignores the aggregate tendency of the populations average age to decrease which means a slight reduction in labor potential.

The fallowing procedure used in the sahel varies substantially in duration. However, an average at least in theory, can be said to exist. If the land pressures increase and the average length of fallow period decreases, then this results in a reduction in capital over the long run. To make up for this capital reduction, increased rates of organic fertilizers or increased labor would be necessarily allocated if the long run trend were to be maintained in output. Unfortunately, measures of fallow period, organic fertilizers and labor are not available. Thus, these situations cannot be addressed directly. They can be addressed indirectly, however.

If both labor and capital inputs were increasing at sufficient rates, then the relative factor prices would be constant over the long run. Therefore, with technology constant and assuming constant returns to scale, any increases in output would result from increases in the area planted. That is, in terms of micro-production units, the numbers would increase but the traditional production process would continue as before with a constant output per hectare over the long run. To test this situation the following hypotheses were extended.

Ho: 5. The trend in the area planted as adjusted by any short run variables affecting intentions during the period of observation is not equal to the population growth rate.

Ho: 6. The trend in the annual productivity or yield as adjusted by rainfall and any other short run variables affecting yield is not equal to zero.

Ho: 7. The estimated trend of output as a product of trend estimates of area and yield is not equal to the rate of population increase.

Insofar as the observation period was only about a decade, the use of adjusted trends is imperative. This is most clearly examplified with respect to the rainfall impact over the period. If rainfall was decreasing on the average in a sustained manner, than the simple unadjusted yield trend would include this negative aspect and attribute it to decreases in intentions. This same arguement carries for other short run adjustments in intentions and they too must be accounted for in the

estimation procedure. However, before these short run considerations are discussed, a final consideration of population needs to be covered. That consideration is the situation of sustained changes in the population structure.

The labor input into the production cereals stems from labor available in the rural sedentary sector. While this segment makes up the majority of the entire population in both countries, substantial outmigration is occuring. Both countries are exhibiting rapid rates of urbanization as well as substantial sustained migrations to other countries. the net result is that labor is being transferred out of the rural sedentary sector in a sustained manner. As such, the trend estimate of intended production may well be less than the growth rate of the entire population and still be an equilibrium trend rate. This is, because of the preponderance of subsistence production where allocations are made on the basis of the size of the extended families and the growth rate of this segment would be less than the average for the population as a whole. This aspect can be tested (although not conclusively) by the actual magnitude of the trends.

4.3.4 Short Run Supply Response

Aggregate cereals production intentions in the sahel like elsewhere, change as a result of changes in expected relative factor product price ratios. In the aggregate, these will almost entirely result from changes in the implicit price of cereals as a result of supply conditions facing the subsistence sector. When a particular years output decreases because of poor rainfall the implicit price increases. This increase in the implicit price increases the marginal value productivities of both labor and capital inputs into cereals production. With respect to labor this means less leisure in an economic sense, labor is bid away from alternative crops and finally labor which may be temporarily working out of the country, returns. With respect to capital, it means more organic fertilizer is allocated to cereals and more land (decrease in fallow or land allocated to other crops) is planted to cereals.

Other stimuli could change these ratios but the impact would be little in the aggregate unless marked shifts occured. Market prices for cereals fluctuate greatly, however unlike the implicit price of

cereals which is tied to known supply and demand conditions of the family unit, it is uncertain. Thus, expectations are slow to change in terms of abrubtly moving the aggregate. Also, by sheer proportions, this stimulus is reduced in the aggregate. Changes in announced producer prices for alternative cash crops as well as other market determined alternatives also have short run consequences on adjustments of intentions of cereals. However, the former have been slow to move and are limited in a spacial sense to only the southern extremes of the sahel. Again sheer proportions would also reduce any impact. On the input price side, few major movements are noted aside from those mentioned above which result from the abrubt shift in the implicit price. Two which may have been present, include an increase in the price of organic fertilizers as a result of large scale reductions in cattle numbers from the drought and an increase in the opportunity cost of young people who are willing to migrate. However, the former had not occured during the period of observation to a major extent and the latter is only speculation at this point.

In the context of assessing this impact on short run adjustments in intentions, two hypotheses are formed. The first is the supply response in terms of the area planted to a change in the implicit price of cereals. Unfortunately, the implicit price of cereals is not an easily quantified variable. Therefore a proxy was used. The proxy used was lagged rainfall. Rainfall, largely determines the extent actual output varies from intentions. Thus, it is a reasonable proxy for the shortfall or excess that exists in the total supply and demand situation facing the subsistence sector and therefore the implicit price level. The hypothesis used was,

Ho: 8. lagged rainfall is not significant explanatory variable in explaining changes in the area planted to cereals.

Recognizing the limitations this presents in interpretation of results, its inclusion does allow a rough measure of aggregate response to be made. Also it adjusts the data to more fully bring out the correct trend.

The second hypothesis formed was that when a marked increase in the area planted occurred, increases in labor and capital were also allocated on a per hectare basis. This would result in increased productivity. Again recognizing the problems of obtaining any measurements on

these exact increases a simple dummy variable was used, where the 0 to 1 value was ascribed to what appeared as a swing area of cereals being in or out of production. The actual hypothesis was,

Ho: 9. A dummy variable (0 or 1) determined by the fact that the swing area is in or out of production in a particular year has no impact on explaining changes in productivity over the period.

Such a position (increase area and increase yields) requires further explanation.

An increase in area to cereals may result in both decreases in labor/hectare and capital/hectare. In the former case one must assume total labor is fixed and fully utilized to its potential. In the latter case, organic fertilizers are fixed, and none is shifted between crops and that the fallow comes in and reduces the average capital level. (Land out of fallow early has had less time for natural capital build up in the form of vegetation growth.) While the arguement for fallow appears valid the others do not, and actual increases in labor/hectare alone can be expected to swamp the decrease in capital as a result of increased intensity on fallow.

The situation of temporary migrations to work in the coastal areas presents a major shift in the labor input in cereals production. This movement of labor over a given period simply reflects opportunity costs in agricultural production and therefore rather than having a sustained impact may well be more of a short term adjustment. When ample cereals are available and implicit prices low, employment on the coast represents a net improvement. The younger members of the family can work and obtain money and are not particularly needed at home. However, when implicit cereal prices are high as a result of shortfalls, this labor input is required if the family is to survive. Labor is required for clearing fallow as well as the crucial weeding operations. When implicit prices return to normal levels the opportunity costs again favor migration to the coast. In terms, of area planted and productivity levels one might expect large abrubt movements from one year to the next. Simple observations of the data on area planted bear this out in terms of a large swing area in cereals. Insofar as when the area is increased substantially this increased labor is also available for weeding, it follows

that productivity should be greater during that year. When the swing area is not in cereals production, this labor is out of the country and not available.

5 DATA AND ANALYTICAL PROCEDURE

5.1 Data

The data requirements for the aggregate cereals production inquiry were minimal. First, valid time series data on the aggregate area planted and aggregate productivity for both sorghum and millets for each of the countries had to be available. Second, time series data on rainfall throughout the countries had to be available. While both countries proved to have ample rainfall data, only Niger possessed sufficiently valid aggregate area and yield data for sorghum and millets.

5.1.1 Area and Yield Data

Aggregate production time series statistics for subsistence agricultural crops in many developing nations are of poor quality. However, rather then dwelling on the negative aspects of data and reasons why the problem exists in many developing regions, an effort is made here to describe what the minimum quality needs to be for the analysis that was conducted. First, the aggregate data must stem from a fairly homogeneous production environment. It makes little sense to aggregate crops grown under wide extremes with regard to weather in this type analysis. Second, the aggregate time series had to be available. Lastly, the data available however estimated, needed to be consistent. If a bias is present it had to be a consistent bias.

In Niger, cereals are grown in areas with a range in average rainfall of about 300 m.m. to 900m.m. This is substantial, however aside from the very southern extreme no other crops are really competitive. In Upper Volta, the rainfall range is about 400 m.m. in some areas and over 1200 m.m. in others. The rainfall gradient is steeper and a greater part of the country has areas where other cereals as well as cash crops are grown. Thus, the simple aggregation of data in Upper Volta includes more diversity in rainfall than in Niger. Also, the logical explanations of various results in the analysis are complicated because of increased crop shifting. (This is much less a problem in Niger because only one crop is likely shifted and even then limited to a small area of the country.)

In Niger, aggregate time series were available for each year for the period 1960-1971. In Upper Volta, estimates were available for each year for the period 1956-1970 except for 1969.[1] In fact, for some years, multiple estimates exist which obviously resulted from the changes being made in collection and control of statistics in Upper Volta. As such, the data for Upper Volta failed the minimum quality criterion for not only not having 1969 data available but being inconsistent as well. In Niger, a definite bias was identified but it was found to be consistent. Due to these difference in data quality, only Niger was selected to apply the tests of hypotheses. This does not mean Upper Volta production of cereals was ignored in the analysis but only that the regression techniques used on Niger data require more confidence in data than can be placed in those for Upper Volta. (Again, Upper Volta ORD or cercle level time series data would probably be more than adequate and also make more sense because of the decrease in the heterogenity represented.)

An added note is perhaps required with regard to the aggregate data available for Niger that was used. First, a bias was identified to exist in cereals production data. That bias was a 20.88 percent overestimate of the area planted to sorghum and millets and was estimated by SEDES in 1960. A bias this large may be sufficient enough to compel some researchers to discard the data entirely. In response to this position, the following justification is extended.

Aggregate data on area and yield of cereals crops is obtained by successively aggregating area and output estimates through political subdivisions. Original estimates are made by very simple observations and guesses by village chiefs or other very local level officials. Because of the obvious lack of sophistication in their estimation procedure, the absolute values tend to be biased. For some unknown reason, this bias is quite high in Niger. However, these people live in these areas all their lives and are very much aware of changes from one year to

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[1]While the 1969 data may be available after a substantial effort is made, it is not readily available as were other years. Insofar as an apparent change in collection and control of agricultural statistics was being done in and around 1969, it was felt that efforts to secure the data were not warranted.

to the next. Thus, the bias is likely to be consistent over the years as nothing has essentially changed in the collection and compilation of these estimates.[1]

The actual data for sorghum and millets used can be reviewed in Appendix Tables 1 and 4 for Niger and Upper Volta respectively. These data were converted to indices for the sake of ease in analysis. These indices in the same order of country are found in Appendix Tables 2 and 5.

5.1.2 Rainfall Data

The rainfall data available in both Niger and Upper Volta was abundant.[2] Currently in Niger there are 64 rainfall reporting stations. In Upper Volta, there are 200. The stations are operated under the auspices of various groups and the quality of data varies somewhat. Quality in context of periodic omissions which render the station unsatisfactory in providing time series data. Thus, because of data limitations some stations could not be used. The number of stations was further reduced because of inadequate time in operation. That is, some stations are to new to provide the necessary data in earlier years. As a result of these considerations and limitations, in Niger 33 stations were available and in Upper Volta 55. With regard to Niger, these stations provided monthly rainfall data for a 13 year period 1960-72 and for Upper Volta monthly data for 17 years, 1956-72 was used. The listing of stations are found in Appendix Table 7 for Niger and Appendix Table 8 for Upper Volta.

The desired indices series for rainfall included both series for sub-national political units as well as for the countries. For the former, the unit was the department in Niger and the ORDs in Upper Volta.

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[1] In the Warren report entitled "A Millet and Sorghum Crop Estimation Program for Niger and Upper Volta", it was mentioned that sample surveys began in Niger in 1967. These include both area estimates and crop cutting surveys. However, this author's review indicates that the official government statistics do not reflect these estimates. They are however offered in the official annual report on agriculture.

[2] Special thanks are due to Monsieur Diallo and Monsieur Ouedrago of the Service Meteorologique in Niger and Upper Volta respectively, for their assistance in providing the original rainfall data.

Simple averaging of monthly data by station in the sub-political units was done to construct the index series where the base in each sub-political unit was the mean over the time frame. To get the rain indices for each country, each sub-unit was weighted by its proportion of cereals crops planted. In the case of Niger, this was the average of both 1970 and 1971 area planted data and for Upper Volta it was only 1970 data as 1971 data was not available on production.

The rainfall which was required was only for the months April through October. This period would insure both early and late seasonal rainfall patterns for a particular year to be included. For Niger, the Apr/Oct rainfall indices by department and for Niger as a whole are given in Appendix Table 9. Also, for Niger the Apr/July early rainfall index was calculated. It however is only offered for Niger and is found in Appendix Table 10. For Upper Volta, both ORDs and the all Upper Volta index series are presented in Appendix Table 11. Only total seasonal rainfall indices are given. (A computor program was set up to calculate these indices and the early rain indices and a printout of it can be reviewed on request to the author.)

5.2 Analytical Procedure

The analytical procedure used can be essentially divided into four separate steps. First simple analysis of actual cereals output, area and yield at the national level for both Niger and Upper Volta was carried out. Second, analysis of the rainfall dimensions within each country as well as for each country as a whole was conducted. Third, two alternative models for each aggregate cereals area and aggregate cereals yield were applied for Niger to test the various hypotheses as presented in 4.3. Lastly, forecasting both historical intentions as well as likely future intentions and actual output levels were done. The actual analytical procedures and models used in each of the steps follow.

5.2.1 Review of Actual Production

A simple review of the actual output, area and yield fluctuations and average trends of sorghum and millet and the two combined as cereals

for each country provides an excellent departure for more rigorous analysis. Also included for Niger is an attempt to determine the extent variation in total cereals output stems from sorghum versus millets and what extent variation in total cereals area stemmed from changes in sorghum area versus millet area over the period. The results from this simple analysis for both countries, is presented in 6.1.

Techniques used include simple plots for visual examination, coefficients of variation to measure relative fluctuations from year to year as well as the standard error of the estimate when it appeared time was a significant factor in affecting fluctuations. Annual fluctuations in the case of Upper Volta were measured by simple relative changes. Average trends in actual production data for Niger were measured using a simple semi-log linear model which provided a compounded trend and a test of significance on the trend parameter. Insofar as some of the annual data in Upper Volta was suspect a selection of two periods with the application of the compounding formula provided estimates of average trends. Again, because of the data limitations for Upper Volta, no further analytical inquiry into production data were made.

5.2.2 Analysis of Rainfall

The two major concerns with regard to rainfall were that the average levels were decreasing over time and that this decrease was relatively greater in the northern part of the sahel. To test the hypotheses (stated in null form) time parameters had to be estimated. Estimations of time parameters were made using the semi-log linear model. (Model itself presented with results.) The model was applied to each of the country indices as a whole and for the individual ORDs in the case of Upper Volta. In Niger, simple plots only of departmental indices are offered. Implications with regard to the first hypothesis stems from the estimated trends for the countries as a whole. Implications with regard to the second hypothesis can be obtained by contrasting the time trends for individual ORDs which lie on a vertical cut across Upper Volta from north to south.

The analysis of rainfall also provided estimates of the magnitude of normal annual fluctuations as measured by both coefficients of variation and standard errors of estimates. The severity of the recent drought

is also plainly depicted. In the case of Upper Volta, a partitioning of the country into rainfall regions was also conducted. The basis of the partioning was simple correlations. All the results of the rainfall analysis are presented in 6.2.

5.2.3 Area and Yield Analytical Procedure -- Niger

Two general models were used with respect to the analysis of the area planted to cereals. They were:

Model 1. AREA = f (LAGGED RAINFALL, EARLY RAINFALL, TIME)

Model 2. AREA = f (LAGGED RAINFALL, TIME).

As such, two different points of intentions with respect to the area planted are formulated. In Model 1, the intentions refer to those after the season has progressed through the early rainfall period (through July.) Poor early rains hint that seasonal rains will be poor and productivity down. If increased adjustments in plantings can be made then the area planted will increase in expectation of lower yields. Model 2 refers to intentions a priori of the season. Aside from this difference, the assumptions underlying the two models are the same. Those assumptions are again briefly reviewed.

The area planted to cereals varies from year to year in response to changes in current supplies and increase over time to meet the steadily increasing demand. Lagged rainfall is a proxy variable to reflect changes in cereals supplies available for consumption. A poor rainfall in the previous season means privately held stocks were drawn down to maintain subsistence consumption. Also, a poor rainfall means total marketed supplies were short and prices increase. Both imply an increase in intended production to replenish stocks and capture the higher prices in the commercial sector. The time variable is included and will provide an estimate of the long run growth rate in the area planted after adjusting to variations stemming from response to short run shortages.

The actual functional forms of the models were:

Model 1. $AR_t = A\ RN_{t-1}^{b1}\ EA\ RN_t^{b2}\ T_t^{b3}$,

Where: AR = area planted to cereals,

A = intercept value,

RN = index value of rainfall in Niger (April-Oct.),

EA RN = index value of early rainfall in Niger (April-July),

T = time value 1-11,

t = year, 1961-71 and

b1, b2, b3 = are the elasticity estimates for lagged rainfall, early rainfall and time; and

Model 2. $AR_t = A\ RN_{t-1}^{b1}\ T_t^{b2}$,

Where script notation is the same as above except b2 = elasticity estimate of time.

The actual estimated equations were the log linear counterparts of these equations where the regression coefficients on the independent variables are the estimates of elasticities. The values of the dependent variable area were the index values calculated from official government data and are available in Appendix Table 2. The values for the independent variables of rainfall stemmed from the all Niger weighted rain index series which were constructed from thirty three rainfall stations located throughout the country. These series are given in Appendix Tables 9 and 10. The models were each applied to sorghum and millet separately and also combined as a singular cereals category.

With these models, the various hypotheses concerning the area planted to cereals can be tested. In the case of Ho: 3, the level of significance of the early rainfall variable can be measured. If the simple to value on the b2 parameter of Model 1 is low, then early rainfall must be discarded as a significant explanatory variable in characterizing the area intentions. Similarily, if the b1 parameter has an insignificant t value, the hypothesis, Ho: 8, of short run area adjustments to changes in implicit and explicit prices is in question. (Assuming lagged rainfall is a reasonable proxy.) Assuming that there is a short run response and lagged rainfall reflects this tendency, then the simple time parameter (b3 in Model 1 and b1 in Model 2) should more accurately reflect the trend in the area planted. The estimated trend values can then be reviewed in context of Ho: 5 where the trend in area planted is hypothesed to be not equal to the population growth rate. Also, the position of net migrations reducing available long run labor in cereals production is supported if the time parameter estimated is significant and approximates a value similar to what might be expected in terms of the actual growth rate of the rural sedentary sector.

In the examination of cereal yield in Niger, two separate models were also used. They were:

Model 3. YIELD = f (RAINFALL, SWING AREA, TIME) and

Model 4. YIELD = f (RAINFALL, TIME).

The differences of the models result only from the inclusion of the hypothesis on the swing area. Again, the assumptions used in formulating the models were as follow.

Actual average productivity in a given year essentially stems from the intended level of productivity plus or minus the impact of weather as measured by rainfall. Intended productivity, will vary from year to year and overtime as product prices (explicit and implicit) and factor prices vary. If the relative factor price ratios change with respect to land and lobor and land and capital, then intended levels of labor per hectare and capital per hectare will change and in turn change intended productivity. These changes, may occur abrubtly as a one factor becomes a technical constraint or they may occur slowly over time or both. In the case of Model 3, the assumption is that when the swing area is in production, further increases in land area are costly and relative factor prices favor increasing labor and capital per hectare to achieve intended production levels. When the swing area is out of production the reverse happens. Over the long run, any changes in inputs per hectare will show up as a trend. In Model 4, only long run changes in inputs per hectares are hypothesized. That is, short run adjustments in inputs per hectare are unlikely and intended productivity in the short run is constant.

In the case of Model 3, the actual functional form was:

(3) $YLD_t = A\ RN_t^{b1}\ b2^{SA}\ T^{b3}$,

Where: YLD = productivity of cereals or specific cereal crop,

A = intercept value,

RN = total seasonal rainfall,

SA = dummy variable equal to 0 or 1 and denoting if swing area was in production or out,

T = time value (1-12),

t = year (1960-71),

b1 = estimated rainfall elasticity,

b2 = estimated value denoting change in intercept value, and

b3 = estimated elasticity of time.

