

**Production Systems in the Lower
Casamance and Farmer Strategies
in Response to Rainfall Deficits**

by

J.L. Posner, M. Kamuanga and S. Sall

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SPECIAL NOTE FOR ISRA-MSU REPRINTS

In 1982 the faculty and staff of the Department of Agricultural Economics at Michigan State University (MSU) began the first phase of a planned 10- to 15-year project to collaborate with the Senegal Agricultural Research Institute (ISRA, Institut Sénégalais de Recherches Agricoles) in the reorganization and reorientation of its research programs. The Senegal Agricultural Research and Planning Project (Contract No. 685-0223-C-00-1064-00), has been financed by the U.S. Agency for International Development, Dakar, Senegal.*

As part of this project MSU managed the Master's degree programs for 21 ISRA scientists at 10 U.S. universities in 10 different fields, including agricultural economics, agricultural engineering, soil science, animal science, rural sociology, biometrics and computer science. Ten MSU researchers, on long-term assignment with ISRA's Department of Production Systems Research (PSR, Département de Recherches sur les Systèmes de Production et le Transfert de Technologies en Milieu Rural) or with the Macro-Economic Analysis Bureau (BAME, Bureau d'Analyses Macro-Economiques) have undertaken research in collaboration with ISRA scientists on the distribution of agricultural inputs, cereals marketing, food security, and farm-level production strategies. MSU faculty have also advised junior ISRA scientists on research in the areas of animal traction, livestock systems and farmer groups.

Additional MSU faculty members from the Department of Agricultural Economics, Sociology, Animal Science and the College of Veterinary Medicine have served as short-term consultants and scientific advisors to several ISRA research programs.

The project has organized several short-term, in-country training programs in farming systems research, farm-level agronomic research, and field-level livestock research. Special training and assistance has also been provided to expand the use of micro-computers in agricultural

research, to improve English language skills, and to establish a documentation and publications program for PSR Department and BAME researchers.

Research conducted under this collaborative project was originally published only in French. Consequently, the distribution of results has been limited principally to West Africa.

In order to make relevant information available to a broader international audience, MSU and ISRA agreed in 1986 to publish selected reports as joint ISRA-MSU International Development Paper Reprints. These reports provide data and insights on critical issues in agricultural development which are common throughout Africa and the Third World. Most of the reprints in this series have been professionally edited for clarity; maps, figures and tables have been redrawn according to a standard format. All reprints are available in both French and English. A list of available reprints is provided at the end of this report. Readers interested in topics covered in the reports are encouraged to submit comments directly to the respective authors, or to Drs. R. James Bingen or Eric W. Crawford, Co-Directors, Senegal Agricultural Research II Project, Department of Agricultural Economics, Michigan State University, East Lansing, MI 48824-1039.

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*In December 1987 MSU, ISRA and USAID/Dakar negotiated a 2 1/2 year contract (Contract No. 685-0957-C-00-8004-00) to extend MSU's program of research support and training in the social sciences, agronomy, forestry and research planning.

**PRODUCTION SYSTEMS IN THE LOWER CASAMANCE AND FARMER
STRATEGIES IN RESPONSE TO RAINFALL DEFICITS**

by

J.L. Posner, M. Kamuanga and S. Sall

1988

The authors are members of the Djibelor Production Systems Team.

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TO RAINFALL DEFICITS**

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ABSTRACT¹

Rainfall deficits for more than fifteen years have turned the Lower Casamance from a region of food self-sufficiency to one of food deficits. A regional production systems team has monitored these changes since 1982 and seeks to propose relevant solutions to the peasant farmers' problems.

This paper suggests that plentiful upland areas and the availability of animal traction to the north of the Casamance River have enabled farmers to adapt to the present drought cycle by giving them the means to increase the production of groundnuts, millet and maize. In the Southern Zone, essentially a rice production area with limited access to upland fields, farmer strategy is based on the intensive cultivation of rice fields and off-farm activities. The Production Systems Team's research themes are adapted to these different agricultural zones in the Lower Casamance and seek to respond to the farmers' problems within the framework of the agricultural development agency's recommended policies for the region.

¹A preliminary version of this paper was presented at the SAFGRAD Seminar on Appropriate Technology, Ouagadougou, 2-5 April 1985. The authors would like to thank C. Jolly for his contribution and the other members of the Djibélor Team and the Central Systems Analysis Group (Production Systems Research Department) for their useful comments.

**PRODUCTION SYSTEMS IN THE LOWER CASAMANCE
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INTRODUCTION TO THE LOWER CASAMANCE

Geography

The Lower Casamance covers an area of 7,300 km² in Southern Senegal from the Soungrougrou Valley to the Atlantic Coast (see figure 1). It became the Ziguinchor administrative region in July 1984 and comprises the Ziguinchor, Oussouye and Bignona Districts (Départements).

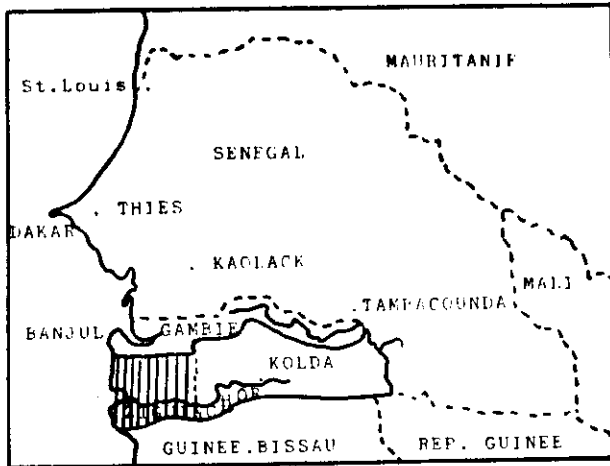
Climate and Hydrology

The region's SubGuinean Climate receives a strong maritime wind and is characterized by two seasons: a dry season from November to May and a rainy season from June to October, with August receiving the heaviest rainfall. The Atlantic Ocean has a dominant influence on the hydrology of the region because of its very low relief and the current rainfall deficit. Salt water frequently flows as far as 220 km upstream from the mouth of the Casamance River. The region has an extensive network of lowland swamps which facilitate even further penetration of the sea water.

Soil

The nature of the soils depends on their position in the topographical sequence. On the plateau, the soil is sandy loam with a sandy surface. Two types predominate: (1) red, low base status iron soils (ferralitique) with a higher clay content in the B-horizon and (2) ferruginous, leached tropical beige soils found in the central well-drained uplands.