In Model 4, the functional form was:

(4) $YLD_t = A\ RN_t^{b1}\ T^{b2}$, and

Where all notations has the same meaning as above except, b2 = estimated elasiticity of time.

Again, the actual estimated equation were the log linear forms of these equations where the estimated regression coefficients are the estimates of the elasticities. The values of the dependent, yield variable were the sorghum, millet and combined sorghum and millet index values calculated from official government sources. These can be found in Appendix Table 2. The values of the rain variable stemmed from the all Niger weighted index series; see Appendix Table 9. The determination of the swing area value 0 or 1 was by visual examination of the plotted data of actual area planted from Table 6.1. In the case of both combined cereals and millet, the swing area was in during the years 1960, 62-63 and 69-71 and out the remaining six years of the observation period. For sorghum, the swing area was in all years except for three. Those years when the swing area was out were, 1964-65 and 1971. Each model was applied to each crop separately as well as combined.

The hypotheses with regard to rainfall impact on determining yields (Ho: 4) is easily tested as a result of the t value for b1. More importantly however, is the estimated value of b1 because it represents the elasticity of rainfall on yield. This estimate together with the normal variation estimate of rainfall provides an indication of the degree yield can be expected to vary as a result of normal variation in rainfall. This in turn provides a rough approximation to the size of the normal privately held stocks required to maintain average consumption levels over the years for the subsistence sector. The level of significance of b2 in Model 3 provides a test for Ho: 9. If found to be of the correct sign and significant, then the sahelian producers can adjust intended yields in the short run. Given the nature of capital constraints, shifts of organic fertilizers and fallow in the short run, this short run

adjustment capacity most likely stems from increased labor/hectare during weeding. Finally, the long run nature of yield adjustments can be tested (Ho: 6). If when adjusted to rainfall the trend is negative, support for a position of decreases in output due to increased land intensity is supported.

5.2.4 Forecasting Procedures and Comparisons

The forecasting procedure included two types. First, historical forecasts were made with regard to past levels of intended output over the period 1960-1971. These levels were then used in comparison with past actual and required levels. Second, future levels of intended output were forecasted and compared with future requirements. Also, estimates of likely variation around intentions were also done. The manner in which these estimates were made is now discussed.

Actual area as aforementioned is equal to intended area. Actual yields however vary overtime from intended yields as a result of rainfall variation. Intended yields are also hypothesized to vary as a result changes in relative factor price ratios. With the results obtained in the previously described analysis these changes in intended yields can be roughly approximated for each year. Thus, the estimated intended yield for a given year would be equal to the rain adjusted average yield over the period which is further adjusted by the impact of the swing area variable and the time value. If the swing area was found to be not significant then the value in a particular year would be the rain adjusted mean yield plus or minus the impact of the trend. If the trend was not significant and the swing area was then the rain adjusted mean would be affected only by the swing area impact. If neither were found to be significant, then the rain adjusted mean would be the intended yield throughout the period (constant yield). In any event, the level of intended output for each year was the product of the two for each year.

Comparing these estimates of intended output with actual levels and required levels then provided the means to fulfill the second general objective. Also, when market prices are used to supplement the analysis the nature of producer response to explicit prices is clarified.

Projecting the future level of output was also dependent on the previously described analysis in 5.3.3. The usual manner in which

projections are made is via the extrapolation of simple trends where the assumption that weather over the period was normal. The period here was not of sifficient duration and weather cannot be assumed as normal. Thus, the rain adjusted trend in yield and the short run adjusted trend in area were crucial to making projections. Given the trend in intended output as adjusted, future levels of output were presented. Likely variations in actual output levels as a result of rainfall variations were also presented. These were then compared to a simple projection of requirements based on population growth rates through the next decade.

6 PRODUCTION RESULTS AND IMPLICATIONS

6.1 Past Actual Cereals Production -- Trends and Fluctuations

This first subsection, provides a simple overview of the actual production of cereals in Niger and Upper Volta during the previous decade. The overview is simply descriptive in nature and attempts to place the elements of actual area planted and the resulting yields into perspective with actual cereals output. Simple descriptive techniques were utilized including visual examination of plotted data, percentages at the means, average compounded trends, and coefficients of variation. In the case of Niger, the data base was satisfactory to apply the semi -log linear compound regression equation to estimate the average compounded trend and the regression application of proportioning the variation in a statistical identity to estimate variation aspects of production. In both countries, sorghum and millet were reviewed individually as well as collectively as cereals.

6.1.1 Niger -- Past Cereals Production

The estimated average compounded trends in actual sorghum, millet and combined sorghum and millet output in Niger over the period 1960-71 were -.82 percent, +1.36 percent and .85 percent, respectively. Insofar as millet comprised 76 percent (calculated on the mean) of the total cereals production, its positive trend offset the negative trend in sorghum output and a small positive combined trend in cereals resulted. However, in estimating these trends, a semi-log linear regression was used and allowed a test of significance on the time parameter (trend). In all three instances, the time parameter was found to be not significantly different from zero. Thus, it can be stated that over the twelve year period in Niger there has been no sustained growth in actual cereals output.

The annual fluctuations is the level of sorghum and millet output from year to year have been substantial. Between the years 1967 and 1968, sorghum production dropped 37 percent and millet 27 percent. This was the maximum annual change over the period. The minimum annual fluctuations in both cereals were between four and five percent. Given

that the time parameter was not significant in either case, the coefficient of variation (standard deviation as a percent of the mean output over the period) can be utilized as a measure of fluctuation over the period. In the case of sorghum the coefficient of variation was approximately 16 percent while millet was slightly less at 13.6 percent. This measure suggests that two years out of three, the level of output during the period varied in the range of plus or minus the value of the coefficient of variation. For example, in the case of sorghum, the level of output varied within the range of a plus 16 percent or a minus 16 percent of the mean output over the period two years in three. One year in three, the level of output was either greater than 16 percent or less than 16 percent. The point is, that these levels of annual fluctuations are quite high.

Combining the two cereals into one category decreases the value of the coefficient of variation slightly. The combined cereals value was 13.4 percent. Thus, it seems that a change in sorghum output did not particularly offset a change in millet production. To better measure this aspect of the combined cereals output fluctuation, the technique of proportioning the variation in a statistical identity was used. Here, the variation in total cereals singularly caused by sorghum output fluctuations was 8.2 percent. For millets singularly, it was 59.9 per cent and together the two cereals accounted for 31.9 percent. Splitting the interaction proportion evenly between the two, results in sorghum accounting for 24.2 percent of the variation in the combined cereals output levels and millet 75.8 percent. These proportions are approximately equal to the relative proportions of the two in making up the total. On the average over the period, sorghum output was 24 percent to the total output and millet the remaining 76 percent. This strongly suggests that similar factors affect both levels of output and very little is lost by combining the two into a single cereals category in the analysis. The evidence also permits the following generalization. Annual cereals output levels in Niger have been subject to large fluctuations with no sustained growth over the twelve year period.

The output levels of cereals of course result from the area planted to the crop and the resulting average productivity that prevailed during the particular year. In this context, it is necessary that an

overview of the past actual area planted and the actual average yields that prevailed be made. The description of the past actual area planted is next and is followed by an overview of average productivity.

past actual area

The indices of the official area planted to sorghum, millet and combined sorghum and millet are plotted in Figure 6.1. Also, included are the estimated average compounded trends over the period. The sorghum area planted increased over the period at a rate of 3.02 percent per year. The millet trend was slightly less at 2.96 percent and when the two are combined the trend rate was 2.98 percent. These trends were again estimated by the semi-log linear regression technique and in this instance all three time parameters were highly significant (.01 level). Thus, it can be stated that area planted to cereals in Niger over the twelve year period increased at a sustained rate of about 3 percent annually.

From Figure 6.1, the fluctuations in the area planted around the trend can be seen. The year to year variation in sorghum appears to be quite small except for a 6.5 percent drop in 1964 and an abrubt 17.4 percent increase in 1966. Thus, the period for sorghum area planted can be described as a rather steady period in plantings with a sustained annual increase except the two years in 1964 and 1965 when about 8 per cent (percentage from the average trend) of the area was shifted out of sorghum production.

The millet area fluctuations were also quite small but slightly larger than those in sorghum. The years 1962 and 1969 represented substantial increases in area planted from the previous years but not the trend area. Those shifts were 12.5 percent and 19.9 percent in order. Three years registered small 3-5 percent decreases from previous years, they were 1961, 1964 and 1966. In general, the millet area planted seems to have been characterized by two plateaus of area planted which represents a certain proportion of the land area being shifted in and out of millets. Averaging the areas in (60, 62, 63 and 69-71) and the areas out (61, 64-68) and calculating the relative difference, results in an area being shifted of approximately 15 percent. (Simple averaging is permissable insofar as equal areas in and out layed on each side of the mean time point of the period.)

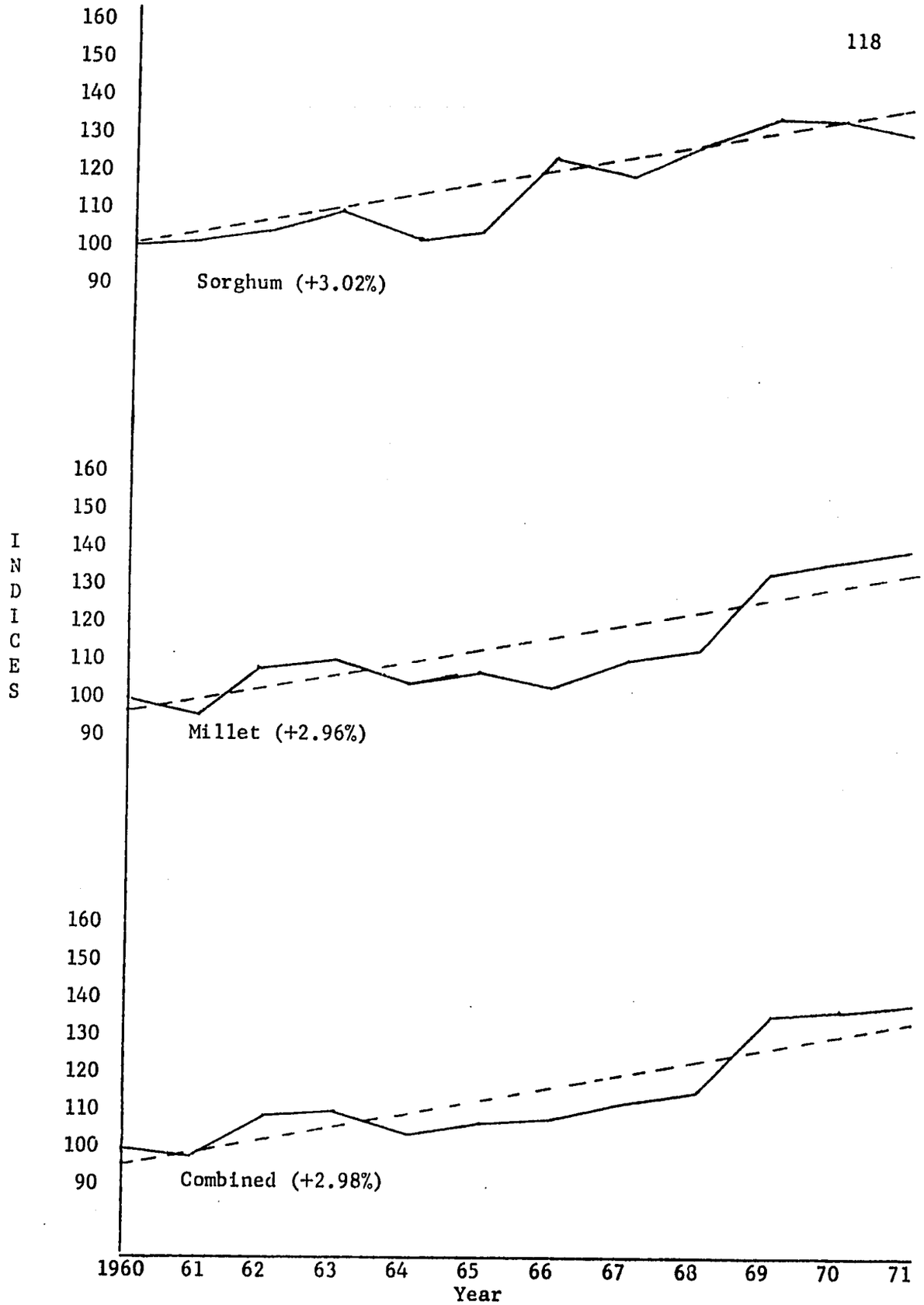

Figure 6.1 Niger - Indices of Annual Cropped Area and Estimated Trends for Sorghum, Millets and Combined Sorghum and Millet. (base year-1960)

Combining the two into the cereals category indicates that some of the changes in sorghum area were offset by changes in millet area. That is, some shifting between the two occured. This can be noted by observing the tendency of the total cereals area planted to flatten out during the period 1964-68. This period for both sorghum and millet individually was characterized by both small and abrubt shifts however when the two are combined the period is characterized by a constant steady increase. Using the technique of proportioning variation again tends to substantiate this. Here it was found that the variation in total cereals area was accounted for by 4.0 percent variation in just sorghum changes, 68.7 percent in millet and 27.3 percent in the interaction of sorghum and millet area changes. While the positive interaction means that over the entire period, the net impact of factors affecting changes in area affected sorghum and millet similarly, the relative impact was different. That is when the interaction variation is split evenly, sorghum variation accounted for 17.7 percent of the total while millet accounted for the remaining 82.4 percent. However, the relative percentages in making up the total area planted on the mean were 21 percent and 79 percent for sorghum and millet respectively. Thus, sorghum variation accounted for a smaller proportion of the variation in total cereals than one would expect. This results from the switching of sorghum to millet and vice versa.

The most important result indicated in Figure 6.1 is the two levels of area planted to cereals over the period. The year 1961 and the five year period 1964-68 represent the years when a substantial area of crop land was shifted out of cereals production. The remaining years represent years of production when the "swing area" was in cereals production. Using the actual estimates of the cereals area planted and the deflating coefficient, the magnitude of this swing area was estimated. The estimate was 243,250 hectares. (Using official undeflated data the area would be about 294 thousand hectares.) If one assumes the mean over the period is the normal area planted, then this swing area amounts to a relative shifting capacity of about 12 percent of the normal area. Application of this swing area estimate to the later years of the period, provides some interesting insights.

In 1969 the area planted to cereals increased about 17 percent or roughly 343,729 hectares when deflated. This substantial increase in area obviously was the result of the severe shortfall in 1968 cereal production. A quick perusal of the changes in the area planted to other crops reported by the Niger government indicate that substantial absolute decreases in the area planted from 1968 to 1969 were registered in only one crop; groundnuts. In 1969, the area planted dropped by about 112 thousand hectares. Undoubtedly, this area was shifted into cereals production. However, approximately 230 thousand hectares are yet unaccounted for by any major decrease in other reported cropped area. This amount is about the same area as the swing estimate of 243,250 hectares. This suggests that the 1969 increase in cereals area stemmed from both crop shifting and decreases in fallow where the former accounted for one third of the increase and the latter, two thirds.

In the two years since 1969 where estimates of area planted are available, this increased intensity on using fallow land has remained. The slight leveling off of the cereals area planted can be attributed to the crop pattern shifting back to groundnuts. In both 1970 and 1971, the areas planted to groundnuts increased about 37 thousand hectares. However, while the increased intensity on fallow land has continued at the higher level it has not increased particularly. This suggest that labor begins to be a constraint, inasmuch as the incentive for more production certainly continues in light of the shortfalls in production during this period.

past actual yields

The indices of the official productivity or average annual yields of sorghum, millet and combined sorghum and millet for Niger for the twelve year period are plotted in Figure 6.2. The estimated average trends during the period are also plotted. In both cereal crops, the average trends were negative. For sorghum the trend over the period was a large negative of 3.73 percent annual. Millet was less but still an unsatisfactory 1.56 percent annual decrease. Combined, the two registered about a two percent annual decrease. Unfortunately, the time parameter was significant in the case of sorghum (.05 level), it was not significant for millets. When combined into cereals, the time parameter was significant but at a lessor level of confidence (.10).

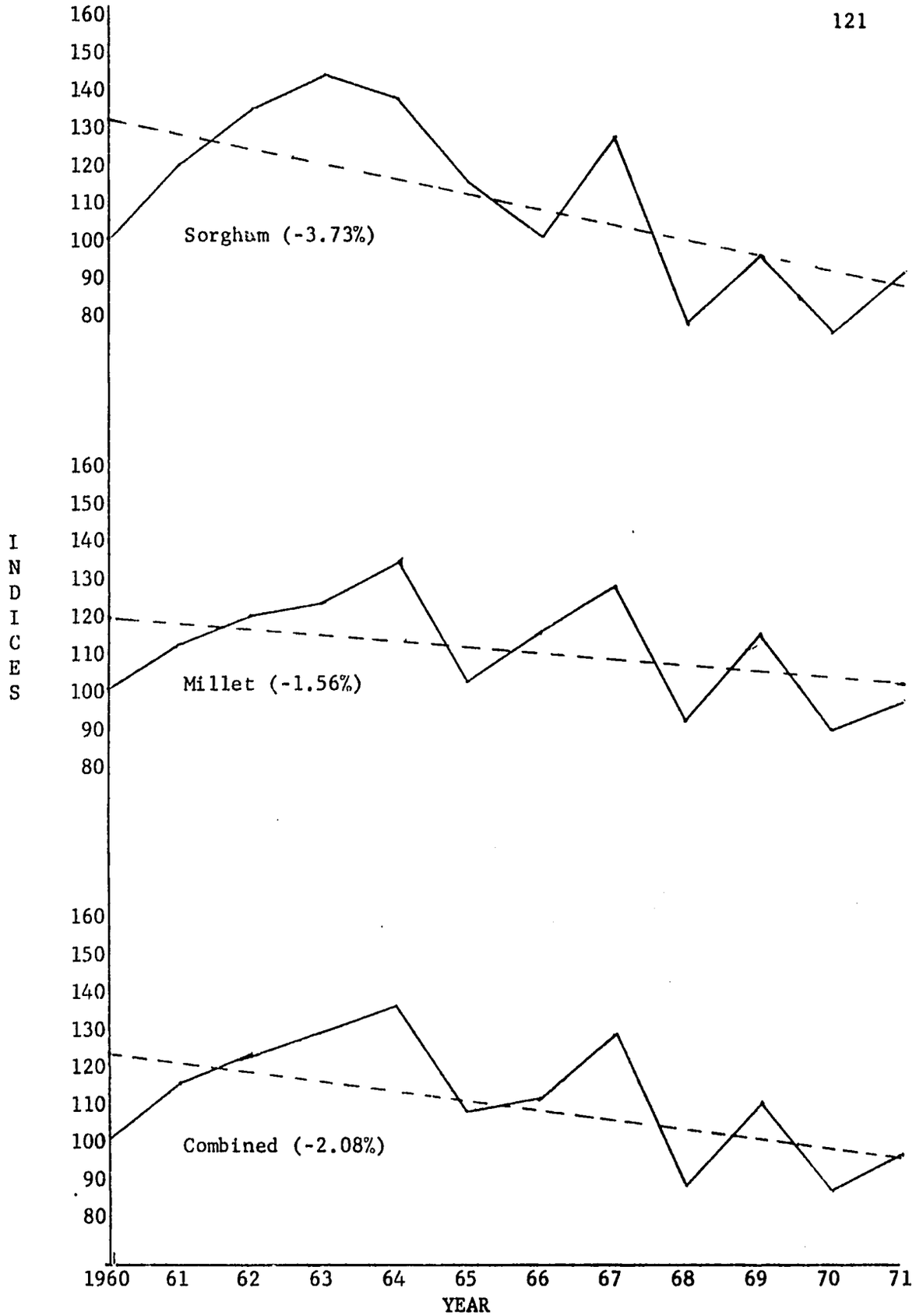

Figure 6.2 Niger - Indices of Annual Yields and Estimated Trends for Sorghum, Millet and Combined Sorghum and Millet (base year - 1960)

Figure 6.2 also points out vividly the large amount of variation in cereal yields. In the case of both sorghum and millet, two distinctive periods are apparent. The first period is 1960 through 1964. During this period both cereals had varying yields but the variation amounted to successive increases except for the sorghum decrease in 1964. The next period however, was characterized by both cereals varying drastically but with an undeniable downward trend. While one normally expects cereals yields in developing regions to vary substantially from year to year insofar as producers have few protections available to offset poor weather, this apparent productivity variation can only be described as severe.

To measure the extent of the variation, the coefficient of variation was again used. However, in this instance the trends were too large and also significant, such that the time dimension could not be ignored. Thus, instead of the simple standard deviation being used, the standard error of the estimate resulting from the semi-log linear regression was used. It was found that sorghum productivity even after adjusting to the downward trend, had a variation value of 17.4 percent. Millet had a value of 12.6 percent and when the two were combined the value was 13.4 percent.

Combining this description of yields with the former on area planted, points out several facts concerning production levels over the past twelve year period. Production levels for sorghum had a negative trend because of the large negative trend in annual productivity in spite of a three percent annual sustained growth rate in the area planted. Millets on the other hand, being able to withstand less rainfall did not have as large a decrease in productivity and as a result, the sustained increase in area resulted in a small positive average trend in output levels. When the cereals are combined the impact of sorghum further reduces the average trend in output and a production increase of less than one percent resulted. A level of cereals increase which was unsatisfactory in maintaining consumption levels.

6.1.2 Upper Volta -- Past Cereals Production

The cereal output levels in Upper Volta are undoubtedly increasing. Unfortunately, because of the aforementioned data problems, the estimates provided here are all offered with reservations and at best, can only be taken as suggestive of the magnitudes of change.

The annual compounded trend for combined sorghum and millet over the period 1957-1970 was a positive 3.68 percent. Over a shorter period from 1961-1970 the estimate was 5.04 percent. Insofar as the data was subject to question the trend estimates were simply based on the beginning and end years with no consideration of the intervening ones. Both trends are quite high but much more reasonable than the increases which were being reported in the early sixties. For example, total cereals output from 1961 to 1964, more than doubled. Obviously the data during the intervening years is not plausible when aggregated. (Some data on particular ORD's may be satisfactory.)

The individual trends for sorghum and millet are not offered. Suffice it to say that both have increased with the increase in millet output being greater than sorghum. In 1961, sorghum production accounted for about 68 percent of the total combined cereals. In 1970, it had dropped to 60 percent. This is again quite feasible in light of millets greater capacity to make a crop in bad weather years.

past actual area

Figure 6.3 plots the official data of the cropped area. For sorghum and millets separately the period 1961-1970 is offered. When the two are combined as cereals more data was available and the period 1957-1970 is plotted. Compound trends were estimated using the simple compounding formula for each crop separately and two trends were estimated for cereals when combined. All are plotted; however in the latter case the two overlapped and appear as one. The 1969 data was not available and the line connecting 1968 and 1970 is not meaningful.

The average trend in sorghum area over the 1961-70 period was a small but a positive 1.55 percent. The trend in millet over the same period was a healthy 3.42 pecent. No satisfactory method is available to statistically determine if either are significant. But simple

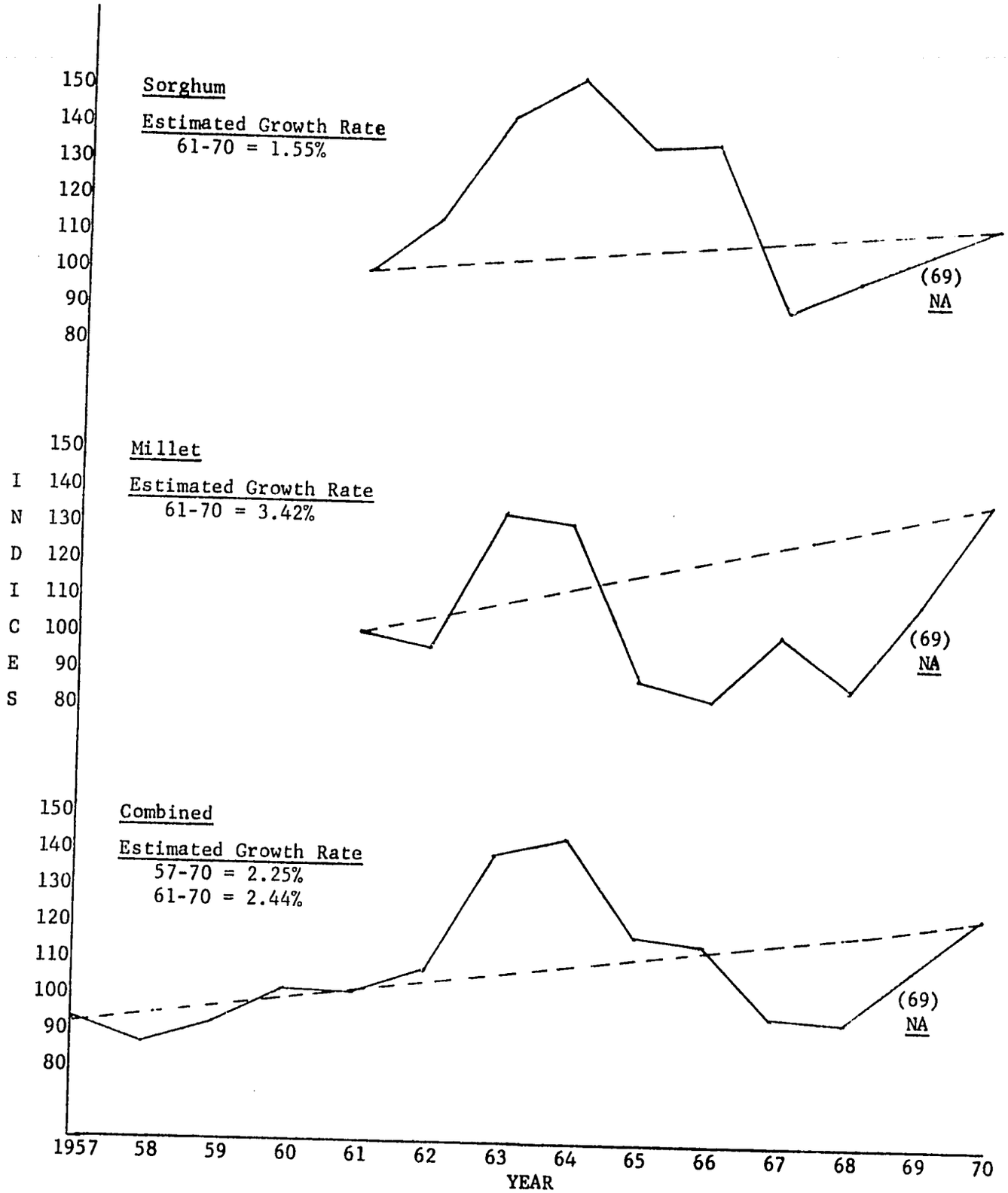

Figure 6.3 Upper Volta - Indices of Cropped Area and Estimated Trends for Sorghum, Millet and Combined Sorghum and Millet (base year - 1961)

observation indicates that if 1968 had been chosen as the end year both would have had negative trends. This points out the large variation that the data suggests. Granting even the biases that might enter into estimates, the annual variation in area planted in both cereals is large, much larger than in Niger. This may be a result of the greater flexibility in cropping patterns as a result of greater levels of rainfall.

The best indication of cereals area trends and fluctuation stems from the combined data. For the longer period, the estimated trend was a positive 2.25 percent and for the shorter 2.44 percent. Both quite logical. From Figure 6.3 it is also clear that the variation around the trend was small until 1962. Then the area increased until 1964, decreased until 1967, leveled off and then increased again. The largest moves were the 1963 increase and the 1965 decrease and both are consistent with price movement incentives. Retail prices in the May-July quarter of 1963 had increased more than 80 percent above the 1962 May-July quarter while the 1965 May-July quarter prices had dropped nearly 17 percent from the previous year. May-July price levels are determined simultaneously with planting and are simply used here as indicative of prevailing price levels.

past actual productivity

Figure 6.4 plots the indices of the official yield data for sorghum, millet and the two combined for Upper Volta. Again two periods are given because of data availability. Average compounded trends for these two periods were given for combined productivity. No estimates of time trends are offered for the crops individually because the data qualitity is simply to questionable.

The questionable nature of the data is examplified by comparing sorghum yields and millet yields. The former is relatively stable when compared with the latter. One might accept these differences if the two were assentially cropped in different regions of the country. While millets dominate in the north and sorghum in the south each ORD has substantial proportions of each making up its cereals. Thus, no logical explanation is available to accomodate such differences. These differences also result in a lack of faith in the combined data.

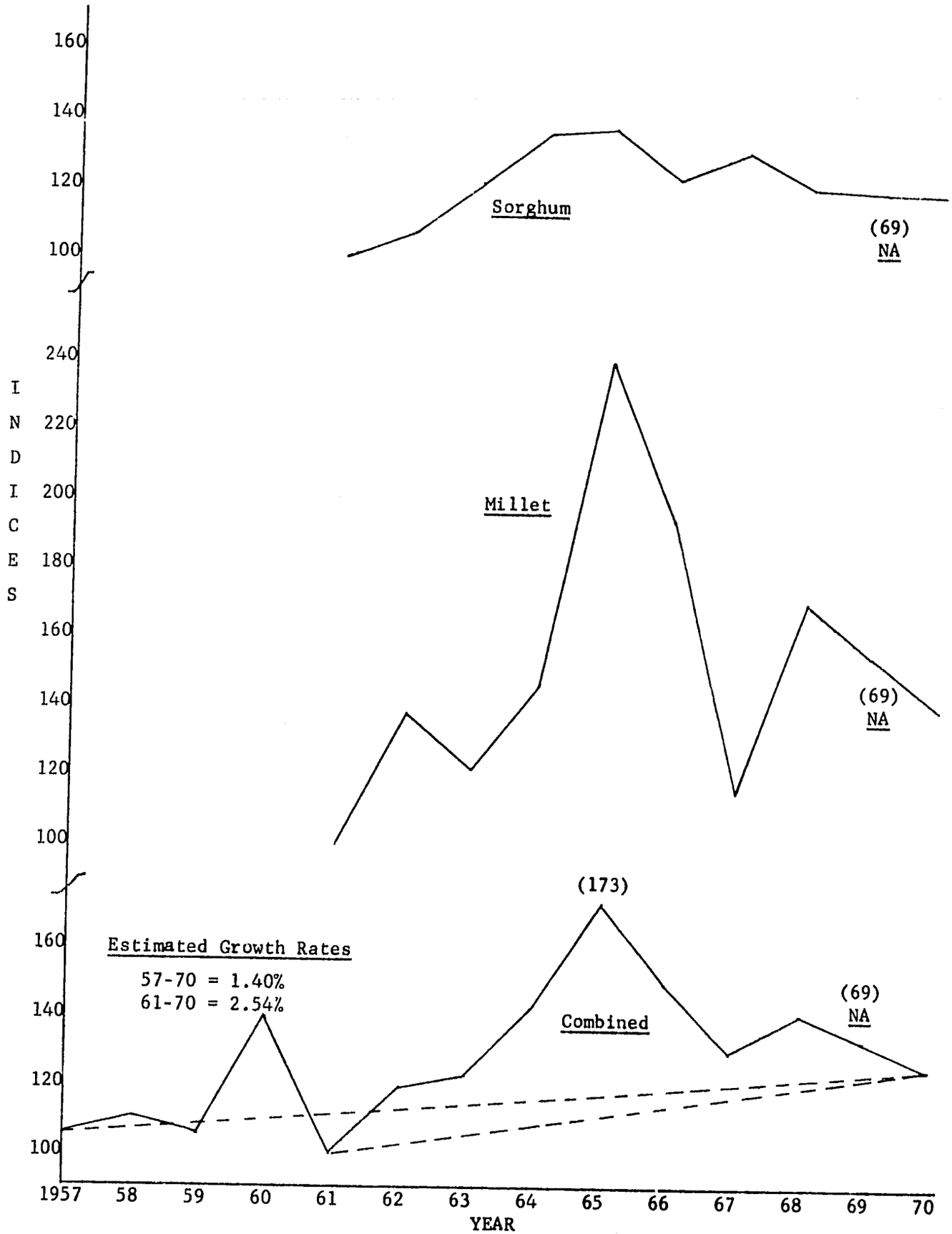

Figure 6.4 Upper Volta - Indices of Annual Yield and Estimated Trend for Sorghum, Millet and Combined Sorghum and Millet (base year - 1961)

Calculating the compounded trend for cereals results in an estimate of a positive 1.40 percent for the period 1957-70 and an estimate of 2.54 percent for the period 1961-70. If any credence can be placed in the data provided for other years, these estimates are low insofar as they were calculated on all of the low yield years except 1959.

implications

Insofar as little other output analysis was done on Upper Volta at the aggregate level, the implications from this limited review will be offered at this point. With regard to the area planted, a trend increase of about 2.3 percent annually is accepted as being a fair approximation and entirely consistent with what one might expect. The variation around this trend was quite large during the sixties but when a consideration of the swing area similar to that in Niger is made, the variation in area planted could be expected to be large. Not as large as the data indicates but quite large nonetheless. Also, the higher levels of rainfall give the producer greater flexibility in cropping patterns and this may add to variation in the area planted.

Implications stemming from a positive trend in annual productivity are numerous but more subject to question. If assumed correct, then the increase in cereals output levels over the decade would apparently have been adequate to maintain consumption and any increases in demand stemming from incomes. However, by reviewing imports it was noted that they began to rapidly increase in the 1966-67 market year. This same period from Figure 6.3 was characterized by a substantial decrease in yields. This suggests that the early period was quite prosperous and the latter less so and production levels while continuing to increase did so at much reduced levels. Thereby placing substantial pressure on both availability and price levels. The period under review excludes the 1971 to present period. But given the severity of rains during these latter years, a decrease in yield levels undoubtedly continued such that in recent years actual output decreased in an absolute manner.

6.2 Rainfall Analysis Results

This subsection presents the results of the inquiry on rainfall data for Niger and Upper Volta. Essentially the techniques of analysis were the same in both countries and allow many comparisons to be made between the two. However, the rainfall data for Niger was prepared for analytical use with production data and the discussion of it takes a slightly different bent than does the discussion of the Upper Volta results. In the case of Upper Volta the rainfall inquiry was more of an end in itself. Therefore, it was reviewed more thoroughly. These differences will become clear as the discussion proceeds. The format is the same as the previous subsection. First, Niger results, then Upper Volta.

6.2.1 Niger -- Past Rainfall

Section 5 discussed the manner in which the individual departmental rain index series were constructed from individual rain stations throughout Niger. Figure 6.5 is a map which illustrates the approximate locations of these stations. The map points out that the distribution of stations was quite good. The bulk lying in the heavy production areas. In fact, the stations in Agadez were not used in the index as it was weighted to crop area and Agadez essentially has no sorghum and millet areas. Similarly, Diffa has a very small percent and thus only two stations in it did not amount to much of a disadvantage. The other departments all have at least three with Niamey having eleven. The other districts comprise the bulk of the production area and the plots of their individual index series are illustrated in Figure 6.6.

departmental rainfall patterns

The plots in Figure 6.6 are for total seasonal rainfall from 1960 to 1972. The dashed line is the mean in each case. The 1972 values are given in the parantheses as the values were lower than the vertical distinctions in some cases. This also clearly points out the severity of the 1972 drought in each of the major cereals producing departments. The plots also show a rather distinct difference between

NIGER

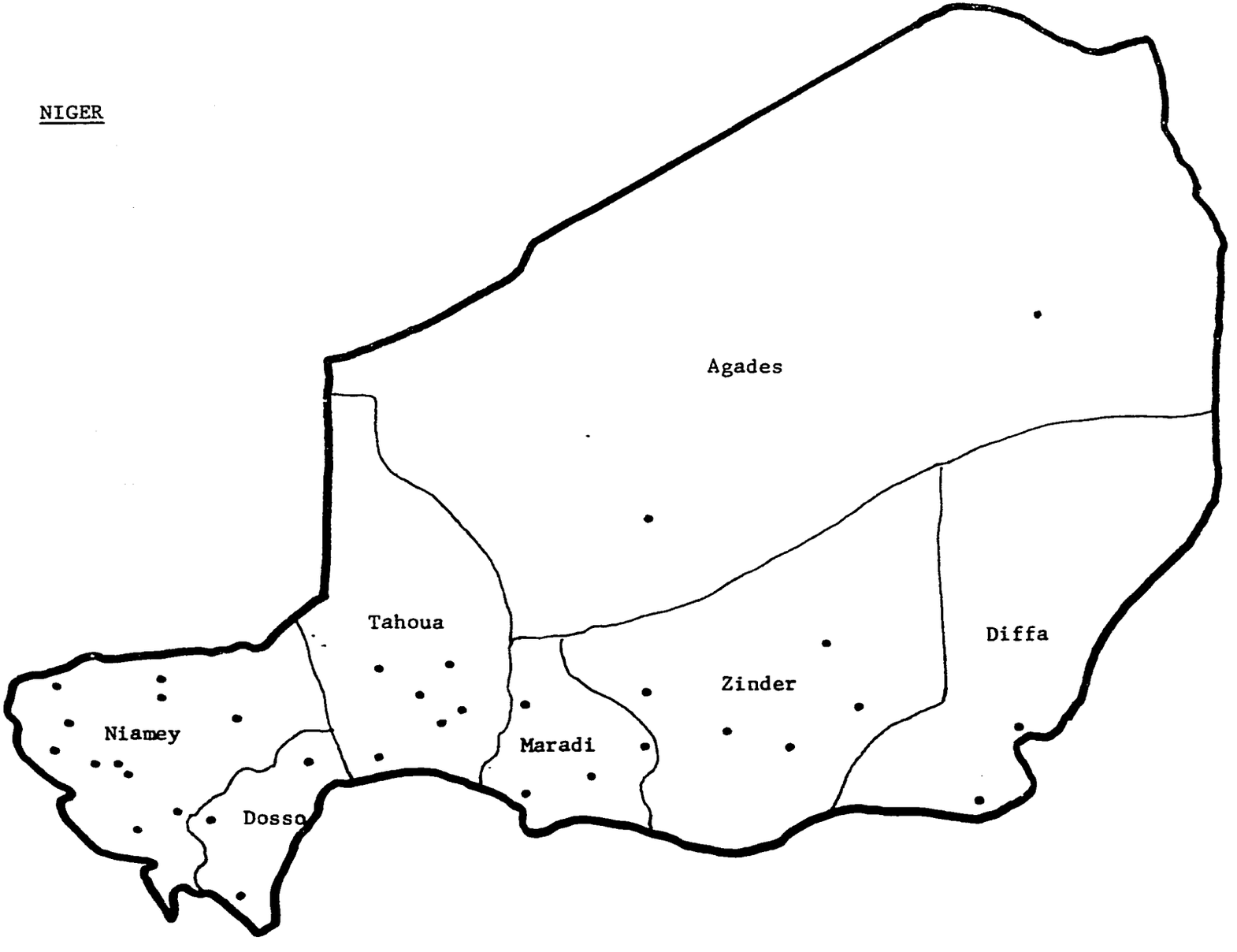

Figure 6.5 Approximate Distribution of Rain Stations Used in the Construction of the Rain Index for Niger