Along the talwegs (inland valleys) and the river itself can be found a sandy zone (sol gris de nappe) that is temporarily flooded during the rainy



LEGEND

ZONES: I: Diola-type organization; no animal traction; trans-

LEGEND

- ZONES:** I: Diola-type organization; no animal traction; transplanted rice dominant
- II: Diola-type organization; no animal traction; rainfed crops important; direct seeded rice
- III: Mandingue-type organisation with some other types; some animal traction; direct seeded rice
- IV: Mandingue-type organization; rainfed crops dominant
- V: Diola-type organization; animal traction important; transplanted rice significant

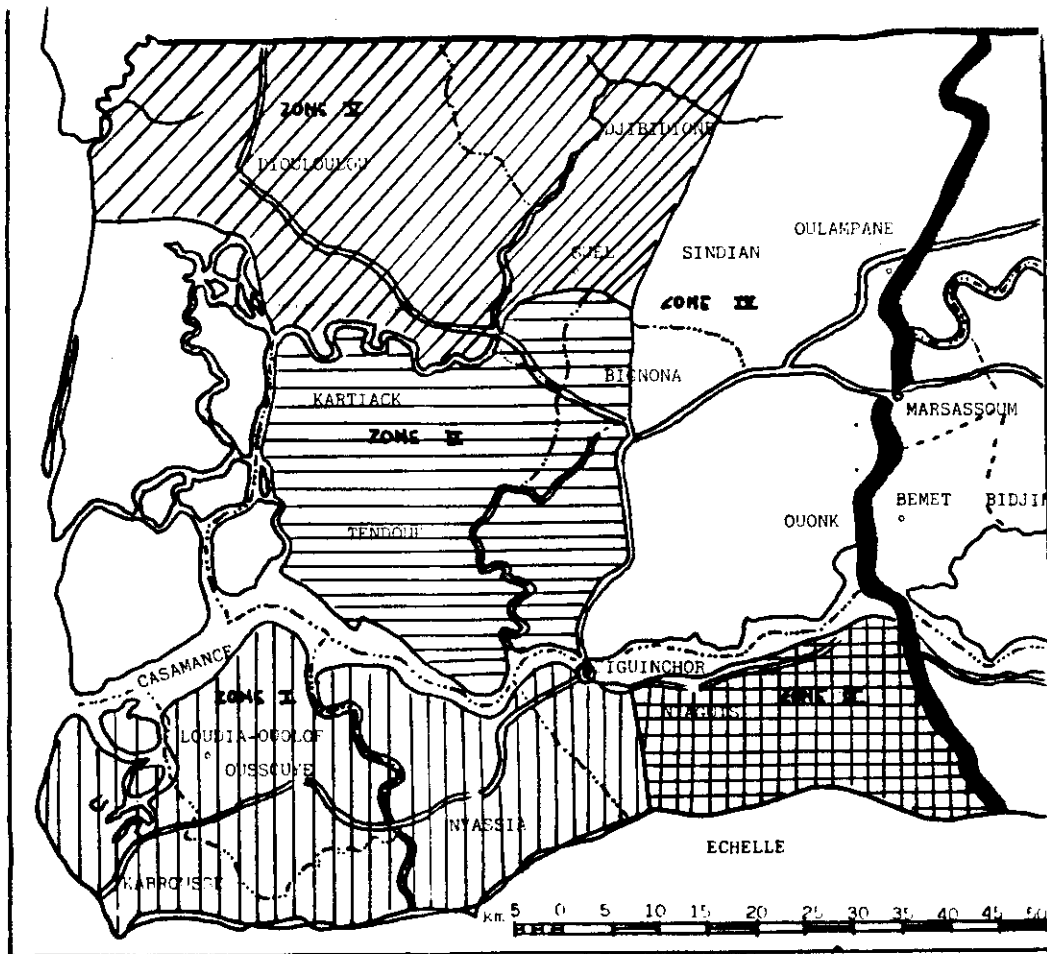


FIGURE 1. MAP OF SENEGAL AND AGRICULTURAL ZONES OF THE LOWER CASAMANCE

season and is favorable to palm groves. In the low-lying areas of the talwegs, rice is grown during the rainy season and commercial production of vegetables is carried on in the off-season.

The saline soils are found in the river bottomland, the lowest position on the topographical sequence--alluvial flats (para-sulphate and acids or sulphate soils) and the mangrove swamps (potentially acid sulphate soils). "Mangrove" rice can be cultivated in these soils if there is sufficient rainfall to leach the salt.

Demography

The rural population in the Lower Casamance is estimated at 261,000¹ living in approximately 330 villages. The population is unevenly distributed and ranges from a density of around 10 per km² in the Northeast (Bignona District) to 35 per km² in the Southwest.² The population is young and fairly mobile. About 45% of the population is less than 15 years of age. Recent surveys show that 10% to 36% of the working village population migrate during certain seasons of the year.³

There are two main ethnic groups: (1) the Diola, who constitute the majority (85%) of the total population and who form a group which is composed of several distinct sub-groups (Kassa, Blouf, Fogny-Kalounaye) and (2) the Mandingues, a minority group (5%), but whose cultural influence is great in the North, the Northeast and around Ziguinchor.⁴

¹The total population of the region is estimated at 362,000. The urban centers of Ziguinchor, Bignona and Oussouye account for 101,000.

²Linares (1981).

³See the demographic census of January 1985 in 10 villages studied by the Djibélor PSR team.

⁴Several other minority ethnic groups (Mancagnes, Mandjak, Balante) originate in Guinea-Bissau.

Agriculture and Livestock

The Lower Casamance is essentially an agricultural region and because of its relatively abundant rainfall it plays an important role in Senegal's agricultural development policy.⁵ Groundnuts, rice, millet/sorghum and maize are the main crops. At present the government places great hopes on rice production, as shown by the construction of saltwater intrusion dams and small antisalt, farmer-built dikes designed to protect and desalinize potential aquatic rice production land (approximately 70,000 ha.).