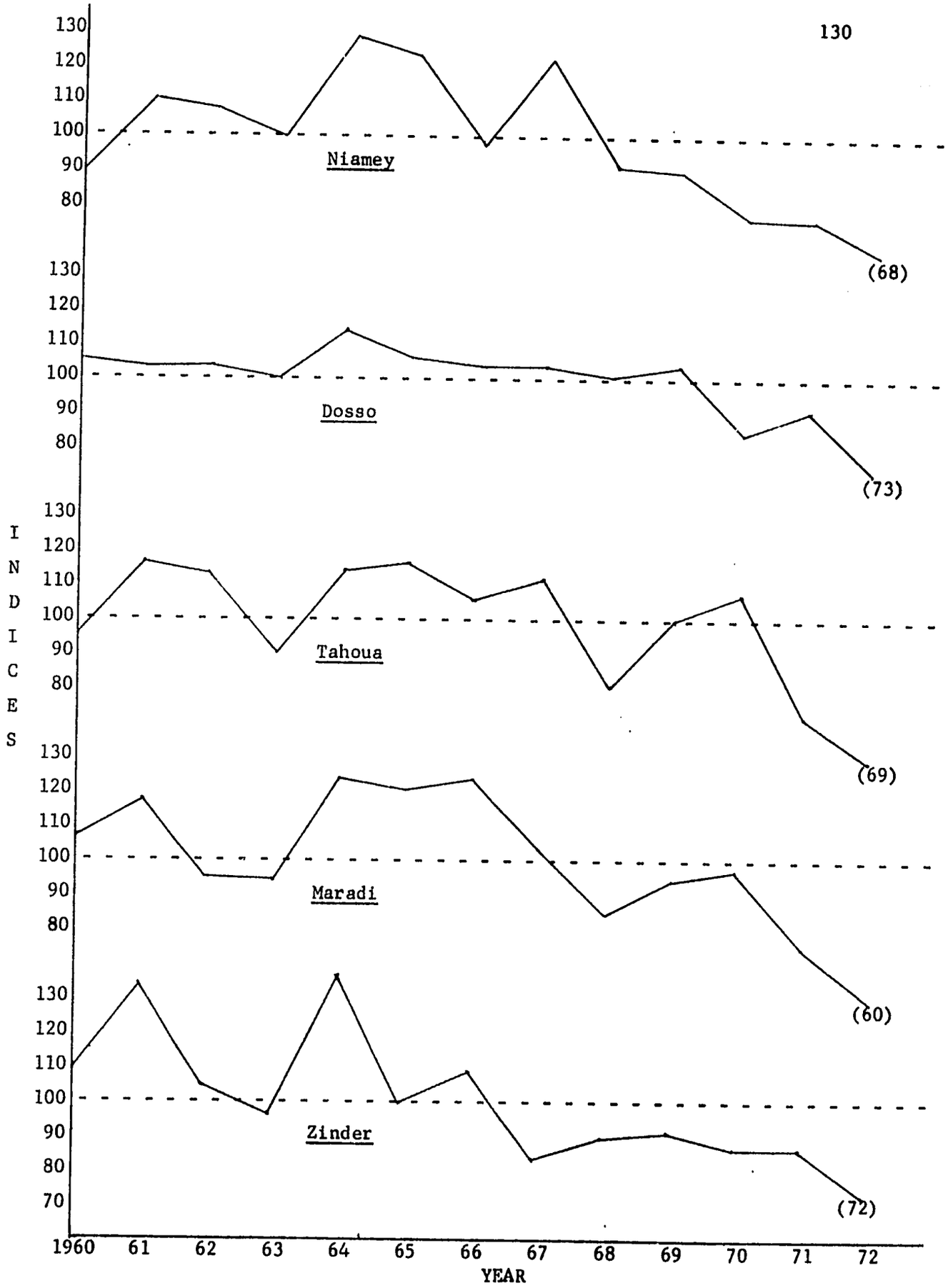

Figure 6.6 Niger - Apr/Oct Rainfall Indices for the Five Major Departments (13 year average is the base and = 100)

the early sixties and the latter part of the decade and the early seventies. No effort was made to estimate trends in the individual departments in Niger. However, it is fairly obvious that a general negative trend prevails in each of the five. Least pronounced in Dosso (Southern extreme).

Dosso is also the least variable from year to year. In fact, it is surprisingly stable in comparison with other departments. Annual fluctuations are most pronounced in Zinder until 1967. Since then it has been quite stable but quite low. Niamey is similar to Zinder and Tahoua and Maradi are variable throughout.

all Niger rainfall trend and variability

The major purpose of contructing all Niger rain indices was to provide a means of estimating intended production trends and adjustments for the major cereals. Thus, the indices for Niger have been weighted and should not be construed as an indices representing general rainfall across the country. In fact, rainfall patterns in Agadez did not even enter into the indices used here because of this weighting procedure. Given this reservation in the interpretation, the trends and variability of two rainfall series were estimated. The first series was the early rainfall and latter the total seasonal rainfall. Insofar as no production data was available for 1972, the rainfall data for that year was ignored in the analysis. It obviously would have increased the negative nature of the trend even greater then estimated.

Early rainfall included the months April through July. April was included only to insure if the rains started early in a particular year that it would not be ignored. April rains however are usually nil. In estimating the trend, three alternative functional forms were used; they were linear, semi-log and double-log forms. The linear and semi-log forms provided the best fits and because the interpretation of the latter is simplest it is reported. No appreciable differences result in either the linear or the semi-log form.

The specific form estimated was:

$$\text{Early Rain}_t = A\ G^{T}$$

Where early rain = the weighted index value of Apr/Jul rainfall,

A = intercept value,

G = estimated value where G-1 = trend,

T = 1-12 and

t = year 1960-71.

The R squared was .50 and the value of the F was significant to the .05 level. The R squared value means little in this case but is surprisingly high for a independent variable which is usually not regarded as having any impact on weather. The time parameter or trend factor was significant to the .02 level. The estimated value was a 3.35 percent compounded annual decrease over the period. The coefficient of variation (if one chooses to ignore the trend factor) was 16.3 percent. Approximating the relative variation using the standard error of the estimate and the mean, results in a lessor fluctuation value of 14.8 percent. With no implications towards the future one can state that during this period at least, the early rainfall decreased annually and was subject to substantial variation.

Total rainfall for the season (Apr/Oct) is much more important than early rainfall. Again its trends and variability were estimated using the same three functional forms and similar fits resulted. Thus the one reported here was the semi-log form where:

$$\text{Total Rainfall}_t = A\ G^T,$$

Where total rainfall = the rain index value of the Apr/Oct rainfall and all other scripts have similar interpretation.

The R squared was .40 and means only that time explains less of the variation in total rainfall then in early rainfall. The value of the F was significant to the .05 level meaning the equation was a significant explanatory equation. The estimated trend was -2.25 percent and was significant to the .05 level. The coefficient of variation was 12.8 percent and using the standard error over the mean the relative variation was 10.8 percent. A plot of the actual total rainfall index and the trend are presented in Figure 6.7.

Granting the limitations of twelve years of data in determining trends, it cannot be denied that in Niger the evidence available is not conducive to optimism. Figure 6.7 illustrates this plainly and again

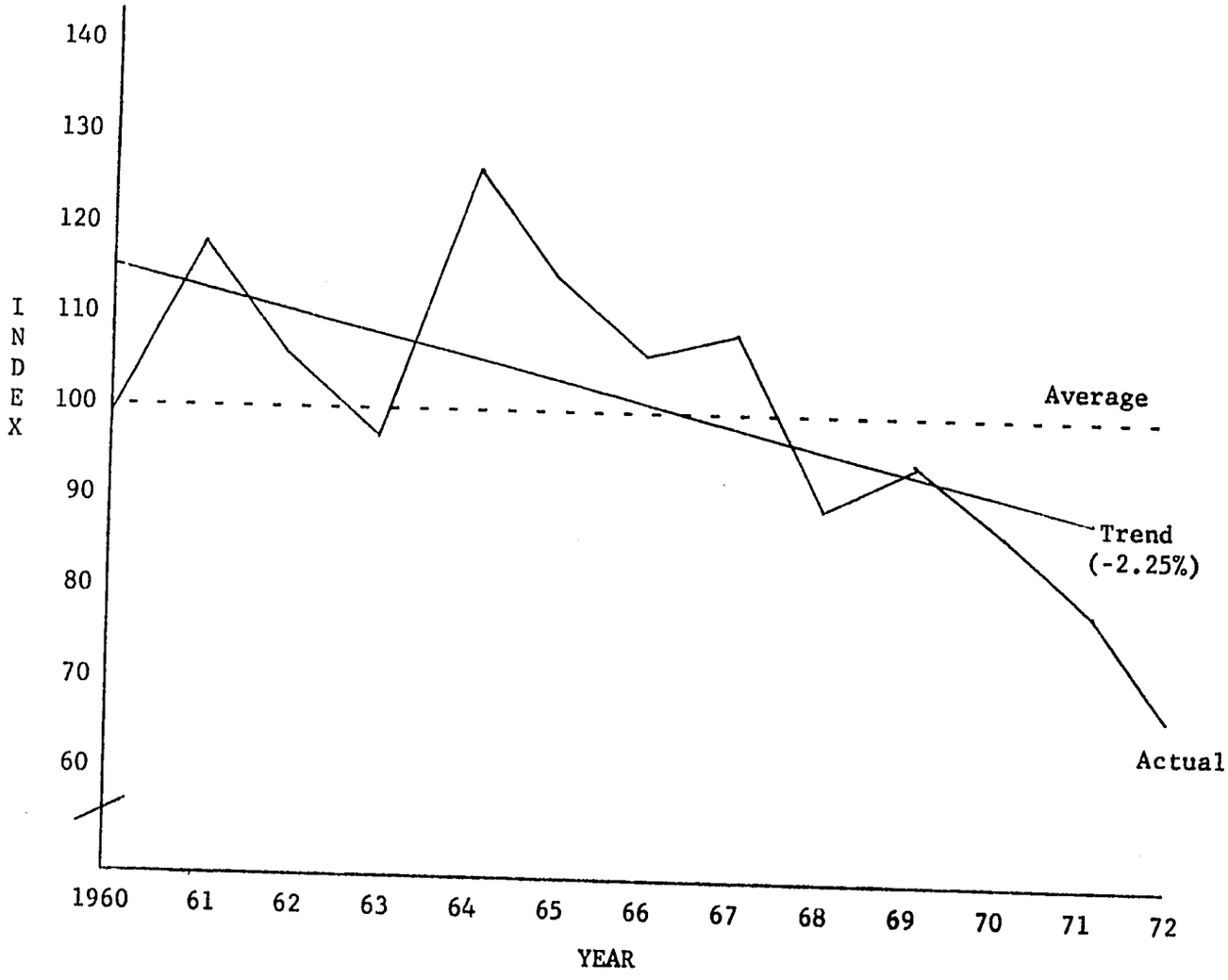

Figure 6.7 Niger - Apr/Oct Wtd. Rainfall Index and Estimated Trend for All Niger (13 year average is the base and = 100)

the trend estimate ignored the 1972 data. The plot of actual seasonal rainfall also reaffirms the earlier point on the severity of the drought. Five successive years in Niger of below the 13 year average.

Returning breifly to subsection 6.1 on the discussion of the two plateaus of area planted to cereals in Niger. The 1968 rain failure relative to prior levels in the early sixties is clear from Figure 6.7. In 1969, the "swing area" went into cereals production as a result of the 1968 rainfall failure and its consequence on output. Years since have been poor rainfall and the incentive for the swing area in cereals remained. The relative abundance of cereals in the early sixties is also consistent with the rainfall that occured.

With regard to the general hypotheses concerning climatic change in the sahel as measured by rainfall patterns, the results obtained support a position of, fail to accept the null hypotheses. That is, granting the limitations of twelve years of data the time parameters were found to be significant and negative. Thus, a null hypotheses suggesting the time parameter was not significantly different from zero is not supported. The general results of the inquiry into rainfall in Upper Volta also tend to substantiate this position. These results are considered next.

6.2.2 Upper Volta -- Past Rainfall

The rainfall indices for Upper Volta were constructed in similar fashion as those in Niger. Major differences were that a greater number of rainfall stations were available to use and for a greater number of years. The number of rainfall stations were 55 and their approximate distribution by ORD throughout Upper Volta can be seen in Figure 6.8. The greatest number of stations by ORD was in Ouagadougou with eleven; the least was Yatenga with only two. However, when the relative size of the ORD's are considered and the location of the stations in each, the representation throughout is fairly good. For a more definitive listing of the rainfall stations in Upper Volta as well as those in Niger, consult the Appendix of this report.

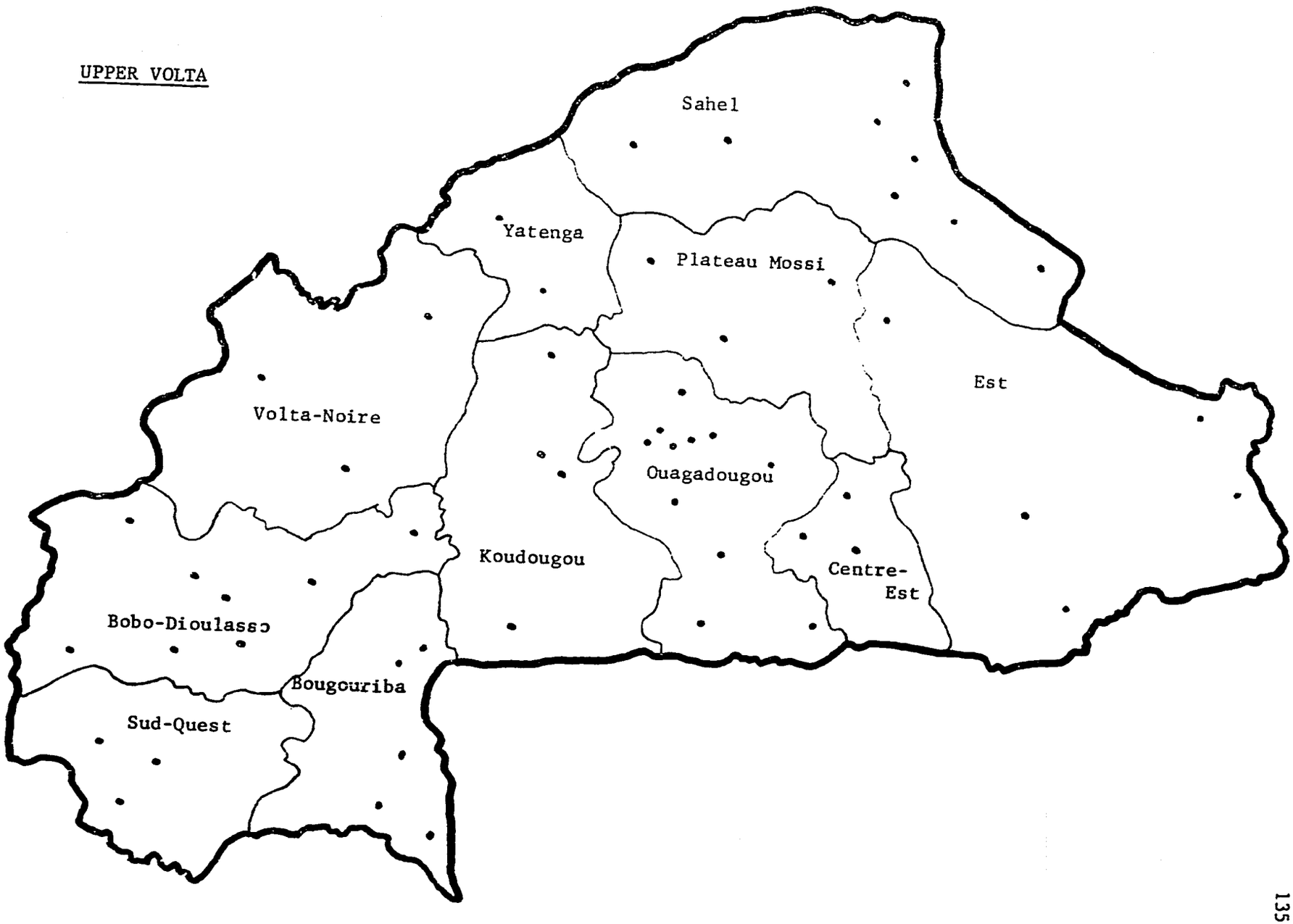

Figure 6.8 Approximate Distribution of the Rain Stations Used in the Construction of the Rain Index for Upper Volta

ORD rainfall trends and fluctuations

Individual trends and estimates of annual variation were estimated for each ORD in Upper Volta for total seasonal rainfall over the seventeen year period 1956 through 1972. Two functional forms were used, linear and semi-log, and as in the case of Niger, little if any differences in results were apparent. Thus, the semi-log functional form is opted for because of its direct interpretation to an annual compound trend. The fits of the individual equations as measured by the R squared and the F test ranged from 0 to .60 in the case of the former and included both those not significant and some significant to .05 level. Again these measures of fit are not particularly important. What is important, is the magnitude, the sign and the level of significance of the time parameter. These for each ORD are included in Figure 6.9.

From Figure 6.9, the ORD's have rainfall trends which are both significant and not significant. Trends which are both negative and positive and trends which range in magnitude from a -3.37 percent to a +.79 percent. The positive trends however are not significant while the higher negative trends are. Also, the high significant negative trends are in the northern extremes while the low not significant positive trends are in the south. This situation is made more clear by taking a vertical section through Upper Volta beginning with the ORD sahel, then the Plateau Mossi, then Ouagadougou and lastly skipping over to Bougouriba. The plots of the actual total rainfall indices and the trends are in Figure 6.10.

A second general hypotheses advanced concerning rainfall patterns in the sahel region was that of the ITD is in fact moving less in a northernly progression during the rainy season, the relative impact would be greater in the north than in the south. Such a situation tends to be confirmed by the vertical cut through Upper Volta. The ORD Sahel is in the northernmost extreme of Upper Volta. It also registers the largest negative trend over the seventeen year period of any of the ORDs. This ORD is plotted at the top of Figure 6.10. Moving to the next ORD south, the Plateau Mossi, the trend is less negative but still significant. The next ORD is Ouagadougou and here a smaller negative trend was registered but was not statistically significantly different from

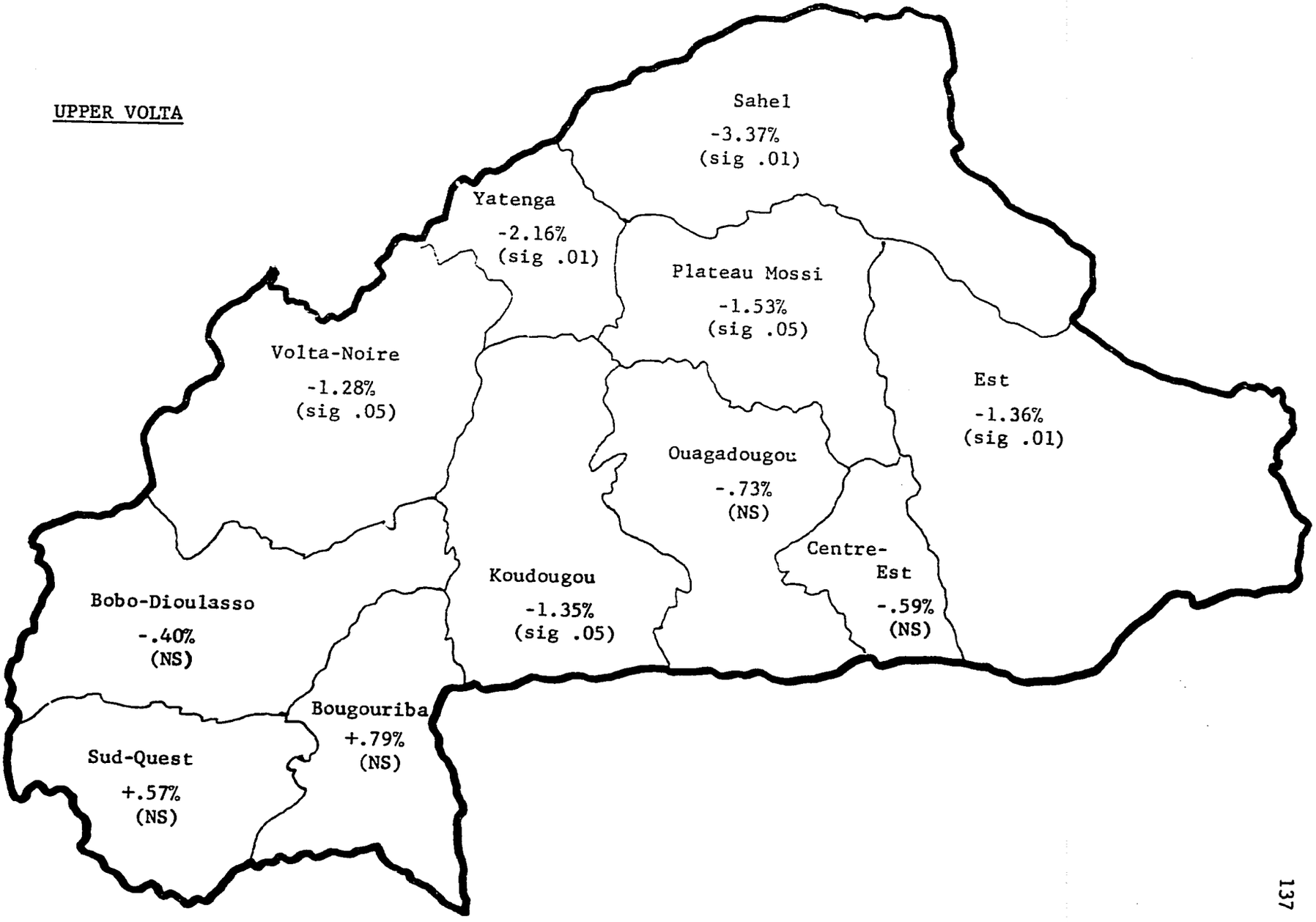

FIGURE 6.9 Rainfall Trends and Significance by ORD in Upper Volta

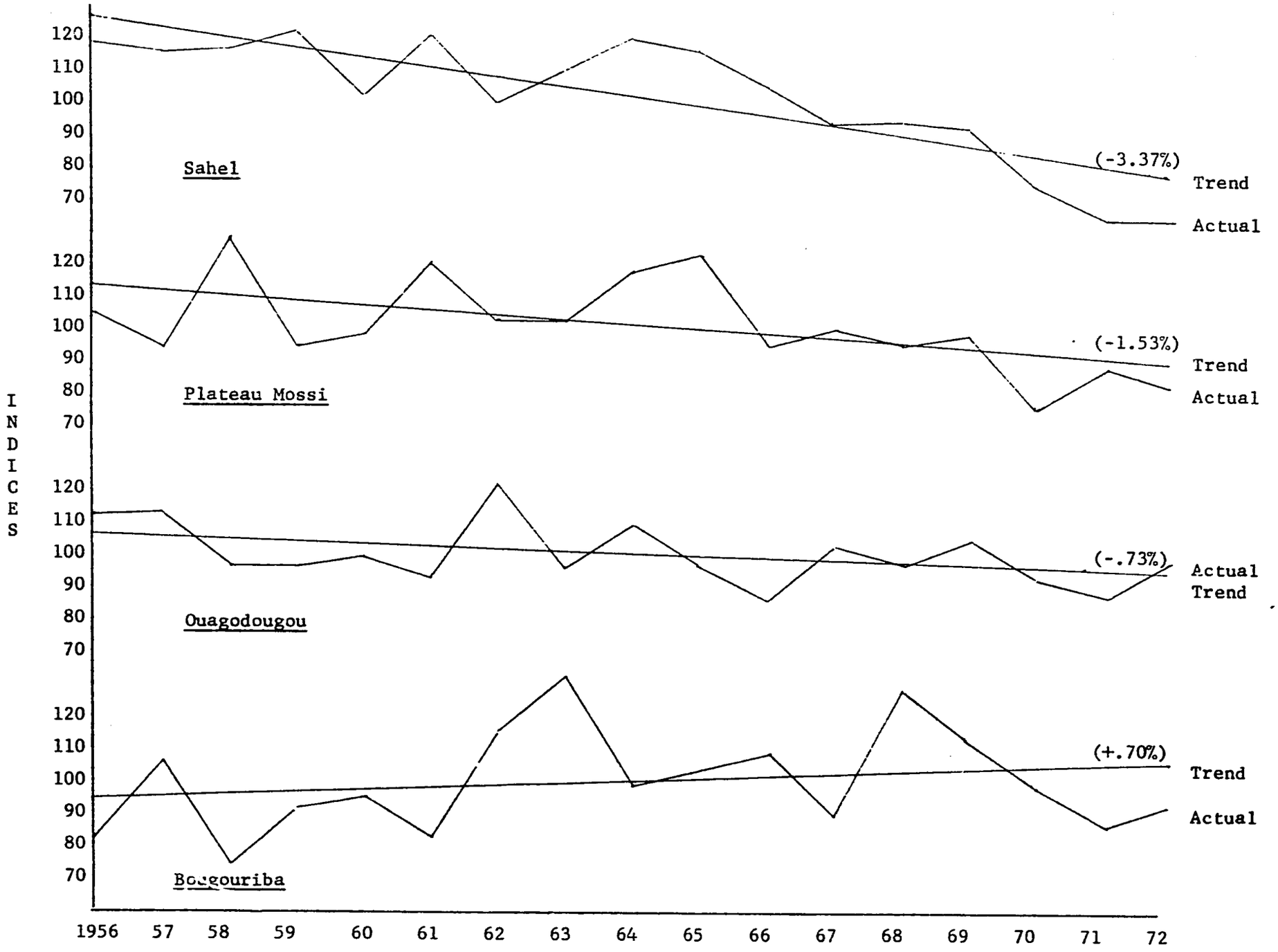

Figure 6.10 Upper Volta - Apr/Oct Rainfall Indices for Four Selected ORDs in Upper Volta (17 year average is the base and = 100)

zero. The final southernly move is to Bougouriba which is plotted at the bottom of Figure 6.10. This ORD registered a small positive trend over the period but was also not significantly different from zero. This situation in Upper Volta suggests that the same moisture is being carried to the sahelian region, but because of changes in pressures the ITD moves less in a northernly direction. Thus, the same absolute quantities of moisture are being dropped but the decrease in the north is being distributed in the south. This same absolute change across the sahel is proportionally greater in the north than in the south because of smaller mean levels in the north. Therefore, larger negative trends in the north are registered and smaller positive trends in the south.

Figure 6.10 also provides a visual illustration of the annual fluctions in rainfall. Abrubt year to year changes are not uncommon. However, the changes in one ORD do not seem to imply a similar change in any other. To better measure this aspect of correlation between the rainfall patterns in individual ORDs, the matrix of simple correlations between them was reviewed. This matrix is provided in Appendix Table 12. While, the bulk of the correlations were quite low some were not, suggesting that some ORDs could be grouped as rainfall regions.[1] Such a grouping of ORDs was done and are represented by Figure 6.11.

The criteria used in making up Figure 6.11 was simple. If two ORDs with a contiguous boundary had a correlation coefficient below .50 a heavy solid line, indicating no similarity in annual rainfall patterns existed was drawn. If the correlation coefficient was below .70 a heavy dotted line was drawn and if above .70 a light light representing only the ORD boundary was used.

Using the below .50 criterion, only two ORDs were sufficiently individual enough in their annual rainfall patterns to be regions in and of themselves. They were Bobo-Diolasso and Centre-Est. The below

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[1]The term rainfall region is not wholeheartedly correct because of the limitations of the political units as a basis for comparison. Actually each station should correlated with others to determine rain -fall regions which would undoubtedly cross the ORD boundaries.

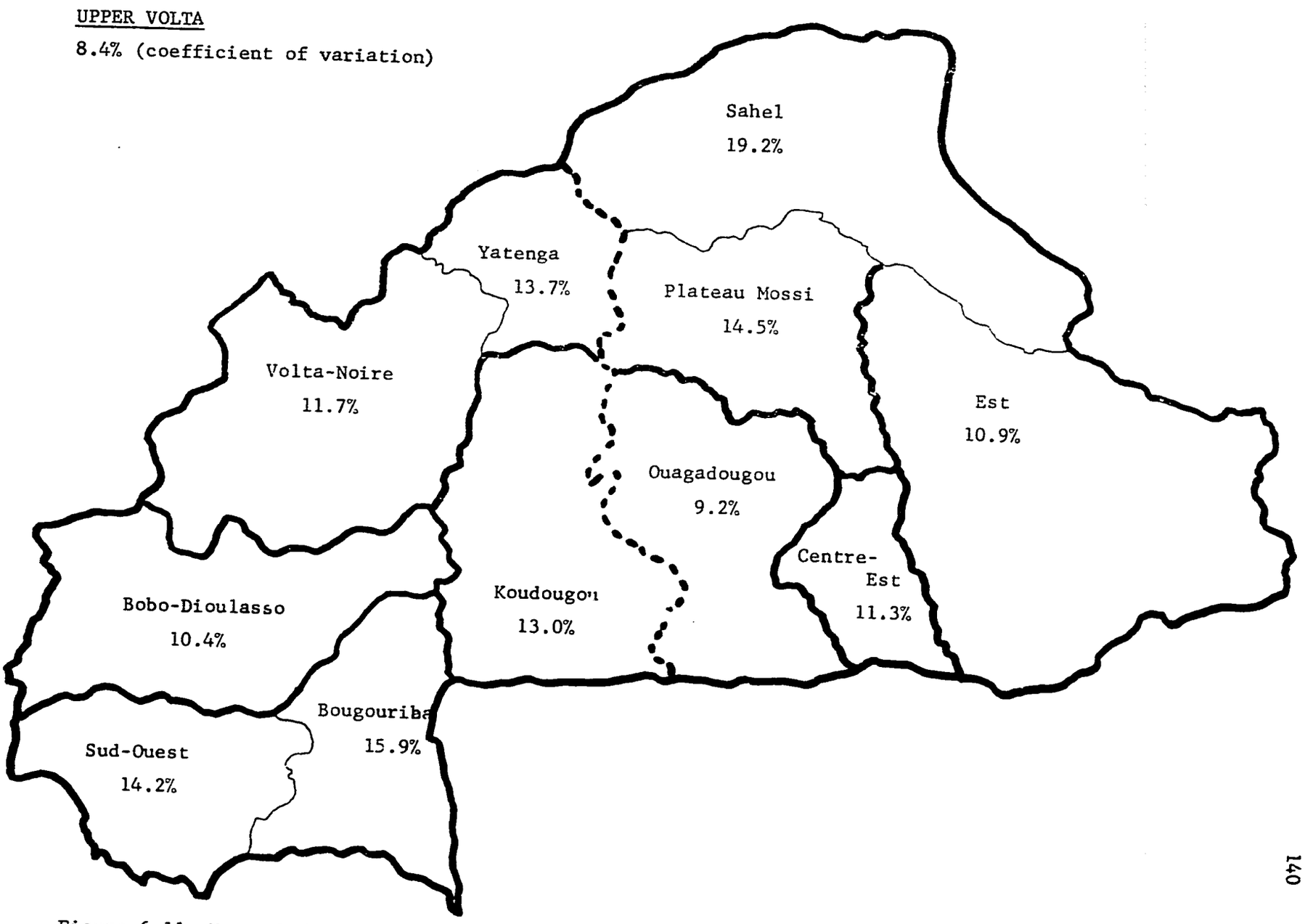

Figure 6.11 Upper Volta - Grouping of ORDs into Approximate Rainfall Regions Based on Simple Correlations with Coefficients of Variation of Total Seasonal Rainfall

.70 criterion indicated that Koudougou and Ouagadougou were separate regions. All remaining ORDs had at least one contiguous boundary with an ORD with a similar rainfall pattern over the seventeen year period. Using the below .70 criterion also indicates that all of ORDs with significant negative trends except Koudougou could be consider as one contiguous rainfall region. Such an area would range from the ORD Volta Noire to the ORD Est and include the ORD's of Yatenga, Sahel, and Plateau Mossi. The ORDs most severely affected by the drought in recent years.

Figure 6.11 also includes the simple coefficients of variation. They range from 19.2 percent to 9.2 percent and again apparently decrease in a southernly direction. That is, until the higher rainfall areas in the far south are reached. Then they tend to increase slightly. In magnitude they can be all regarded as high and severe. Particularly those in the northern extreme which indicates that they are regions of low rainfall and high variability. Using the standard error of the estimate on the mean to compare variability in annual rainfall does not change the general results. It does however reduce some variability in the northern extremes. However this is little consulation to those in the area to know that the variability is less around a negative trend.

all Upper Volta rainfall trend and variability

The individual ORD indices were also grouped to form an index series for Upper Volta. The weighting procedure was based on the relative proportion of the 1970 area planted to sorghum and millet in each ORD. Thus, again the reservation must be exteded that the all Upper Volta rainfall index over the seventeen years does not reflect average rainfall but rather average rainfall in areas planted tosorghum and millet. A further stipulation is the offsetting nature of rainfall patterns within the ORDs. Good rainfall in one offsets bad rainfall in another and the variability for all Upper Volta is reduced. Nonetheless, the all Upper Volta index does provide further information concerning the rainfall trends and fluctuations in the sahel.

The semi-log functional form was again used to estimate the trend. The result was a negative time parameter of 1.19 percent compounded annually, It was significant to the .01 level. The fit as measured by

the F test was excellent and the equation was significant at the .01 level. The R squared was .50. The coefficient of variation was 8.4 percent and the relative variation based on the standard error of the estimate was 6.2 percent. Obviously, the trend was negative in some individual ORDs and the variation was reduced. Unfortunately, the fact remains that over the period the average level of rainfall for the production of sorghum and millets in Upper Volta has decreased. Figure 6.12 plots this decreasing trend as well as the actual values for the index for the seventeen year period.

Figure 6.12 illustrates the relative good rainfall prior to 1965 and the relative poor rainfall since. Such a situation is consistent with the relative decreases in cereals availability since the 1966-67 market year, the increased price levels (particularly the Nov-Jan quarterly prices reflecting harvest output -- see Appendix Table 6) and the necessity of imports. It also suggests that if abundant or at least satisfactory rainfall prevailed in the early sixties and cereals were abundant, then agricultural policy to increase cash crops could hardly be considered as incorrect. Given the variability in annual rainfall from year to year the serious nature of rainfall situation does not really become obvious until 1971 and 1972. Until this time frame the rainfall pattern would certainly not become apparent as a problem by simple observation of plotted data.

rainfall in the sahel

The evidence which results from both the rainfall inquiry in Upper Volta and Niger, tend to support the position to "fail to accept" the null hypothesis that rainfall in the sahel is not decreasing with time. Granting the limitations due to number of observations, the results certainly do not support the reverse position. Furthermore, the relative decreases being greater in the northern extreme supports the theory of desert encroachment. Thus, while the evidence presented here <u>can not</u> be construed as conclusive, there is no doubt that it suggests further efforts must be made to determine the future of this all important variable in cereals production.

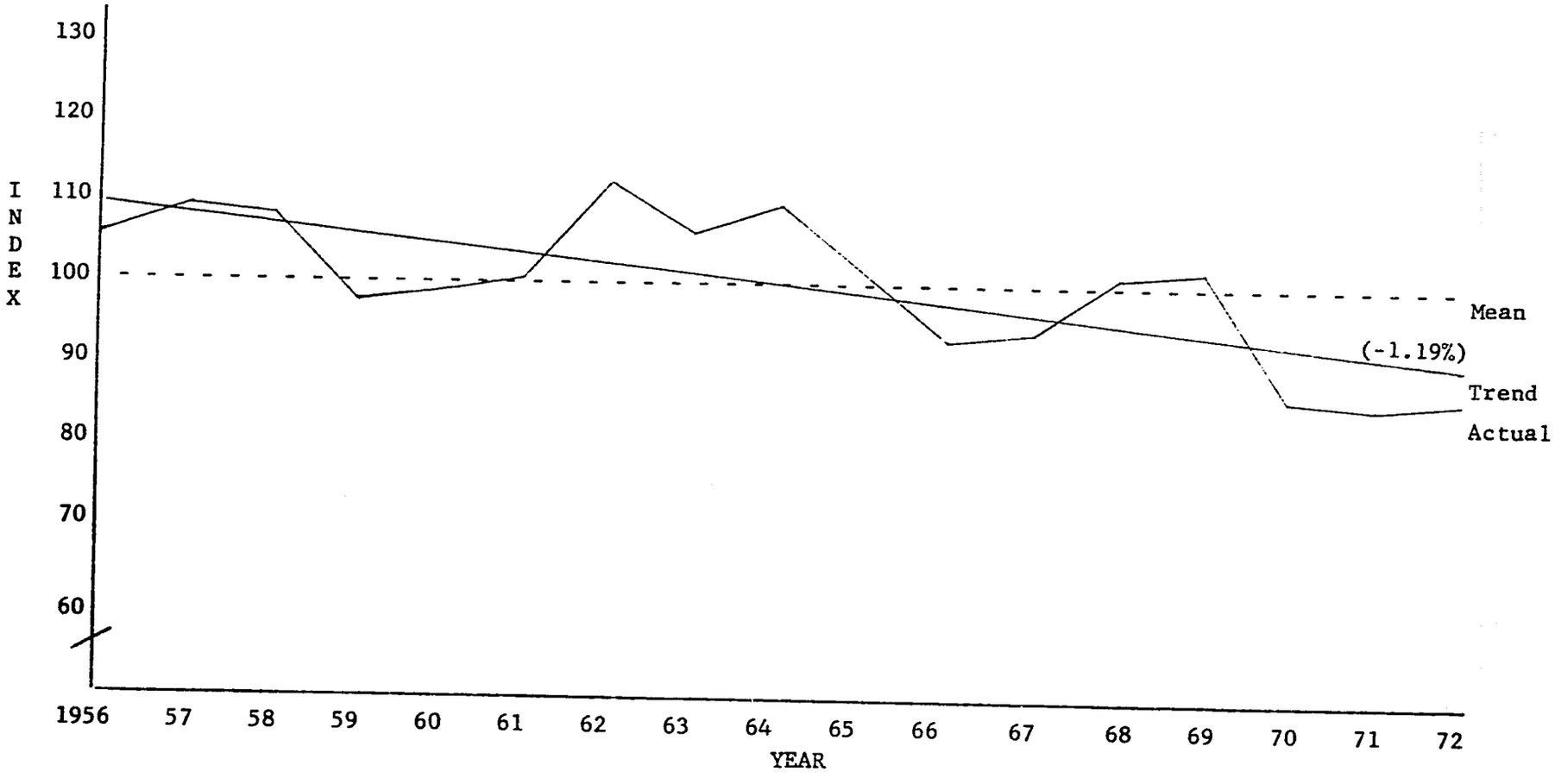

Figure 6.12 Upper Volta - Apr/Oct Wtd. Rainfall Index and Estimated Trend for All Upper Volta (17 year average is the base and = 100)

6.3 Production Response -- Niger

This subsection has three parts to it. The first presents the results of the models applied in the analysis of the area planted to cereals. The second presents the results of the models used in describing past cereals productivity levels. In both parts, the implications towards specific hypotheses are discussed. The last part, combines the results of the area and yield analysis together, to estimate what the intended production levels were and contrast them to the actual and required output levels. Also, this latter section, considers the implications of the findings to various hypothesized constraints.