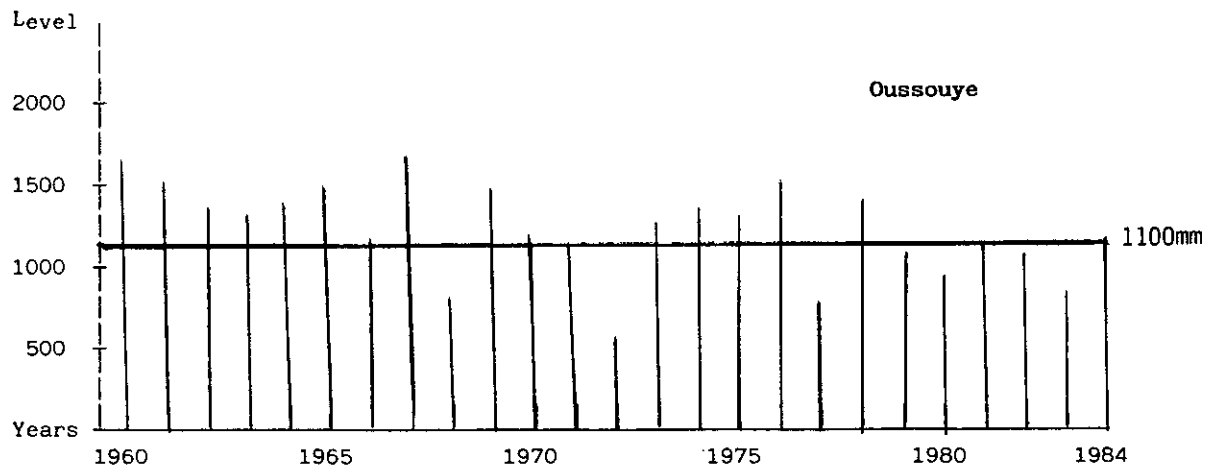
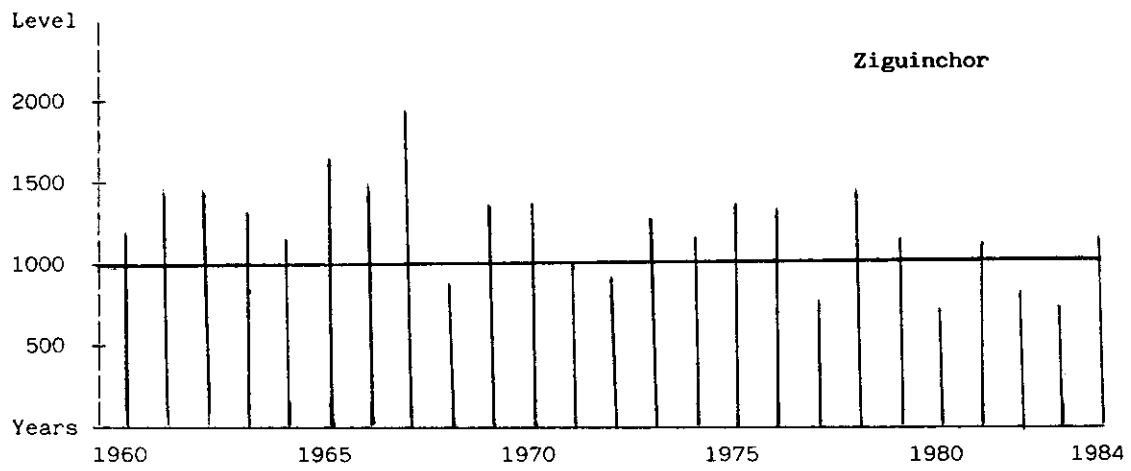
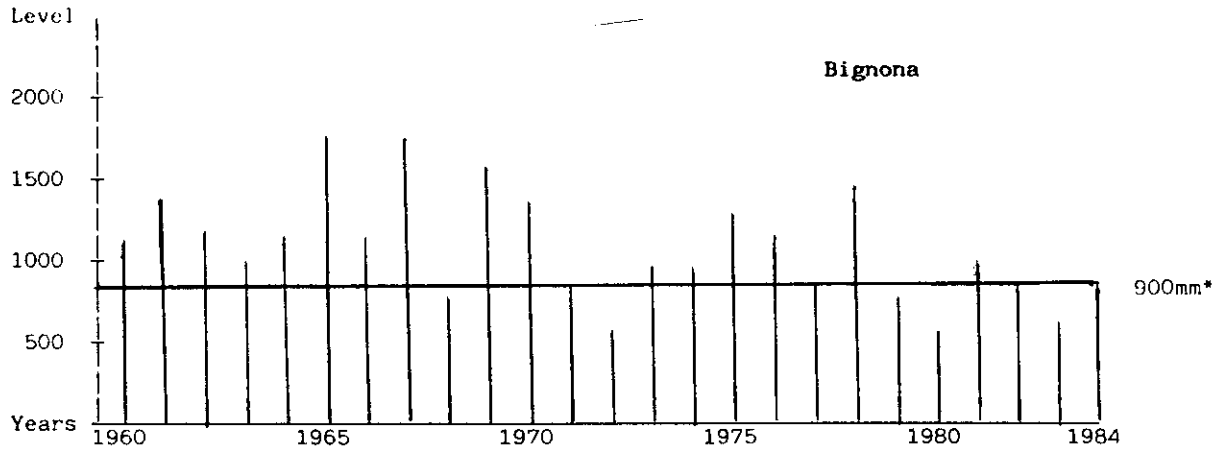
Different types of livestock are found in the Lower Casamance, such as N'Dama cattle and Guinean species of sheep, goats and pigs; however, very few donkeys and horses exist. The cattle are unequally distributed throughout the region: 84% of the herd is in the Bignona District, 9% in Ziguinchor and 7% in Oussouye. Herd organization and management vary from North to South in the region.

THE RAINFALL DEFICIT AND ITS CONSEQUENCES FOR AGRICULTURAL PRODUCTION IN THE LOWER CASAMANCE

Rainfall Deficit

Like other regions of Senegal, the Lower Casamance has had a considerable drop in rainfall over the last twenty years. During the period 1940 to 1960 the region averaged 1,500 mm of rainfall per year; over the last ten years the mean has fallen to 1,100 mm in Ziguinchor. This average, however, does not reflect the significant inter-annual variations. Each of the three districts has suffered several years of drought over the past ten-year period--so severe as to put the agricultural system in serious jeopardy four years in Bignona, four years in Ziguinchor and three years in Oussouye (see figure 2).

⁵PIDAC, (Projet Intégré de Développement Agricole de la Casamance) is the "extension" agency supplying agricultural inputs and technical assistance to peasant farmers.



* In these especially dry years, cereal production is less than one-half of the production during "normal years".

FIGURE 2 - ANNUAL RAINFALL, THE BIGNONA, ZIGUINCHOR AND OUSSOUYE DISTRICTS (1960-1984)

Evolution of Agricultural Production

The regional agricultural production statistics available for the last two decades reveal considerable fluctuations in rice production with a definite decline from 1971 to 1974 and from 1977 to 1980. Millet and sorghum show a similar tendency. Only maize has shown steady growth between 1970 and 1982 (19% increase per year). With respect to rice, the rainfall deficit has led to salinization of the paddy fields, especially in the South of the region. As a result, farmers have modified their production systems, formerly based on aquatic rice, by moving to upland agriculture where food crops for home consumption and groundnuts as a cash crop are produced.

Table 1 presents an analysis of available production and annual rainfall data from the Oussouye and Bignona Districts, which revealed that: (1) the area seeded and total cereal production are both closely correlated to the rainfall; and (2) rainfall variations affect the production of rice more than that of groundnuts, millet and sorghum. The millet, sorghum and groundnut varieties used, even during a low rainfall year, managed to reach maturity. Instead of rainfall, other factors such as the availability of seed, especially for groundnuts, and insect attacks on millet had more influence on production.⁶

Table 2 summarizes observations relative to rainfall, area seeded and crop production. An examination of two geographically separated regions over a period of 20 years reveals a considerable decrease in the total area cultivated, (53% in Bignona and 63% in Oussouye). Rice especially has dropped to 11% of the area cultivated in Bignona and to 77% in Oussouye. The drop in food crop production is also clear. Zones which in 1962-1963 had a surplus (more than 100 kg. per capita in Bignona and more than 181 kg. per capita in Oussouye) now show a deficit (Bignona with 170 kg. per capita and Oussouye with 121 kg. per capita). As a result, rice imports in the Lower Casamance have risen from 2,000 MT to 3,000 MT between 1960 and 1965 to almost 30,000 MT in 1982-1983 (see D.G.P.A., 1983). Under the present circumstances, not only is such a deficit hard to make up through groundnut

⁶Based on PSR team observations and agronomic monitoring since 1982.

TABLE 1

**CORRELATIONS BETWEEN ANNUAL RAINFALL AND SELECTED
INDICATORS OF AGRICULTURAL PRODUCTION,
BIGNONA AND OUSSOUYE DISTRICTS
(1963-1983)**

Indicators	Districts (1963-83)	
	Bignona	Oussouye
Total area cultivated	0.63**	0.59**
Area in rice	0.71***	0.59**
Area in groundnuts	0.42	0.14
Area in millet and sorghum	0.36	0.06
Cereals production	0.62**	0.53*
Rice production	0.75***	0.54*
Groundnut production	0.52	0.15
Millet and sorghum production	0.14	0.004

* Significance levels: * 5%.
 ** 1%.
 *** 0.1%.

TABLE 2

**THE EVOLUTION OF AGRICULTURAL PRODUCTION, OUSSOUYE
AND BIGNONA DISTRICTS (1962/1963
AND 1983/1984) (AVERAGES)**

	Bignona		Oussouye	
	1962 and 1963	1983 and 1984	1962 and 1963	1983 and 1984
Rainfall (mm)	1,257	784	1,450	1,049
Total area seeded (ha)	76,751	35,969	12,699	4,005
Groundnut area (ha)	30,225	21,619	718	772
Millet/sorghum area (ha)	20,970	7,722	100	--
Rice area (ha)	22,975	3,995	11,000	3,084
% of area, rice	30%	11%	86%	77%
Groundnut production (MT)	28,078	23,901	646	658
Millet/sorghum production (MT)	16,013	5,119	60	--
Rice production (MT)	31,013	2,666	12,100	3,450
Cereal deficit ^b (kg/capital)	+ 100	- 170	+ 181	- 121

^aDate for 1962 and 1963, DGPA, Ziguinchor - Data for 1983 and 1984, SOMIVAC. Population Data, 1978 Census.

^bThe cereal deficit is calculated according to cereal production and the total population in each district. Cereal needs are estimated at 200 kg/capita (FAO standard). During the same period the rural population of Bignona had doubled reaching 179,000; Oussouye's population estimated at 21,500, only increased by 30%.

sales, but it has become necessary to review the role of the Lower Casamance development plans and programs.

In order to address these problems of lowered agricultural productivity in the Lower Casamance, and in two other regions, ISRA created three production systems teams. The Djibélor team began its analysis by identifying several agricultural zones within the Ziguinchor Department.

THE AGRICULTURAL ZONES OF THE LOWER CASAMANCE AND FARMER STRATEGIES

Agricultural Situations

In spite of its relatively small area and the predominance of one ethnic group, social organization of agricultural production in the Lower Casamance is quite heterogeneous. In order to control for this heterogeneity, the PSR Team divided the region into zones which cover relatively homogenous agricultural situations.

An agricultural situation, as defined by the PSR Team, is a geographical area in which farmers confront similar constraints, have comparable potential to produce, and thereby constitute a group for which a common development strategy can be devised (ISRA, PSR Department, 1984). The three criteria used by the Djibélor PSR Team to divide the region are not derived from the land's geographic or agronomic characteristics, but from the peasant farmers' methods of exploiting the land.

Division of Labor

Among the Diola in the South and the Northwest, men clear and plow the fields while the women transplant and harvest rice. The plowing and transplanting of rice fields, the most labor intensive activities, do not begin until mid-August, allowing farmers sufficient time to plant their nurseries, household gardens and upland fields in July. Among the Mandingues

and the Diola "mandinguisé"⁷ the division of labor is more simply defined by the topographical location of the crops: men cultivate upland, rainfed crops while the women cultivate swamp rice.

The Relative Proportion of Upland Versus Lowland Crops

As the rainfall levels decline from the Southwest to the Northeast, the type of cropland gradually changes from aquatic rice land (with transplanted rice) to rainfed, upland crops. Upland crops represent less than 50% of the total land under production in the Southeast, but exceeds 80% in the North. Similarly, labor time on upland crops follows this division of cropland, with 65% of all agricultural labor time in the North and only 46% in the South spent on rainfed crops.

The Use of Animal Traction

This criterion differentiates one production system from another in the Lower Casamance. More than 90% of the upland areas in the Sindian-Kalounayes (Northeast) and 50% in the villages of Fogny-Combo (North) are plowed with animal-drawn equipment. Animal traction is almost unknown in the Southwest.

Figure 1 illustrates the five agricultural zones identified in the Lower Casamance. These zones exclude the coastal zone (Caronnes) with their sparsely populated islands and the small southern frontier zone near Guinea-Bissau where shifting cultivation is practiced. For ease of presentation, the following discussion of farmer strategies is restricted to two extreme zones: the North (Sindian-Kalounayes and Fogny-Combo) and the Southwest (Oussouye).

⁷A term used to refer to Diola groups which have been influenced culturally by the Mindingues as a result of political and religious domination.

Recent Pattern of Rainfall (1982-1984)

Before discussing the farmers' strategies, it is useful to examine the pattern of rainfall over the last three years (see figure 3) in order to illustrate differences in the growing season between the North and the Southwest.

The rains begin in the Northeast (Boulandor) and move Southwest (Loudia-Ouolof). In 1982 and 1983 they began during the last ten days in May in the Northeast and did not reach the Southwest until the middle of June. In both zones, however, the average total rainfall during the last three years has been lower than the 15 year average (1970-1985).

In Boulandor, the rainfall is irregular. During the driest year, 1983, there was less than 600 mm. and for one month (20 July to 20 August) only 60 mm. fell. The total rainfall for 1982 (944 mm.) was only slightly less than that in 1984 (1,015 mm.). Of particular importance in 1984 was the abundant rainfall in June and July (562 mm. versus 208 mm.), critical months for crop establishment and weeding the uplands. Such inter-annual variations in the rainfall patterns encourage farmers in the Northern villages to seed directly and early. There is obviously little incentive to produce aquatic rice.