6.3.1 Analysis of the Area Planted -- Niger

The models as previously discussed in section 5 were applied to both sorghum and millet as well as the two combined as a cereals category. The results obtained by the runs made on the crops individually add little information above that obtained in the combined cereals category. Thus, in the following discussion, only the results of the combined cereals analysis are given.

results of Model 1

Model 1 was found to be a significant explanatory model of the area planted to cereals as measured by the F test and the value of the R squared. The former was found to be significant at the .01 level and the value of the R squared was .82. With respect to the independent variables the lagged rainfall was found to be significant at the .10 level and time was significant at the .05 level. Early rainfall was found to be not statistically significant.

While the early rainfall was found to be not significant, the sign was negative as one would anticipate. That is, a decrease in early rainfall would result in an increase in the area planted that year. The elasticity that was estimated was .15 and suggests that a one percent decrease in early rains would increase the area planted by .15 percent. This is less than the estimated response to lagged rainfall which is also consistent, given the reduced ability of producers to adjust the area planted during the growing season. However, granting the logical findings

of the response to early rains, the fact that the parameter was not statistically significant means we must fail to reject the null hypotheses (Ho: 3) that early rains have no bearing on area planted in the aggregate. In other words, if adjustments can be made in plantings after the rains begin the model fails to support this arguement.

The estimated elasticity coefficient of lagged rainfall in Model 1 was a negative .39 percent. This means that a one percent decrease in the previous years rainfall results in a .39 percent increase in the area planted the following year. While little interpretation can be given at this point with regard to the size of the coefficient because the impact rainfall on yields and in turn production is yet to be covered, the sign is consistent with expectations and the level of significance suggest that producers do respond to short run changes in incentives (stock depletion or market prices) and adjust the area planted accordingly in the following year. Thus we fail to accept the null hypothesis (Ho: 8) that producers do not react to short run incentives in the production of cereals as measured by lagged rainfall.

The elasticity of time was estimated at .085 percent. As such, it means little because a one percent increase in time is a nonsense concept. However, using the average percentage change around the mean time value over the observed period and multiplying by the estimated coefficient, results in an estimate of the growth rate. This was done and an estimate of a 1.55 percent annual increase in the area planted was determined. This growth rate in the area cropped represents the adjusted long run trend over the period. Two points become clear with regard to this result. First, the simple trend as previously discussed in subsection 6.1 of 2.98 percent annual growth in the area planted clearly includes a net short run adjustment. That is, because of the short run response to deficits, an increase in area is being unjustifiably attributed to long run growth. Second, the estimated value is substantially less than the population growth rate. This will be discussed more in depth after the results of Model 2 have been covered.

results of Model 2

Model 2 was also found to be a highly significant explanatory representation of the area planted to cereals in Niger. The value of

the F ratio increased above that in Model 1 and the R squared dropped slightly to .79. The dropping of an independent variable and this type of fit remaining, highly suggests Model 2 is more appropriate. Both remaining independent variables were significant; in fact, the level of significance for lagged rainfall increased to the .05 level.

The estimated elasticity coefficient of lagged rainfall remained negative as expected but its value increased to .4637. Suggesting that some of the variation attributed to early rains in the first model was actually due to the lagged rainfall. Or in other words, a response to short run production incentives rather than expectations of current yields. However, in general the same conclusions follow with respect to lagged rainfall as in Model 1, except that the extent of short run response is slightly greater than that suggested in Model 1.

The more important results of Model 2 are those concerning the trend parameter. In Model 2, the estimated elasticity coefficient for time remained positive as in Model 1 and it increased to a value of .102. Again converting this to a more meaningful concept,. an estimated growth of 1.86 percent annually compounded results. While this rate of growth is slightly higher than that suggested by Model 1, it is still below both the simple trend of 2.98 percent and the population growth rate of 2.7 percent. Again, this suggests that because rainfall has decreased over the period, a positive net impact on short run adjustments has resulted. When, this impact due to rainfall is netted out, the sustained growth rate in the area planted is determined. With respect to the hypotheses (Ho: 5) that the long run trend in area planted is not equal to the population growth rate, we must fail to reject the null statement. The fact that the estimated growth rate is less than the population growth rate as a whole, suggests that either the productivity trend is positive and compensates for the less than adequate growth in cropped area or if not, then the growth rate in output was insufficient to maintain per capita availability. This overall question brings us to the review of yields.

6.3.2 Analysis of Aggregate Yields -- Niger

The aggregate yield models discussed in section 5 were applied in a manner similar to those for the area planted. Runs were made for both

crops individually as well as for the two combined. Again the results for the combined cereals category are of major importance and accordingly stressed in the discussion. However, the findings with respect to individual crop when necessary to make a point are noted.

results of Model 3

The equation fitted in Model 3 for combined cereals resulted in a R squared value of .65 and an F value significant to the .05 level. While the F test indicates the equation was significant, the low R squared indicates that a substantial amount of variation in aggregate yields was left unexplained. Rainfall was found to be a highly significant variable in explaining yield variation and was significant at the .01 level. The dummy variable for the swing area being in or out was significant at about the .10 level and the time parameter was found to be not significant but positive. Model 3 when applied to sorghum productivity was unsatisfactory as measured by tests of fit and explaining variation in yields, although rainfall was a significant variable. In the case of millets, results similar to those obtained for combined cereals were found.

The total seasonal rainfall, not surprisingly, was found to be significant in all three runs. Thus, we fail to accept the null hypothesis that rainfall is not a significant explanatory variable in describing changes in annual yields (Ho: 4). More importantly however, are the estimated elasticity values. In the case of combined cereals, the estimated elasticity value was 1.38. This means that a 1 percent change in rainfall, results in a 1.38 percent change in combined cereal yields. For millets, the estimated rainfall elasticity was 1.24 percent and for sorghum 1.01 percent. The fact that the estimated elasticity is less for each individually than when combined is due to the values attributed to the swing area being different in sorghum. However, the major point remains. Rainfall variation affects yield variation on or around a 1 to 1 basis in the aggregate. Given that the normal variation in rainfall ranged within a plus or minus 14-16 percent around the mean, much of the wide variation in actual yields can be easily attributed to weather. Also, in terms of making projections of normal variation around future intended output levels that can be expected simply as a result of normal weather variation, this estimate of impact is crucial.

The swing area value (dummy variable) introduced into Model 3 of yields was found to be significant with respect to combined cereals as aforementioned.

This means we must fail to accept the null hypothesis as presented in Ho: 9 where the swing area was hypothesized as having no impact on short run yield response. It suggests that producers do have a capacity to change intended yields in the short run. In the case of combined cereals, the swing area being in production meant that average cereal yields increased from the mean 483 kg/ha to 521 kg/ha or about 7.9 percent increase. When the swing area was out, yields decreased about 7.9 percent from the mean to about 445 kg/ha. Actually, over the period, the swing area was either in or out and the mean value of 483 kg/ha is simply the average of the two intended levels of productivity. They are intended levels insofar as they have been adjusted by rainfall variation.

Similar results were obtained in millets. Here the average yield when the swing area was in production was 497 kg/ha and when out 431 kg/ha. The latter is a decrease in intended yields of about 13 percent from the level when the swing area is in. For sorghum, the reverse position was suggested by the results. When the swing area shifted out of production in 1964 and 1965, the intended yields increased about 3 percent. However, this is not much and again the dummy variable was not found to be not significant. Hence, little if any faith can be placed in this latter result.

In all three runs, the time parameter was not significant. However, it was positive, for millets and positive when sorghum and millets were combined into cereals. In the latter instance, the value of the estimated trend was .88 percent and the former, 1.03 percent. The lower trend in combined cereals resulted from the negative rainfall adjusted trend in sorghum offsetting part of the trend in millets. The aggregate yield trend for sorghum was -.91 percent annually. Regardless of the average adjusted trend values, the point remains that they were all statistically insignificant. Therefore, we must fail to reject the null hypotheses (Ho: 6) that the adjusted trend in annual aggregate yields were not significantly different from 0. This means constant long run productivity in cereals over the period which tends to deny the arguement that increased intensity on the land is resulting in decreasing yields.

results of Model 4

The equations fitted in Model 4 were less satisfactory for combined cereals and millet but more satisfactory in the case of sorghum. It was more satisfactory for sorghum insofar as the inclusion of the swing area hypothesized impact did little to improve results above those of just rainfall and time in Model 4. In all three instances, the signs of the relationships remained the same as well as the magnitudes except for the elasticities of rainfall for millet and combined cereals which dropped. This, however could be expected because rainfall during the latter part of the observation period although severe, its impact on yields was overshadowed by a movement along the intended production function.

The actual results of Model 4 applied to all three cereals reaffirmed the significance of rainfall being a determinant of actual productivity levels. For sorghum the estimated elasticity was 1.05 and for millets .74 percent. Combining the two into a single cereals category resulted in a rainfall elasticity of about .76 percent. Again, the results of Model 3 point out that this understates the elasticity of rainfall but this comparison suggests that sorghum is more responsive to changes in rainfall than are millets which is consistent. (The reason this doesn't happen when comparing the results of Model 3 is because of the inability to accurately denote the shifts in area in sorghum by using the dummy variable approach.)

The actual estimates of trends resulting from equation 4 were all of similar sign as found in Model 3, all were not significant but the magnitudes changed. The trend for sorghum was -.77 percent; a small decrease in the earlier estimated negative nature of the trend. The trend for millet and cereals combined were .31 percent and .06 percent respectively. These results only tend to confirm the position that no long run sustained changes have occured with respect to annual productivity levels.

6.3.3 Intended Output Comparisons and Conclusions -- Niger

The results of the analysis of aggregate yields of cereals via Model 3 coupled with the actual area planted data for each year provided the basis for estimating the intended output levels over the period. Briefly the procedure was as follows. The intended area planted for each year was equal to the actual area planted as total rainfall does not affect intentions. Insofar as it was also found that early rainfall has no statistically significant impact on intentions, these intentions can be assumed to represent those a priori to the season. (The actual purpose of the analysis on aggregate area was to determine the extent of short run response and adjust the long run trend.) The intended aggregate yield for a particular year was equal to the rain adjusted mean yield over the period[1] adjusted by the impact of the swing area being in or out of cereals production. This adjustment is the proxy variable for increased inputs per hectare which are allocated (most likely labor) during a given year. Insofar as the trend parameter was not significant, no long run adjustments in intended yields were warranted. Thus, for a particular year when the swing area was in cereals, the intended productivity was estimated to be 521 kg/ha. When the area was out of cereals, the value was estimated as 445 kg/ha. Combining these year specific estimates of intended aggregate yield with the actual areas planted, result in the following estimated intended output levels for the years 1960-1971. (Note: these are undeflated estimates.) Also, presented are the year to year relative changes. (Presentation of estimates, next page.)

Using these estimates of intended output and comparing them with the actual required provide some interesting insight into the past decade of cereals production and the extent of supply response. These comparisons are best handled by plotting and they are presented in Figure 6.13

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[1]The rain adjusted mean yield equals the simple average over the period because no estimate was made to identify normal rain. If however one wishes to assume the average rain over the period was depressed a given percentage, the mean yield can be adjusted accordingly using the estimated elasticity coefficient.

along with a plot of the all Niger cereal rain index. The values have all been indexed with the 1960 SEDES estimate of 848.0 million tonnes as a base. (Note: the actual and intended output levels have been deflated in Figure 6.13.) The SEDES base estimate was that of normal required in 1960 and it has been compounded over the period at a rate of 2.7 percent which is consistent to maintain simple per capita availability levels of 1960 in light of simple population increases.

Year	Intended Output 000 mt	Relative Change t-1/t in %
1960	1111.1	
61	931.7	-16.1
62	1202.5	29.1
63	1225.5	1.9
64	992.4	-19.0
65	1012.4	2.0
66	1018.5	- .3
67	1065.7	4.6
68	1091.1	2.4
69	1494.0	36.9
70	1512.4	1.2
71	1529.2	1.1

The first aspect the aggregate cereal plots depicted in Figure 6.13 is the fact that the entire period can be divided into two distinctly separate periods, where the divergence came between the years 1967 and 1968. (Note the vertical dotted line in Figure 6.13.) Prior to this point, actual output levels were in excess of aggregate intentions each year except for 1960. Since 1968 actual levels of cereals output have fallen short of intentions. In terms of actual output levels and required levels, the first period, 1960-1967, can be characterized as prosperous. Actual cereals output varied around the long term required but essentially nets out as being in excess. Only three years were below and four were above; those above were exceedingly abundant. Looking towards the rainfall plots, this same period had only two years below the 12 year mean and these were marginally below. Those above however, were generally quite high.

The second period is 1968-1972. This period can only be described as disastrous insofar as actual output only exceeded required once (1969)[1]

[1]Actually, as previously discussed output was short in 1969 also when demand for stocks is considered.

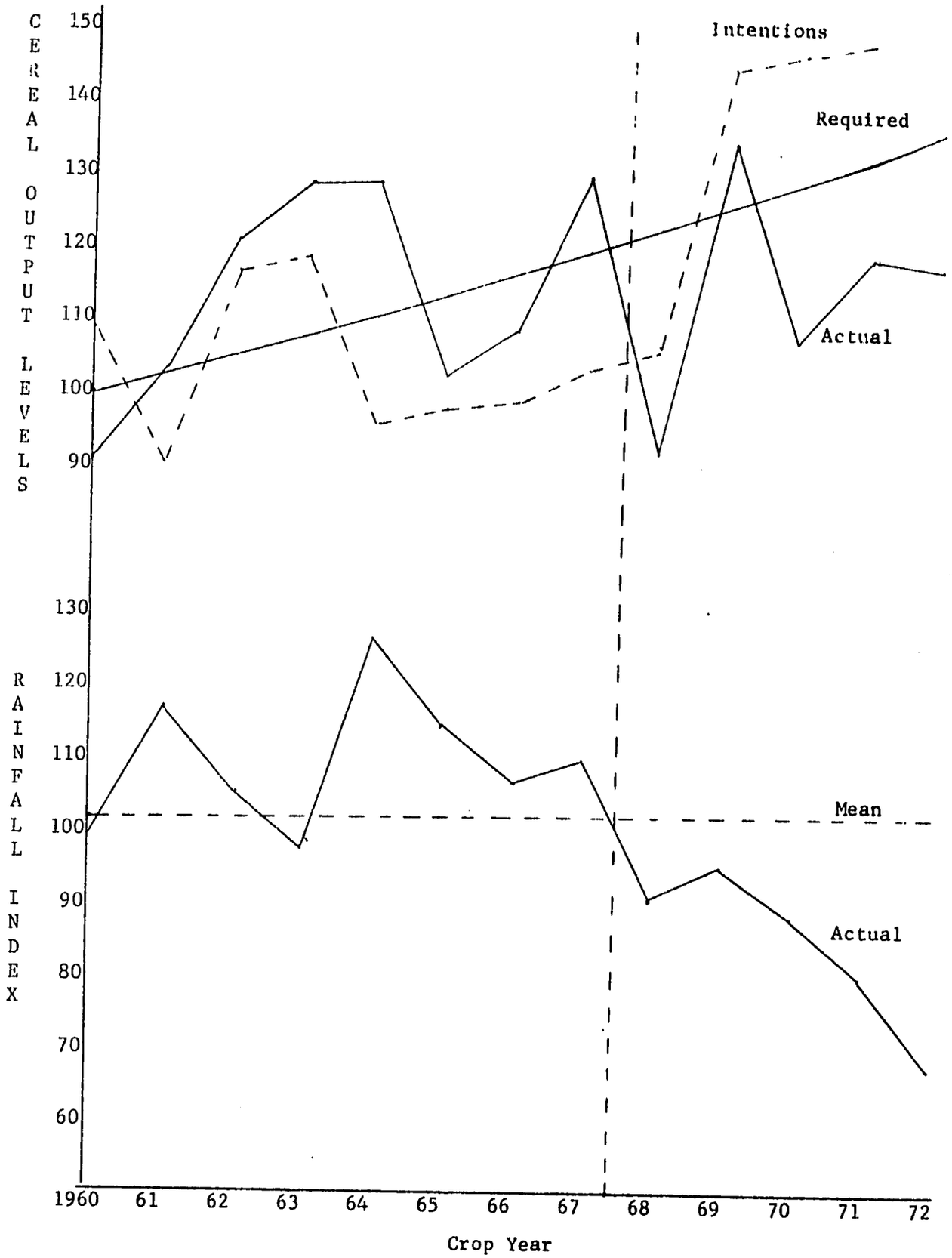

Figure 6.13 Niger -- Comparison of Cereal Output Levels and Rainfall (1960-1972)

Again looking towards the rainfall plot, the reason for this is clear. Since 1968, rainfall has been not only below the twelve year mean but decreasing. In short, aggregate production of cereals was abundantly high prior to 1968 and disastrously low since. This of course, is nothing new to those who are familiar with the situation. However, the plotted portrayal does provide a rather definitive perspective of the situation. However, the major purpose of the plot is to provide insight in the nature and adequacy of supply response.

To more fully understand the nature of supply response the entire observation period is considered not in two periods as previously mentioned but rather three periods. The first period includes the years 1960-63 when intentions fluctuated around the required level. The second period is the next five years, 1964-68, where intentions were consistently below the required levels. The last period is 1969 to 1971 and intentions were consistantly high. Also, to facilitate the comparisons and understand the response, prices will be alluded to on occasion. The prices referred to are the quarterly retail prices of cereals and are found in Appendix Table 3. While no producer prices of cereals were available, an average of the Nov-Jan and Feb-Apr quarterly retail prices are probably sufficient indicators of the general level producer prices which the affect allocation decisions.[1] Also, announced producer prices of groundnuts are considered. These can be reviewed in Appendix Table 13.

Supply response during the first period is a bit confusing. Part of the problem in interpretation stems from the inherent problems affixed with the manner in which intentions were determined.[2] Secondly, as this is the first period, little information is available to deduce the likely extent of stocks on hand for the first two years. Thus, only the response in 1962 and 1963 can be discussed with any degree of confidence.

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[1]Marketing margins are lowest at this point and these prices are those immediately prior to the period when budgeting of inputs is occuring for the next planting.

[2]The actual change in the area planted from 1960 to 1961 was less than a two percent decrease. Yet using the swing area criterion this resulted in 1960 being considered in with the high yield intentions and 1961 out and with the low yield intentions. This impact on yield intentions reflect approximately a 14 percent difference that in all liklihood did not exist. Nonetheless, the area planted did decrease in 1961 from the previous level and then abrubtly increased in 1962.

In 1962, intentions shifted to a level substantially above the required level. The major cause of the shift was in terms of subsistence demand resulting from the net deficit balance of actual output in terms of required for the two prior years. This upward shift in 1962 could also in part have resulted from the decreasing producer prices in groundnuts. Groundnut prices for both 1959/60 and 1960/61 were at 24.00 CFA/kg. They decreased in 1961/62 to 22.50 CFA/kg and were furthered decreased in the 1962/63 crop year to 21.00 CFA/kg. While no decrease in the area planted to groundnuts occured in the 1961 planting as a result of the first price drop, approximately 18,000 hectares were switched with regard to the second price drop. However, assuming this area was switched into cereals it would only have accounted for about 10 percent of the 177 thousand hectare increase in cereals planted during 1962. Obviously, the bulk of the increase had to have stemmed from other area, and this most likely was fallow.

Decreases in fallow require a substantial investment in labor in terms of clearing and burning. Thus, once brought in the land must be used to its greatest advantage. In short, unless cereals are extremely abundant, land brought into production will be used more than one season. Thus, even though the incresed intentions in 1962 were amply rewarded by normal rain and actual output was slightly in excess of intentions, the higher level of intentions remained into 1963. This higher level of intentions could also have been due to a shifting of land and labor from groundnuts production as the producer price for 1963/64 stayed at 21.00 CFA/kg and the area planted decreased further. In any event, again in 1963 rainfall was normal and actual output was in excess of intentions. As a result retail cereal prices were driven to their lowest level at harvest time (14 CFA/kg during the 1963/64 Nov-Jan quarter) and excess stocks were undoubtedly built up on private account. The major result of two successive years of actual output in excess of high level intentions was a sharp decrease in the level of intention which begins the second period.

In 1964, the level of intentions dropped nearly 25 percent. Cereals were much too abundant to continue the high land and labor inputs and land went back to fallow. Yet in 1964, the best rainfall year over the entire period occurred and the actual output level was far in excess of

both intentions and current requirements. Prices remained low and stocks on private account most certainly increased. Intentions in 1965 increased only slightly and while rainfall was more than adequate it was not sufficient enough to cause the high level of output as in 1964. Actual output from 1964 to 1965 dropped about 30 percent. Such a decrease, resulted in shortfalls in marketed supplies and retail prices beginning in the Nov-Jan quarter of 1965/66 were already increasing and continued to increase through the soudure season of 1966. However intentions in 1966 did not increase. This would lead some to believe that cereals are not responsive to the market. Such a conclusion is not warranted because much of the 1965/66 market year price increases can be attributed to speculation in markets. Stocks were held at too high levels for implicit prices to have increased the same extent as market prices. Also, the fact remains that while 1965 actual output dropped substantially, it was still in excess of intentions.

The low level of intentions in 1966 combined with normal rains resulted in actual output in excess of intentions. This level was also above the 1965 output level but less than current requirements. This latter fact implies that stocks on private account were being held as prices during the 1967 soudure did not rise appreciably above those which prevailed during the harvest. Had retail prices increased as they had during the 1966 soudure one might conclude that aggregate supplies in 1966 had been short. However, with aggregate supply conditions being similar for the two years and no sharp soudure season price rises in 1967 plus the lack of response of producers in 1966 intentions all suggest that the market price rise in 1966 was due to speculative conditions which stemmed from the abrubt drop in actual output from the previous abnormally high levels of 1963 and 1964.

Intentions in 1967 increased about five percent. The reason is not clear as the average prices prior to the season (Nov-Jan and Feb-Apr) had dropped to 15.5 CFA/kg in retail markets, a level similar to those prevalent during the abundant years earlier. Producer prices for groundnuts had dropped to their lowest level over the entire period, yet no decrease in the area planted occured in groundnuts. Thus, the increase in cereals must have been a simple expansionary move although five percent is a bit too high. Nonetheless, rainfall was normal and actual output

was far in excess of both intentions and current requirements. Price levels were again driven down, stocks on private account accrued and 1968 intentions continued at their low level.

The year 1968 was not a particularly abnormal year as production was concerned. This may seem surprising in light of the fact that the 1968 actual output had dropped about 43 percent from the previous year, was about 35 percent below current requirements and for the first time in eight years actual output had dropped below intentions. Nonetheless, intentions were low and rainfall was below average. In fact, the seriousness of the situation again was confined to only those dependent on marketed supplies. Prices at the harvest time were not particularly high, 19 CFA/kg, but after that supplies simply dried up. By the 1967 Feb-Apr quarterly price level, just three months later, they had risen to 48 CFA/kg and continued at this high level through the 1969 soudure. While the producer consumer segment did not reduce consumption particularly, the low level of 1968 certainly required a heavy draw down on stocks. Thus, 1969 intentions shifted abrubtly.

The increased intentions in 1969 begin the final period. That year, intentions increased about 37 percent. Such an increase is no doubt surprising to many who feel that traditional agriculture can not respond abrubtly and therefore requires further explanation. At the end of the 1963 crop year, approximately 147 thousand hectares shifted out of cereals production. This area as previously discussed was likely returned to fallow. Over the intervening years, 1964 to 1967, the area planted to cereals increased at an average rate of 2.42 percent annually, A rate totaly consistent with normal growth resulting from increased populations. However, the land shifted out remained in fallow over the period.

The increase in 1969 intentions was comprised of about a 17 percent increase in area planted or roughly 344 thousand hectares. In spite of an increase in the announced producer price of groundnuts for 1969, approximately 112 thousand hectares were switched into cereals production. This crop shifting accounts for about one third of the increase. The remaining two thirds, about 232 thousand hectares stemmed from the previous intensity on fallow being renewed and accounting for about 45 percent. The remaining amount probably represents an increase in fallow intensity above the 1963 level.

The remaining 17 percent increase in 1969 intentions resulted from an increase in intended yields. Some of this may have stemmed from a capital carryover from the better quality land usually planted to groundnuts. However, the bulk results from increased labor per hectare during the crucial weeding process. The source of the labor, resulted from decreased economic leisure as the marginal value product of labor in cereals had increased substantially as a result of increased implicit prices. Returning labor from the coast as a result of their opportunity cost being greater at home and increased labor allocations to cereals with regard to cash crops.

Perhaps the most obvious proof that such an abrubt adjustment can occur is the simple fact that in spite of a less than average rainfall, 1969 output was at an all time high.

Granting the return of 1969 actual output in line with requirements and prices dropping off, it did not meet intentions. Thus, in 1970 intentions stayed high. Again, the tendency to build buffer stocks back up coupled with the tendency to use the newly cleared land to its greatest economic value were the major reasons for the continuation of high level intentions. Unfortunately 1970 rains again failed and 1971 intentions remained high. While, 1972 intentions were not determined it is fairly obvious in light of 1971 rainfall that they certainly would not have appreciably decreased. Nor would they have decreased in light of the 1972 rainfall levels and consequent shortfalls.

Thus, the nature of aggregate cereals response over the past decade has been quite consistent with regard to what normally is expected in a subsistence dominated crop. Also, the response with regard to relative product market prices appears to be consistent ans one is led to a position of failing to accept a null hypothesis that they do not respond to market price incentives.

With respect to the adequacy of the response, one can conclude that during the previous period the response of producers has been adequate. If intentions had been consistently achieved no widespread deficits would have occured. Thus, one is led to a position of fail to accept the null hypothesis that cereals response over the period has been inadequate. Unfortunately, while the aggregate response has been sufficient in the past, it likely will be inadequate in the very near future. This position is discussed next.

6.4 Future Production Levels

This subsection includes the forecasts of future production levels in the two countries. In the case of Niger, the results of the models are used in making the projections as well as the insight obtained with the comparisons of outputs in the past which provide information concerning the types of constraints. In the case of Upper Volta, the projections are really nothing more than rough approximations of the likely magnitude of trends which may prevail under various assumptions. Also, the nature of response identified in Niger, provides insight into formulating the future for Upper Volta.

In both countries, the future weather variable is assumed normal. That is, no sustained decreases in rainfall are anticipated. Such a position in making forecasts, lends a certain degree of short run optimism in the forecasts, as the inclusion of an assumption on decreasing rainfall would certainly have a calamitous impact. However, with the failure of the rainfall analysis to reject the hypothesis that a climatic shift is occuring, this author feels obligated to touch briefly on the possible ramifications of such a shift.

First assume that the implications of the rainfall analysis are correct and the sahel is narrowing. That is, annual average rainfall levels are decreasing in the northern extreme and staying constant (or possibly increasing slightly) in the south. Second, assume that the shift is completed at some new equilibrium levels. (No one is suggesting that the Sahara will continue to advance to the coast.) Thus, the sahel rainfall gradient will be steeper then the gradient presently found. This means that for any given location in the sahel a new average level of rainfall and annual variability will prevail. This in turn means that previous cropping patterns will be changed. Areas in the northern extreme will no longer have adequate moisture to allow a millet/livestock operation but will change to livestock/millet operations. The millet /livestock operations will be pushed south. (Again, millet/livestock operations are considered as rural sedentary and livestock/millet operations are rural semi-nomadic.) Similarly, those population segments in the middle range who grow mostly cereals and trade for livestock products will be pushed further south as the change in the average level of rainfall will not provide sufficient moisture. Lastly, those areas

in the south may find average levels of rainfall insufficient to grow cash crops and the adjustment will be to cereals. Thus, in the aggregate sahel the long run adjustment may net out with a similar level of aggregate cereals being produced. However, such a long run adjustment process will cause severe problems in the short run.

With the land held by use claims, simple transfers of land will be difficult. Yet out of necessity groups in the north will be continually infringing on land to the south. Undoubtedly, pressures will build and periodic strife between segments of the population will ensue. With respect to aggregate cereals output in the short run, the areas in the south currently raising cash crops will find the probabilities of successfully raising a crop being reduced and a natural tendency to shift to cereals will be present. If this is allowed to occur then aggregate cereals output in the short run may not be severely depressed. However, if the governments offset this tendency by increasing producer prices in a manner that the increased uncertainty of the crop is compensated, then further pressures will be placed on aggregate cereal supplies. A final major adjustment in the short run will be increasing numbers of essentially landless peoples as the absolute cultivatable area in the sahel decreases. They will likely go to urban areas, therebye introducing a new problem to these countries. Other adjustment problems will undoubtedly occur. However, no further speculation will be offered here, as the intent was simply to provide an indication of the seriousness of the problems which would prevail if a climatic shift were in fact occuring. It is clear, that more work on this question needs to be done.

6.4.1 Future Output -- Niger

The future output levels of aggregate cereals in Niger are projected on the basis of extrapolating the trend in intended output levels with the assumption that long run rainfall will be normal. Variability of the output levels estimated, stem from the elasticity coefficient estimate of rainfall on intended yields in conjuction with normal rainfall variability. Tests of adequacy of future output levels are determined by placing them into perspective with projected requirements. This perspective provides a temporal estimate of the point where intentions will be no longer adequate. Finally provided, are the reasons why inadequacy will prevail.

A trend in intentions of aggregate cereals output under the assumption of normal weather provides a better estimate of the future then simply extrapolating growth rates of actual production derived from a relatively brief observation period. Abnormal temporal dimensions of weather during the period may affect the apparent trends. Such was the case in Niger. Abnormal low rainfall in the latter part of the period of observation boosted the area planted and depressed actual yields. Thus, the simple trend in area was above the true long run trend and the simple trend in yields was negative whereas the rainfall adjusted trends were not in both the models. Thus the trend used in making projections is the one which stems from combining the rain adjusted trends from the models. That is, the rain adjusted trend in the area planted is multiplied by the rain adjusted trend in aggregate productivity.

The rain adjusted trend in the area planted is the one estimated from Model 2 and equals 1.86 percent. Model 1, provided a reduced trend, 1.55 percent, where the early rainfall was accounting for some of the increase. Insofar as early rainfall was found to be not significant, Model 2 was deemed more appropriate. While the trend in Model 2 is higher (although probably not significantly) it is substantially below the simple trend of 2.98 percent. Again this is because the simple trend includes the average of the shift that occured in 1969. This type of flexibility in shifting is no longer available. Returning briefly to Figure 6.13, two periods of increased area are important in substantiating the 1.86 percent level.

During the low level of intentions (1964-1968), the average increase in the area planted was 2.42 percent. Such a rate is consistent with simple population expansion in rural sedentary sector after net migration is considered with respect to a population growth rate of 2.7 percent. In short, expansion in output was purely subsistence and obtained via increased area and constant intended productivity. The next period is the most recent one, 1969-1971. Then, area increased an average of 1.6 percent. Obviously, the shifting in of the fallow has impaired the rate of increase in the area planted and land has become a technical constraint. If land were still abundant in fallow the rate in increase would be higher in recent years. Insofar as it is unlikely that sufficient surplus will accrue in the immediate future such that the swing area be shifted back to fallow is occured after

1963, the trend of 1.86 if anything may be a bit optimistic. (This assumes no abrubt shifts in groundnut producer prices which if substantially decreased would result in short run shifts.)

The rain adjusted trend in aggregate productivity from Model 3 was .88 percent and from Model 4, .06 percent. In both cases, the trends were found to be not significantly different from zero. In fact, for all intents and purposes, Model 4 estimated the trend was zero. Thus, no long run trend in aggregate productivity is assumed but will continue as a constant. (This substantiates a position that new technology introdued into sahelian cereals is not being adopted unless that which is being adopted is being offset by decreased traditional inputs per hectare which is very unlikely.) Therefore, the trend in intended aggregate output over the period is then projected at about 1.9 percent annual. This trend however requires a base year to be compounded from and that in turn requires specification of a level of area and yield to be posited. The year selected is 1971.

The year 1971 was the last year that intentions were historically forecasted. The actual area planted that year was 2,428,100 deflated hectares which included both fallowed reserve and part of the area switched from groundnuts in 1969.[1] The estimated intended productivity for 1971 was 521 kg/ha. Together they provided an indexed estimate of intended output at 149.1. (Base, was the 1960 normal required.) This level will serve as the first base of the projections and assumes that in light of continuing shortages in the short run, that both the reserve fallow will stay in production and the higher level of intentions in productivity will prevail. However, some may wish to dispute the high level yield intentions. Thus, a second initial base index is extended that assumes a constant level of intentions at the simple average determined in Model 4 of 483 kg/ha. This level essentially discounts the arguement of increased inputs per hectare as measured by the swing area approach of

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[1]In both 1970 and 1971 in response to increased producer prices for groundnuts, the area planted to groundnuts increased about 30 thousand hectares each year. Thus, in light of further increases in the area to cereals, the intensity on fallow these years must have intensified.

Model 3. It is a more conservative estimate of intentions where the base index value is about 138.2. Both base levels of intentions of aggregate cereals were compounded with the trend estimate of 1.86 percent and are presented in Figure 6.14. The high level of forecasted intentions are labeled as Forecast 1 and the low level, Forecast 2.

Also presented in Figure 6.14 are the variability limits of the forecasts. Only the upper bound of the high level projection and the lower bound of the low level projection have been plotted for the sake of clarity. The variability limits were calculated simply on the basis of the impact of normal rainfall variation. From the analysis of yields it was found that a one percent decrease in rainfall resulted in approximately a one percent decrease in aggregate yields. (In Model 3, the estimate was higher and in Model 4, lower.) In the examination of rainfall, the coefficient of variation of the Niger index was about 16 per cent. This is an approximate estimate of normal variation which can be expected and therefore provides an estimate of the impact on actual output.

Finally, Figure 6.14 includes an approximation of future requirements. This again is based only on population growth which in turn will provide the same per capita output for the population. It is a simple extension of the trend in Figure 6.13.

Immediately, from Figure 6.14 the importance of rainfall levels in determining actual output can be seen. This wide band around the estimates will lead some to conclude that these estimates are really no estimates at all. However aside from the skeptism, the point is that the sahel has extremely variable rainfall from year to year and this in turn leads to extreme divergence between actual output and intentions from year to year and still be normal. The major point of Figure 6.14 is the temporal dimensions of adequacy of aggregate response, however.

Granting the high level yield intentions and that the fallow reserve will stay in cereals production, intentions can be considered adequate until 1984. At that time aggregate intentions will no longer be adequate without the introduction of new technology which will increase output per hectare. Assuming, that the high level intentions are not realistic and that the mean yields are more appropriate results in the year 1975 being the point of intentions falling short of requirements. Both estimates unfortunately are not conducive to optimism for the cereal situation in Niger and we must fail to reject a hypothesis that intentions will be inadequate in light of required.

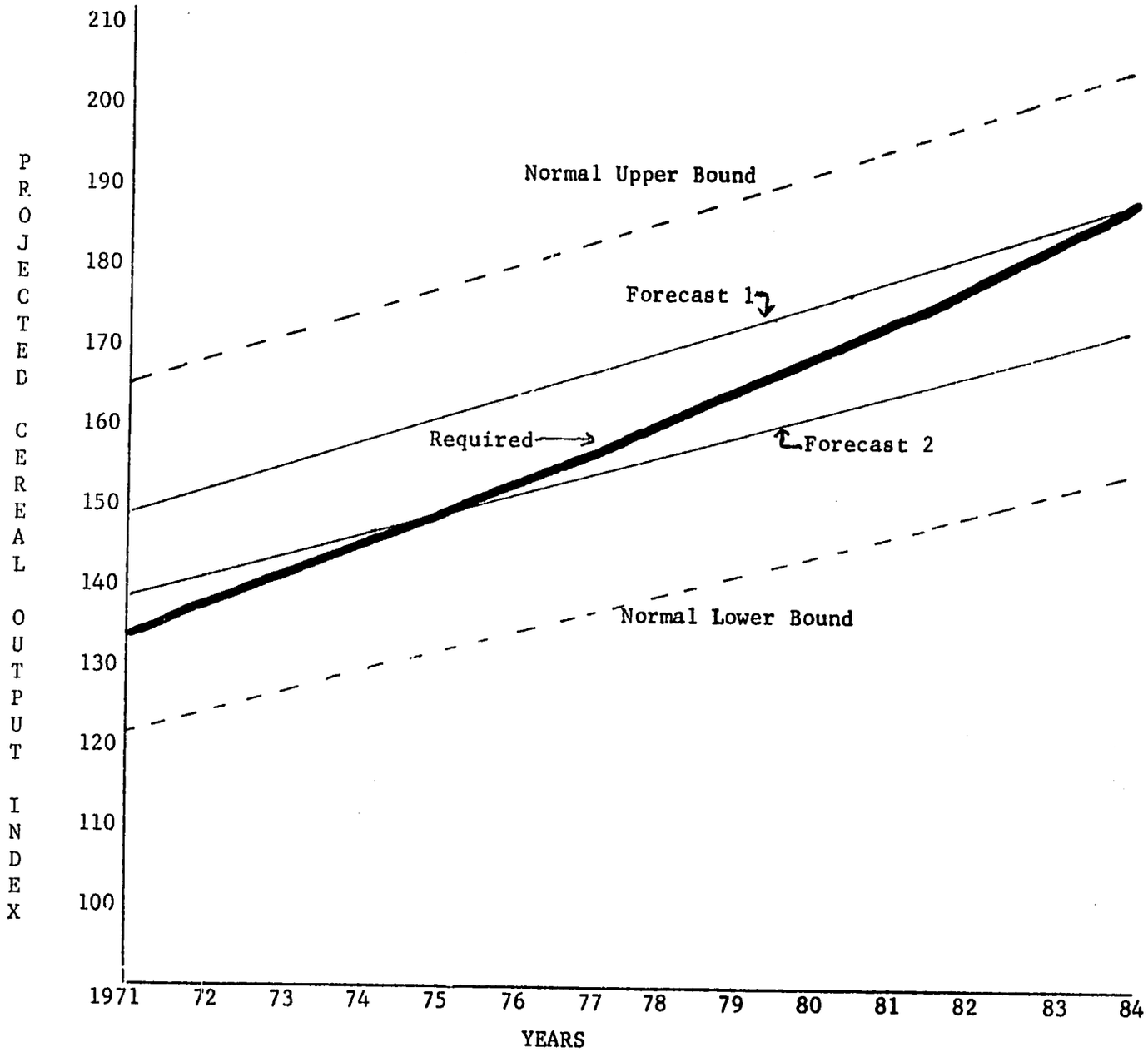

Figure 6.14 Niger -- Projected Cereals Output Levels

6.4.2 Future Output -- Upper Volta

Forecasting specific future output levels of conbimed sorghum and millets in Upper Volta is a difficult task indeed. First, the aggregate data was found to be insufficient to accurately determine the impact of rainfall over the past or to determine the nature and extent of supply response. Second, the aggregate in Upper Volta represents substantial diversity in the context of rainfall patterns and thus in terms of cropping patterns and alternatives. In light of these problems, any forecast of a specific level of output or even a trend would necessitate so many assumptions that they would be impractical. Thus, only a general statement concerning the likely output levels in Upper Volta is extended.

For Upper Volta as a whole, the available evidence suggests that future levels of combined sorghum and millet will be adequate in the future assuming normal weather. Such a position is based on the past simple trends that prevailed in both aggregate area and aggregate productivity.

The simple trend in aggregate area of combined cereals was found to be about 2.25 percent over the period 1957 to 1970. Decreases in rainfall in the latter part of this observation period may have accounted for some of this increase as a result of normal supply in the subsistence sector. Yet, this same trend fits the data quite well for an earlier period 1957-1962. Perhaps at best, we can conclude that the rate of expansion in the area planted to sorghum and millets is at least comparable to that of the population growth rate of 1.9 percent. Such a rate suggests that either net migration is not a constraint as it appears to be in Niger or the population growth rate is underestimated.