In contrast, Loudia-Ouolof in the Southwest zone (Oussouye) shows very little inter-annual rainfall variation over the last three years either in terms of total precipitation levels or the monthly averages. As a result of the heavy rains in late August in 1982 and 1983,⁸ rice paddies were filled and transplanting occurred in early September. If the rains are satisfactory during September and October, as was the case in 1984, a normal harvest can be expected. Oussouye farmers plan their planting activities on this basis. When the rainy season begins in June they hope for heavy rains at the end of August and the beginning of September for transplanting. The successful production of aquatic rice greatly also depends on a late season regular rainfall pattern.

⁸Rainfall levels were respectively 232 mm and 212 mm in 1982 and 1983.

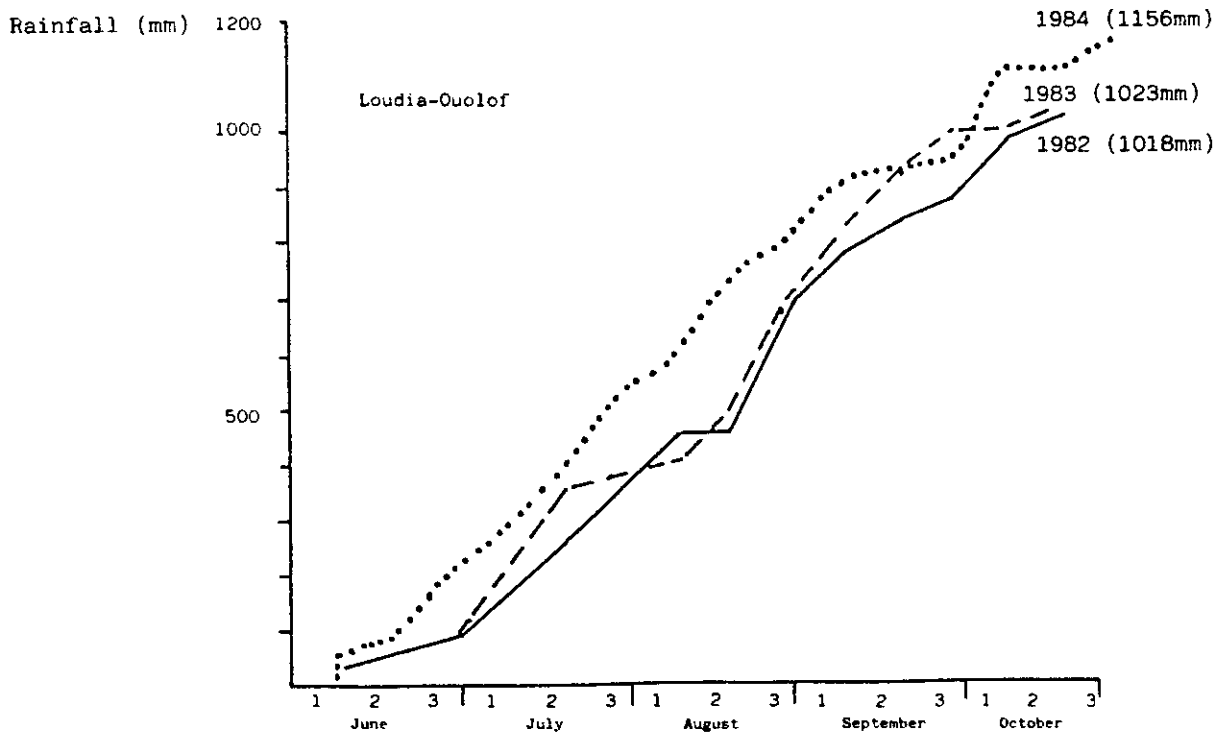
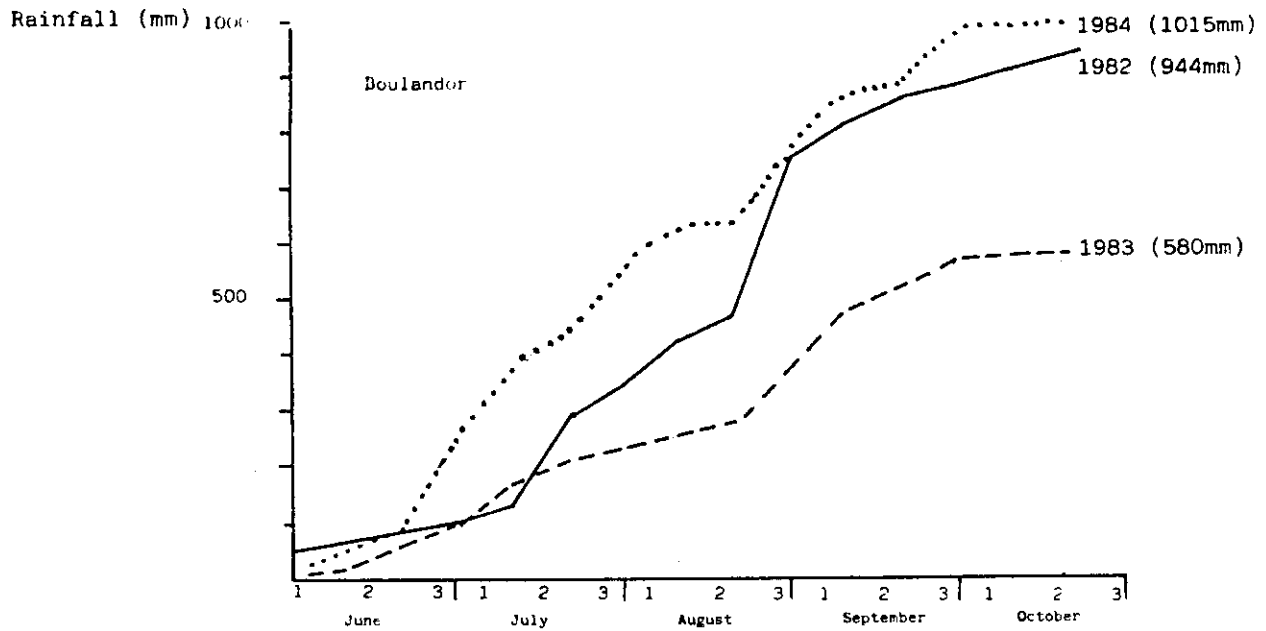


FIGURE 3. ANNUAL RAINFALL PATTERNS, NORTH ZONE (BOULADOR) AND THE SOUTH ZONE (LOUDIA-OUOLOF) FOR 1982, 1983, 1984

Farmer Strategies

The Lower Casamance peasant farmers' principal objective is to market surplus production only after producing sufficient cereal for household consumption. Over the last 15 years, many have faced considerable food deficits because of the drop in rainfall. Surveys carried out in 1983 and 1984 in 10 villages throughout the whole region revealed that cereal production had reached the FAO minimum consumption level of 200 kg. per capita per year in only two villages. A recent survey showed that the average family exhausts its rice supply in six months from the time of harvest, excluding special uses for feasts, receptions, visitors (see Jolly, Kamuanga et al., 1985). Peasant-farmers make-up for this shortfall by purchasing imported (broken) rice.