The simple trend in aggregate productivity over the period 1957 to 1970 was 1.40 percent. Again, this may reflect a supply response element of decreased inputs per hectare in 1957 and increased inputs per hectare in 1970. Assume that this was the case. In 1970, average productivity per hectare was 499 kg/ha in light of a 13 percent decrease in the Upper Volta rain mean. If the rainfall impact is about the same in Upper Volta as in Niger, than the rain adjusted 1970 yield would be about 564 kg/ha. In 1957, average productivity per hectare was 417 kg/ha in light of a 5.5 percent increase. From the same 1-1 impact of rainfall

on yields assumptions as above, the rain adjusted yield would have been about 395 kg/ha. (In 1961, the rain index value was 100.7 and average yield was 398 kg/ha which tends to support the assumption.) Next, assume that a 14 percent level differential between high and low intentions exists in Upper Volta as in Niger. Applied to the 1957 average adjusted by rain the level would be about 454 kg/ha. Thus, with both years approximated as rain adjusted high level intentions a simple average annual increase can be obtained. For the entire period it means about a 24 percent increase; this in turn on an annual average is about 1.5 percent. A rate very similar to the simple trend.

Combining the various trends to obtain a trend for aggregate output in sorghum and millets would result in a range of 3-4 percent annual increase. If this were in fact true, then future output levels of cereals in Upper Volta would not be a problem as this rate of increase is more than adequate to maintain per capita. While this author believes this type of increase is high, one can conclude that given normal rainfall Upper Volta appears as though it should not have problems in maintaining aggregate per capita output levels in the near future.

APPENDIX

APPENDIX
TABLE 1

ANNUAL SORGHUM, MILLET AND COMBINED SORGHUM AND MILLET PRODUCTION AREA AND YIELDS FOR THE PERIOD 1960-71 IN NIGER

	Sorghum			Millet			Combined		
Year	Prod (000 mt)	Area (000 ha)	Yield (kg/ha)	Prod (000 mt)	Area (000 ha)	Yield (kg/ha)	Prod (000 mt)	Area (000 ha)	Yield (kg/ha)
1960	221.7	439.8	504	718.5	1692.9	424	940.2	2132.7	441
1961	275.4	453.5	607	780.7	1640.1	476	1056.1	2093.6	504
1962	315.0	463.5	680	934.0	1844.5	506	1249.0	2308.0	541
1963	352.0	484.7	727	977.1	1867.5	523	1329.8	2352.2	565
1964	315.4	453.0	696	1013.4	1777.0	570	1328.8	2230.0	596
1965	265.6	465.0	571	789.5	1810.0	436	1055.1	2275.0	464
1966	277.1	545.7	508	841.8	1743.0	483	1118.9	2288.7	489
1967	342.2	530.2	645	1000.1	1864.6	537	1342.3	2394.8	561
1968	215.1	556.8	386	732.6	1895.2	387	947.7	2452.0	387
1969	289.3	595.6	486	1095.4	2271.9	482	1384.7	2867.5	483
1970	230.2	593.1	380	870.9	2309.8	377	1101.1	2902.9	379
1971	266.8	579.3	461	958.5	2355.8	407	1225.3	2935.1	418

Source: Director of Agriculture, Ministry of Rural Economy, Republic of Niger

APPENDIX TABLE 2

NIGER - CALCULATED INDICES[1] OR SORGHUM, MILLET AND COMBINED SORGHUM AND MILLET ANNUAL PRODUCTION, AREA AND YIELD FOR THE PERIOD 1960-71

	Sorghum			Millet			Combined		
Year	Prod	Area	Yld	Prod	Area	Yld	Prod	Area	Yld
1960	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
61	124.2	103.1	120.4	108.7	96.9	112.3	112.3	98.2	114.4
62	142.1	105.4	134.9	130.0	109.0	119.3	132.8	108.2	122.8
63	159.1	110.2	144.2	136.0	110.3	123.3	141.4	110.3	128.2
64	142.3	103.0	138.1	141.0	105.0	134.4	141.3	104.6	135.2
65	119.8	105.7	113.3	109.9	106.9	102.8	112.2	106.7	105.2
66	125.0	124.1	100.8	117.2	103.0	113.9	119.0	107.3	110.9
67	154.4	120.6	128.0	139.2	110.1	126.7	142.8	112.3	127.1
68	97.0	126.6	76.6	102.0	111.9	91.3	100.8	115.0	87.7
69	130.5	135.4	96.4	152.5	134.2	113.7	147.3	134.5	109.5
70	103.8	134.9	75.4	121.2	136.4	88.9	117.1	136.1	86.1
71	120.3	131.7	91.5	133.4	139.2	96.0	130.3	137.6	94.7

[1]base year 1960

Source: calculated from Appendix Table 1.

APPENDIX TABLE 3

QUARTERLY CONSUMER SALES PRICES OF SORGHUM AND MILLET FOR THE PERIOD 1960/61-1969/70 IN NIGER

Market Year	Prices (CFA/kg) Quarters: Nov-Jan	Feb-Apr	May-Jul	Aug-Oct
1960/61	15	23	25	18
61/62	15	20	21	18
62/63	18	15	18	19
63/64	14	15	17	15
64/65	15	15	18	17
65/66	21	31	45	36
66/67	20	22	22	22
67/68	16	15	15	16
68/69	19	48	45	28
69/70	21	24	N.A.	N.A.

Source: 1) Data from page 17, unclassified Capital Assistance Paper (AID-DLC/p-1039
2) Original source unknown.

APPENDIX TABLE 4

ANNUAL SORGHUM, MILLET AND COMBINED SORGHUM AND MILLET PRODUCTION, AREA AND YIELDS FOR THE PERIOD 1957-70 IN UPPER VOLTA

	Sorghum			Millet			Combined		
Year	Prod (000 mt)	Area (000 ha)	Yield (kg/ha)	Prod (000 mt)	Area (000 ha)	Yield (kg/ha)	Prod (000 mt)	Area (000 ha)	Yield (kg/ha)
1957	NA	NA	NA	NA	NA	NA	589.6	1415.4	417
1958	NA	NA	NA	NA	NA	NA	579.0	1311.3	442
1959	NA	NA	NA	NA	NA	NA	586.0	1401.0	418
1960	NA	NA	NA	NA	NA	NA	849.2	1535.3	553
1961	410.7	907.6	410	194.9	615.3	315	605.6	1522.9	398
1962	508.3	1041.0	488	261.5	596.9	437	769.8	1637.9	470
1963	719.3	1303.0	552	315.7	823.0	383	1035.0	2126.0	487
1964	877.7	1404.0	625	377.7	806.5	492	1255.4	2210.5	568
1965	779.0	1237.5	630	410.0	540.0	759	1189.0	1777.3	669
1966	700.0	1248.3	561	316.0	510.3	519	1016.0	1758.6	578
1967	498.1	825.8	603	223.9	619.1	362	722.0	1444.9	500
1968	498.3	905.5	550	287.6	529.2	543	785.7	1434.7	548
1969	507.0	NA	NA	382.0	NA	NA	889.0	NA	NA
1970	566.0	104.3	544	377.0	850.1	443	943.0	1891.4	499

Sources: 1957-64 Director of Agricultural Services
1964-70 Director of Rural Development
Data actually compiled from a number of secondary sources including the Weitz-Hettelsater Study, KSU study, Economic Report "Production" and mimeographed copy of "Statistiques Agricoles - 1970". (see references cited)

APPENDIX TABLE 5

UPPER VOLTA - CALCULATED INDICES[1] OF SORGHUM, MILLET AND COMBINED SORGHUM AND MILLET ANNUAL PRODUCTION, AREA AND YIELD FOR THE PERIOD 1957-70

	Sorghum			Millet			Combined		
Year	Prod	Area	Yld	Prod	Area	Yld	Prod	Area	Yld
1957	NA	NA	NA	NA	NA	NA	97.36	92.94	104.76
58	NA	NA	NA	NA	NA	NA	95.61	86.11	110.03
59	NA	NA	NA	NA	NA	NA	96.76	92.00	105.17
60	NA	NA	NA	NA	NA	NA	140.22	100.81	139.09
61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
62	123.76	114.70	107.90	134.17	97.01	138.31	127.11	107.55	118.19
63	175.14	143.57	122.00	161.98	133.76	121.10	170.90	139.60	122.42
64	213.71	154.69	138.15	193.79	131.07	147.85	207.30	145.15	142.82
65	189.68	136.33	139.13	210.36	87.76	239.70	201.66	116.70	172.80
66	170.44	137.54	123.92	162.13	82.94	195.48	172.32	115.48	149.22
67	121.29	90.99	133.34	114.89	110.62	114.82	122.46	94.88	129.07
68	121.33	99.77	121.61	147.57	86.01	171.58	133.27	94.21	141.46
69	123.45	NA	NA	196.00	NA	NA	146.80	NA	NA
70	137.81	114.73	120.12	193.43	138.16	140.00	155.71	124.20	125.37

[1]Base year 1961

Source: calculated from Appendix Table 4

APPENDIX TABLE 6

QUARTERLY CONSUMER SALES PRICES OF SORGHUM AND MILLET FOR THE PERIOD 1960/61-1969/70 IN UPPER VOLTA

Market Year	Prices (CFA/kg) Quarters: Nov-Jan	Feb-Apr	May-Jul	Aug-Oct
1960/61	18	20	22	20
61/62	19	19	16	17
62/63	19	26	29	27
63/64	22	22	30	25
64/65	22	21	25	30
65/66	20	20	29	26
66/67	26	27	31	19
67/68	24	24	30	35
68/69	29	24	34	31
69/70	35	30	NA	NA

Source: 1) Data from page 17, unclassified Capital Assistance Paper (AID-DLC/p-1039)
2) Original source unknown.

APPENDIX TABLE 7

LIST OF RAINFALL STATIONS USED IN THE INDICES AND LOCATION BY DEPARTMENTS IN NIGER

Department	Rainfall Station
I. Niamey	1. Ayouou
	2. Gotheye
	3. Filingue
	4. Koio
	5. Mangayze
	6. Niamey-Aero
	7. Niamey-Ville
	8. Ouallam
	9. Say
	10. Tillabery
	11. Toukounous
II. Dossa	1. Dosso
	2. Gaya
	3. Tibiri
III. Tahoua	1. Bangui
	2. Birni N'Konni
	3. Bouza
	4. Illela
	5. Madaoua
	6. Tahoua
IV. Maradi	1. Kornaka
	2. Maradi
	3. Durafane
	4. Tessaoua
V. Zinder	1. Belbedji
	2. Goure
	3. Guedimouni
	4. Ollelewa
	5. Zinder
VI. Diffa	1. N'Guigmi
	2. Maine Soroa
VII. Agades	1. Agades
	2. Bilma

APPENDIX TABLE 8

LIST OF RAINFALL STATIONS USED IN THE INDICES AND LOCATION BY ORD AND BY CERCLE IN UPPER VOLTA

ORD	Rainfall Station	Cercle
I. Bobo-Dioulasso	1. Benan Keledoga	Bobo-Dioulasso
	2. Bobo-Dioulasso	Bobo-Dioulasso
	3. Boromo	Boromo
	4. Dionkele	Orodara
	5. Farako-Ba	Bobo-Dioulasso
	6. Hounde	Hounde
	7. Nasso	Bobo-Dioulasso
	8. Orodara	Orodara
II. Bougouriba	1. Batie	Gaoua
	2. Dano	Diebougou
	3. Diebougou	Diebougou
	4. Gaoua	Gaoua
	5. Kampti	Gaoua
III. Centre-Est	1. Garango	Garango
	2. Koupela	Koupela
	3. Tenkodogo	Tenkodogo
IV. Est	1. Bogande	Bogande
	2. Diapaga	Diapaga
	3. Fada N'Gourma	Fada N'Gourma
	4. Kantchari	Diapaga
	5. Pama	Fada N'Gourma
V. Koudougou	1. Koudougou	Koudougou
	2. Leo	Leo
	3. Saria-Agric	Koudougou
	4. Yako	Yako
VI. Ouagadougou	1. Gilougou	Zinare
	2. Kamboince	Ouagadougou
	3. Kombissiri	Kombissiri
	4. Manga	Manga
	5. Ougadougou-Areo	Ouagadougou
	6. Ougadougou-Ville	Ouagadougou
	7. Pabu	Ouagadougou
	8. Po	Po
	9. Saba	Ouagadougou
	10. Zabre	Zabre
	11. Zorgho	Zorgho
VII. Plateau Mossi	1. Bam	Kongoussi
	2. Kaya	Kaya
	3. Tougouri	Boulsa

Appendix Table 8 Continued --

ORD	Rainfall Station	Cercle
VIII. Sahel	1. Aribinla	Djibo
	2. Bani	Dori
	3. Djibo	Djibo
	4. Dori	Dori
	5. Gorgadji	Dori
	6. Gorum-Gorum	Ouadalan
	7. Markoye	Ouadalan
	8. Sebba	Dori
IX. Sud-Quest	1. Banfora-Agric	Banfora
	2. Niangoloko	Banfora
	3. Sideradougou	Banfora
X. Volta-Noire	1. Dedougou	Dedougou
	2. Nouna	Nouna
	3. Tougan	Tougan
XI. Yatenga	1. Gourcy	Gourcy
	2. Ouahigouya	Ouahigouya

APPENDIX TABLE 9

NIGER - APR/OCT RAINFALL INDICES[1] BY DEPARTMENT AND FOR NIGER FOR THE PERIOD 1960-72

Year	Department							Niger
	Niamey	Dosso	Tahoua	Maradi	Zinder	Diffa	Agadez	(wtd)[2]
1960	91.3	106.2	97.0	106.2	107.8	99.3	104.4	99.8
61	111.1	103.2	117.1	118.3	134.0	172.7	161.2	117.3
62	108.2	103.8	113.3	95.6	104.3	114.4	122.6	105.8
63	101.1	100.2	91.6	94.6	97.5	87.7	132.9	97.9
64	130.1	115.3	114.9	124.0	135.8	140.5	116.3	126.2
65	124.4	107.4	117.0	120.8	100.1	68.5	110.0	114.3
66	98.6	104.4	107.2	122.8	109.0	131.9	78.0	106.8
67	125.5	104.6	112.4	103.7	83.9	110.0	112.3	109.4
68	93.1	100.9	81.5	84.7	90.4	74.8	133.1	90.8
69	92.9	104.1	101.0	97.4	91.3	53.8	66.6	95.1
70	78.3	85.6	108.3	97.5	87.5	121.5	32.3	88.7
71	77.9	91.6	71.8	74.3	86.8	72.0	65.3	80.4
72	67.5	72.9	66.9	60.1	71.6	53.3	65.0	67.6

[1]Base for the indices are the individual department means over the thirteen year period.

[2]Niger series is a weighted average of the departments where the departmental weight were the relative proportion of average total sorghum and millets planted in 1970 and 1971.

Source: Indices calculated from original rainfall data provided by the Meteorologie Nationale, Republique Du Niger.

APPENDIX TABLE 10

NIGER - APR/JUL WEIGHTED RAINFALL INDEX SERIES[1] FOR THE PERIOD 1960-72

Year	Index Value	Year	Index Value
1960	116.6	1967	95.2
61	113.2	68	118.9
62	115.0	69	95.9
63	96.6	70	90.3
64	124.1	71	63.9
65	101.3	72	70.8
66	94.5		

[1]Base for the series were the individual department means over the thirteen year period and the weight given to each department in constructing the all Niger Index was its relative proportion of average total sorghums and millets planted in 1970 and 1971.

Source: Index calculated from original rainfall data provided by the Meteorologie Nationale, Republique Du Niger.

APPENDIX TABLE 11

UPPER VOLTA - APR/OCT RAINFALL INDICES[1] BY ORD AND FOR UPPER VOLTA FOR THE PERIOD 1956-72

Year	ORD: Bobo Dioulasso	Bougouriba	Centre-Est	Est	Koudougou	Ouagadougou	Plateau Mossi	Sahel	Sud-Quest	Volta Noire	Yatenga	Upper Volta (Wtd.)[2]
1956	95.5	82.5	103.2	97.1	107.6	110.9	104.1	115.8	81.9	110.4	116.0	105.5
1957	119.9	105.5	121.0	106.9	111.6	112.4	93.8	114.3	110.1	97.1	111.8	108.5
1958	101.5	74.6	100.5	103.9	118.8	97.3	127.2	114.8	79.6	115.8	119.1	108.4
1959	81.7	92.3	93.2	121.4	98.4	96.7	92.6	119.9	97.2	87.9	99.3	98.0
1960	107.6	95.2	77.7	98.3	100.8	98.9	96.3	100.0	91.6	98.4	105.4	98.6
1961	95.3	83.4	119.0	105.3	95.6	92.8	119.3	119.8	74.9	98.4	100.4	100.7
1962	94.7	115.4	112.0	110.5	112.6	121.2	102.3	97.8	118.2	119.3	120.6	112.7
1963	103.6	133.0	94.7	105.5	105.6	95.9	101.5	108.6	122.6	110.6	111.2	106.1
1964	116.5	99.4	94.8	111.2	113.4	108.8	117.0	118.6	112.9	107.7	95.0	109.1
1965	106.5	103.1	97.7	96.0	77.2	96.0	122.2	114.4	111.8	114.0	109.4	101.7
1966	94.0	108.2	99.4	93.3	90.3	85.5	94.4	103.7	111.9	95.3	86.8	93.4
1967	93.9	88.7	114.8	88.8	83.6	101.8	97.7	90.7	92.5	97.0	92.9	94.3
1968	103.5	128.3	95.9	105.9	113.4	97.2	93.8	81.6	112.8	98.7	96.5	102.0
1969	102.8	112.5	96.3	100.9	112.2	105.7	96.7	100.0	98.4	94.9	91.6	102.2
1970	109.3	98.3	90.5	92.4	84.9	92.1	72.4	73.5	101.0	90.5	70.8	86.6
1971	87.8	87.2	100.4	74.0	87.3	88.7	87.3	63.1	90.5	90.0	83.5	85.6
1972	85.8	92.4	89.0	88.7	86.5	98.3	81.5	63.7	92.2	74.0	89.7	86.6

[1] Base for the indices are the individual ORD means over the seventeen year period.

[2] The Upper Volta is a weighed average of the ORDs where the ORD weights were the relative proportion of average total sorghum and millets planted area in 1970.

Source: Indices were calculated from original rainfall data provided by the Service Meteorologique, ASECNA, Govt. of Haute Volta.

APPENDIX TABLE 12

CORRELATION MATRIX OF ORD RAIN INDICES

ORD \ ORD	Bobo-Dioulasso	Bougouriba	Centre-Est	Est	Koudougou	Ouagadougou	Plateau Mossi	Sahel	Sud-Quest	Volta-Noire	Yatenga
Bobo-Dioulasso											
Bougouriba	.30										
Centre-Est	.02	-.12									
Est	.21	.27	.09								
Koudougou	.35	.23	.10	.62							
Ouagadougou	.29	.13	.34	.43	.57						
Plateau Mossi	.21	-.21	.28	.36	.31	.16					
Sahel	.29	-.08	.28	.70	.40	.28	.73				
Sud-Quest	.37	.87	-.08	.28	.11	.21	-.14	.01			
Volta-Noire	.37	.15	.25	.35	.45	.42	.73	.58	.25		
Yatenga	.14	.03	.29	.49	.54	.57	.64	.62	.04	.74	

APPENDIX TABLE 13

OFFICIAL PRODUCER PRICE OF GROUNDNUTS IN MARADI WITHOUT SHELLS
(1959/60 - 1969/70)

CROP YEAR	CFA/KG
1959/60	24.00
60/61	24.00
61/62	22.50
62/63	21.00
63/64	21.00
64/65	21.50
65/66	22.25
66/67	21.75
67/68	17.50
68/69	18.00
69/70	20.00

Source: Reported in Economic Indicators, No. 168, Dec. 1969, U.M.O.A., Central Bank of West African States

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