Even if from one agricultural situation to another one finds farmers with similar motivations and preferences, they do have different resources and opportunities. For example, demographic density is over 60 per square km in some parts of the Southwest, but only 15 per square km in the North and Northeast. In terms of cultivable land area, the population densities are even higher. As a result, farmers follow different strategies even though they may have similar, broad objectives.

A farmer strategy is the way in which the farmers, on the basis of the agroclimatic context and the use of available resources, plan and organize agricultural activities in order to achieve their objectives. This strategy is based on some fairly stable factors--the availability of upland fields to be cleared and/or slow changes, such as the climatic changes over the last 15 years. Farmers in the same context with similar objectives will follow similar strategies. A particular strategy is not limited therefore to one agricultural season.

An adjustment to a strategy means the decisions taken by farmers to cope with particular events; it is an individual rather than a collective action that does not alter the basic strategy. One example is a farmer's decision not to plow after harvest if the rains stop prematurely, or the decision to change seed varieties if the rainy season starts late. Changes in the basic strategy lead to modifications in the agricultural production systems. The Diola-Mandingues, for example, have started to use animal

traction to plow the women's fields. This represents a fundamental change and not just a seasonal adjustment or variation in cropping practice.

The relative availability of upland fields determines the two optimal strategies in a rainfed or uplands strategy and a lowlands or aquatic rice strategy. Because of the abundance of upland fields⁹ and farming practices which facilitate rainfed crop cultivation, peasant farmers in the North have adapted to the present drought spell by concentrating on the production of groundnuts, millet and maize. In contrast, in the South where access to upland fields is relatively limited, farmers have intensified the cultivation of good paddy fields and have started market gardening and intensified gathering (mangoes, palm nuts). (In addition, there is an intermediary zone--Blouf--where the production system appears relatively stationary because there is limited productive aquatic and rainfed area.)

Upland Strategy

The production system of the Diola (mandinguized) in the Sindian-Kalounayes zone is based mainly on upland farming. This system has certain endowments which facilitate its adoption in a low rainfall context. It originates in the Malian plateau cultivation system where millet, sorghum and maize are widely planted. The farmers in this zone have considerable experience with animal traction (which explains in part why they cultivate larger areas than in the South). A farm enterprise commonly includes the larger family compound (concession) or several households (ménage) which represents a significant amount of labor (usually 7 to 9 adults) that can be mobilized from the beginning of the rainy season in June. All hands are assigned to plowing at almost the same time (men on uplands and women in the paddy fields). This means that these households get an early start on the growing season.

The agricultural calendar in the Northeast zone is represented in figure 4. Maize is seeded with the first rains in June. Most farmers then ridge plow with an animal drawn ridger and seed groundnuts and millet.

⁹It is estimated that cultivable land in the Lower Casamance uplands represents more than 150,000 ha, of which 20% to 30% is at present cultivated (SOMIVAC, 1985).

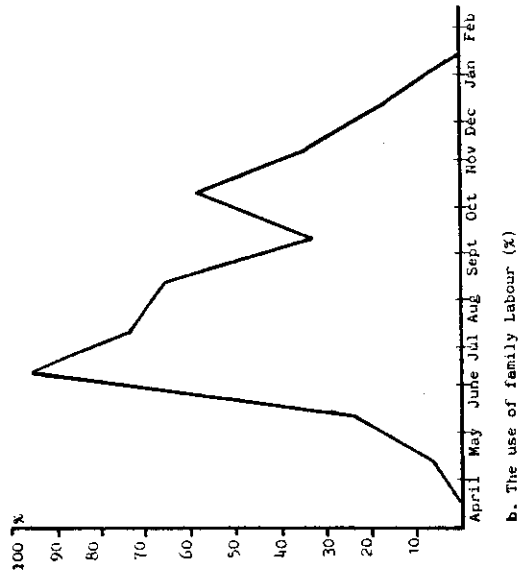
Those who have a UCF plow do flat plowing and seed groundnuts using seeders; ridge plowing is done for millet. At the same time, the women start the phreatic rice fields. They are responsible for the completion of the cultivation process through the harvest.

The peak work period is between June and July, but all hands are mobilized between June and September during which time 74% of the total work is done. According to the farmers, the success or failure of the season can be judged only at the end of September depending on the distribution of rainfall and the possibility of resolving labor constraints at the household level (Sall et al., 1983).

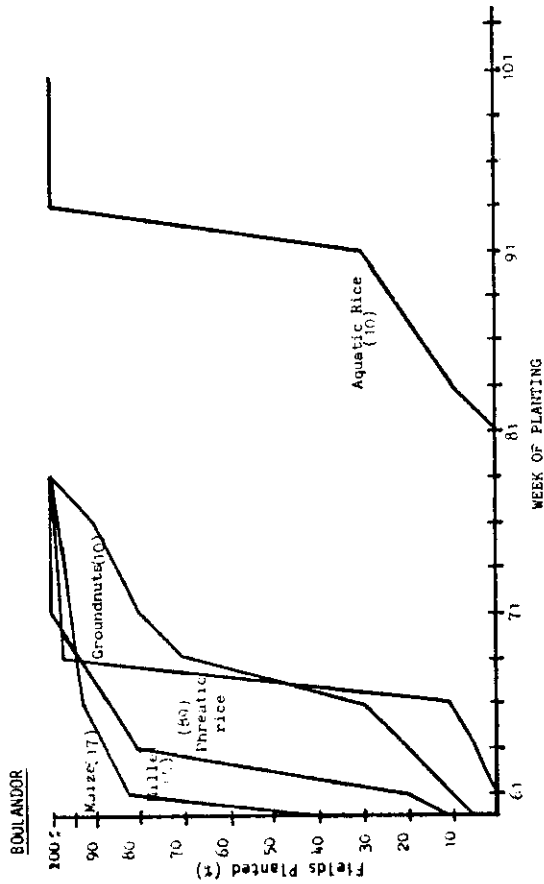
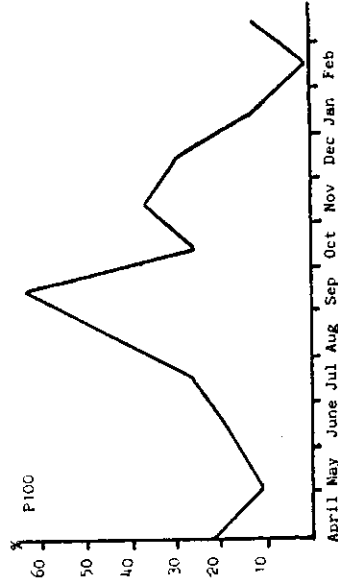
This upland strategy of peasant farmers in the North is characterized by two main aspects: (1) early seeding¹⁰ and (2) intensification and diversification on the uplands. Farmers are anxious to start the season as soon as possible in both the upland and the rice fields. In the first case, there is a general tendency to plant before the end of June as, for example, in 1983 (a dry year) when maize and millet was seeded around the third week of June. In 1984 (a fairly good rainfall year), more than 80% of the fields had been seeded by mid-June (see figure 4).

In some cases, such as Boulandor in 1984, groundnuts were planted by seeder on unplowed fields. Rainfed lowland rice, as well, is being direct seeded and represents an adaptation to the drought, particularly for villages like Boulandor where 84 of the 90 plots monitored in 1984 had been transplanted as recently as 10 years ago. At Médiég, 17 of the plots now being direct seeded were being transplanted less than 10 years ago; the other plots (78%) were aquatic rice plots before 1973-1974. In practice, direct seeding of lowland rice in the North takes place towards mid-July, since the soil in the rice fields is heavy and requires 100 to 200 mm. of rain to be easily worked and to ensure good emergence. It is also useful to note a new technique of working dry soil (plowing by women with a fanting, a long-handled hoe) as early as May, the use of early varieties of rice and

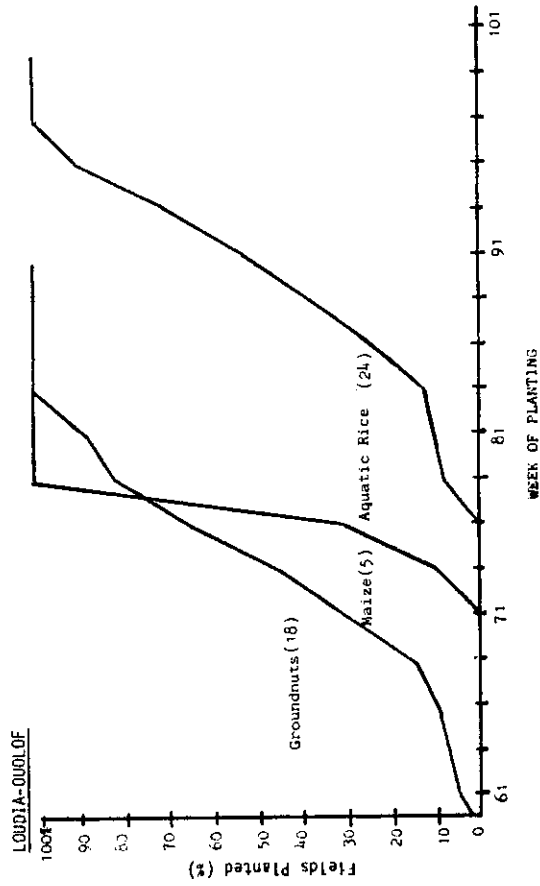
¹⁰There is conclusive evidence of a strong correlation between the date of early seeding and the level of production (see Sall, 1981). In 1984, a PIDAC study of the "Quarter Hectare" program showed a loss of 140 kg of maize for each week's delay in seeding for the fields seeded after the 15th of June in the Lower Casamance.



b. The use of family Labour (%)



a. First Planting Dates and Number of Plots Followed



Example: 61 = 1st week of June; 62 = 2nd week of June
 () Numbers in parentheses are the number of fields/crop in the sample.

FIGURE 4. PLANTING DATES BY CROP AND THE USE OF FAMILY LABOR

the introduction of the seeder in the rice fields, as practices which reflect a desire to plant quickly in order to adapt to the constraints of the present climatic situation (low rainfall and a shorter rainy season.)

The intensification and diversification effort is shown by the emphasis put on certain cultural practices. Thus, stabling cattle on millet and maize plots, formerly unusual, has become a common practice in some villages. Thirty percent of millet and maize plots studied in the zone of Sindian-Kalounayes and 15% in the Fogny-Combo were manured in this fashion in 1983-1984. Further north, for example in Toukara, rice production has been temporarily abandoned for the past 5 to 7 years, in favor of other cereals. Women are reconverting to upland agriculture in order to grow groundnuts and sorghum in individual plots.

To summarize, the upland strategy of the Northeast is based on the increased exploitation of upland fields and involves the increased use of animal drawn equipment by farmers. Indeed, there is high correlation between the use of animal traction and the area cultivated per farm, and labor productivity day's work (see Annual Report, Sall, et al, 1984).¹¹

The Rice Fields Strategy

The production system found in the Oussouye District, in some coastal villages of Blouf and in the western part of the Ziguinchor zone, originated in the swampy lowlands around Oussouye. It is based on aquatic rice production (transplanted) in which men plow both the rice and the upland fields, while the women transplant and harvest the rice. There are several major advantages of this original Diola system. (1) The abundance of low-lying fields which often have a high clay content and organic matter levels (because of frequent manuring) permit an intensive rice monoculture. (2) There is flexibility in the agricultural calendar, as a result of the importance of transplanted rice in the cropping system. Except for

¹¹The well-equipped smallholdings of Boulandor have an average area of 6.75 ha. In Médig, there is little equipment and the average holding is 4.2 ha. In the same villages the wages are 770 CFA per day for animal drawn cultivation and 500 CFA per day for manual cultivation.

post-harvest plowing, the most labor-demanding activity is transplanting. Since this does not occur until August-September, there is a considerable slack for other activities at the beginning of the rainy season (June to mid-August). (3) The presence of numerous saltwater swamps and a forest ecology of the Guinean type around Oussouye encourages a diversification of off-farm activities.

The growing season starts slowly with upland rice and groundnut planting. By the end of July, the rice nurseries are usually in place. The land is prepared with a cayendo, a traditional long-handled shovel used for making ridges; the plowed area is limited (0.75 ha.). As the rice fields are flooded towards mid-August and September, plowing and transplanting of the rice fields become the dominant activities, constituting a peak labor period (see figure 4).

The Southwest system is efficient when the rainfall is normal (1300 mm. to 1400 mm. minimum) and the rice fields are flooded by the end of August. Indeed, before the present cycle of drought, this system of intensive rice cultivation was productive enough to support a density of 65 inhabitants per square km (Linares, 1981).

Under the present climatic conditions, the peasant farmers in the Southwest zone seek to maximize their productivity and maintain a measure of flexibility through a series of adjustments on the margins of their system of production. First, as a consequence of the drought, post-harvest plowing is gradually being dropped because of soil compaction after the December-January harvest. Although this was a common practice, in 1984 only 28% of the plots studied in Boukitingo and 8% in Lydia-Ouolof were plowed at the end of the rainy season. At present, the first plowing is in July followed by a second in August. This adjustment creates a heavier workload during the rainy season; and some farmers only plow once, at the end of August.

Second, the area of upland crops to be cultivated depends on the farmers' assessment of the rainfall pattern as the season begins. In 1983, when the rainfall was low in June and July (375 mm.), 73% of farmers surveyed increased their groundnut growing area by 30%. On the other hand, in 1984, a rainy year (475 mm. of rain in June and July), 75% of the farmers

in the same sample reduced their groundnut growing area to devote more time to aquatic rice fields.

Furthermore, the farmers wait for the flooding of the paddies (end of August-beginning of September) to determine the number of rice plots to be transplanted. This enables them to save on labor and to concentrate on the good rice fields (i.e., those that are flooded and desalinized). After three years of monitoring, it has been found that approximately two-thirds of the flooded rice fields have been abandoned. This selective approach is advantageous for transplanted rice production as opposed to directly seeded rice. Despite potentially higher yields, the latter is more vulnerable to uncertain rainfall conditions. For example, in 1983, 43% of the direct seeded rice crops (seeded in June-July) were lost, compared with 30% for all transplanted plots.¹²

Finally, according to the pattern of rainfall in the rainy season and location of rice fields at different levels of the toposequence, farmers stagger the seeding of the nurseries, thereby permitting them to stagger the transplanting. In 1983 (low rainfall at the beginning of the rainy season), 2% of the nurseries were seeded in June, 89% in July and 9% in August. In 1984, with good rains early in the season, 24% of the nurseries were seeded in June, 54% in July and 18% in August.

Some adaptations to the drought are reflected in the intensification of rice production, the increase in off-farm sources of income and the high level of migration of young people (36% of the active population in certain villages in Blouf). A typical example of such an adaptation is seen in the village of Mangagoulak, southwest of Blouf. Because of the low rainfall and lack of upland fields, aquatic rice production has intensified (210 person days per hectare) with an average yield of 2,800 kg. per hectare. The farmers take great care of the nurseries and put large quantities of manure on the rice fields (Sall, et al., 1983).¹³

¹²An analysis of a twenty-five-year series of production data from the DGPA shows a significant correlation (+0.59**) between the area transplanted and rainfall and a weak and insignificant correlation (+0.16) between the rainfall and the paddy yields.

¹³This is widespread in Loudia-Ouolof and Boukitingo. In Tenimane, the women also spread mango leaves on the rice fields.

Off-farm activities (fishing, fruit picking, collecting palm wine and palm nuts) and market-gardening in the off-season are an important source of revenue for the Diola farmers in the South. For Loudia-Ouolof and Boukitingo, for example, the revenue obtained from all these activities represents respectively 122% and 150% of the farm cash income from agricultural production (PSR Team Report, 1984). A substantial proportion of this revenue is used to buy milled rice during the hungry period.

Adaptations in the Transition Zone

Because of its location north of the river, the Blouf gets less rainfall and has higher rice fields than the Oussouye District. (The average for 3 years in Tendimane is 765 mm. compared with 1,076 mm. in Loudia-Ouolof.) There are relatively few low-lying aquatic rice fields that have not been lost to salt intrusion, and plateau land available per capita is very low compared with the situation in the Northeast.¹⁴

One of the consequences of this situation is the progressive adoption of direct seeded rice in fields that were formerly transplanted and a shift towards upland cereals. In 1984, almost all the lowland rice fields studied in Suel and 20 of the 31 in Tendimane, which were aquatic rice fields (transplanted) ten years ago, have now been converted to direct seeding.

Since the production system remains a fundamentally Diola type, the Blouf farmer attaches great importance to the success of the rice fields. The upland strategy, therefore, is determined by the type of rice fields available. In Suel, for example, where the rice fields are high and sandy, the farmers prefer to finish the groundnut plowing and weeding before cultivating the rice fields, which in their opinion give low yields. In Tendimane where the rice fields are potentially more productive, the men share their time between groundnut plowing and plowing the phreatic rice plots.

The upland strategy is based mainly on millet, which has been only recently adopted, but which is beginning to compete with groundnuts as a

¹⁴The availability of upland plots per inhabitant is related to the density of the rural population; 20 to 25 inhabitants per km² compared with 10 to 15 per km² in the Northeast.

cash crop and is quietly infiltrating a diet in which rice has long been dominant.¹⁵ Another adaptation to the drought, which is not often noted is the urban migration of young people, as many as 36% in certain villages in Blouf. Such migration reduces the numbers to be fed, but in some cases is a source of farm income through the transfer of migrants' savings.

The strategies presented above are evolving and, as indicated, differ considerably from the North to the South of the region. It is useful to compare the essential elements of these strategies (table 3) before looking more specifically at the current research program.

A Comparison of Smallholdings in the North and South

Smallholdings in the North are large in terms of available labor. The familial pattern of organization (large concessions that regroup several households under the authority of the lineal patriarch) makes labor available, and animal traction permits the cultivation of larger areas. In the South, individual households are autonomous. Labor is limited (2 to 5 adults per household) and the use of manual tools (cayendo) for plowing limits the total surface that can be cultivated.

In the North there is a large demand for credit to buy equipment (plows, seeders), and cash crop (groundnut) production is emphasized. In the South, farmers prefer seasonal agricultural credit, especially for fertilizer and custom plowing (two-wheel rototillers). Rice production for personal consumption dominates.

The typical Northern farmer's fields are rainfed, and they demand 65% of the labor time. In Oussouye at most 50 to 60% of the cultivated land is rainfed and requires 46% of available labor time.

This distribution of work between the rainfed and the rice fields and the nature of the cultivation practices in each zone are the principal reasons for yield differences. For maize, the limiting factor is the use of manure. In the North, the household fields are used for stabling the cattle, which accounts for yields of around 1 MT per hectare. In Oussouye a

¹⁵The area of millet production in Tendimane was 7% of the total land under cultivation in 1982, 12% in 1983 and 16% in 1984.

TABLE 3

**CHARACTERISTICS OF FARMS, NORTH AND SOUTH
ZONES OF THE LOWER CASAMANCE**

Characteristics	Smallholding Type	
	North, "Upland"	South, "Aquatic"
1. Average farm size (ha)	6.21	1.55
2. Labor, average number/farm	7.2	4.1
3. Upland cultivation (% of total area)	86	59
4. Time on upland cultivation (%)	65%	46%
5. Time on rice cultivation (%)	35%	54%
6. Average yields (kg/ha) (1982-1984)		
Maize	838	221
Groundnuts	954	621
Millet	539	--
Rice	1,511	888
7. Percent off-farm revenue of total revenue	20%	59%

^aThis table compares two geographically separated situations that represent extremes. The data were obtained during surveys in Boulandor and Médiég (representative for the North) and in Loudia-Ouolof and Boukitingo (representative of the South). All data are averages for three years (agronomic survey), except for labor time that is calculated from two years data (1983 and 1984).

third of the rice fields are manured. Weeding is the major limiting factor in groundnut production. In Boulandor and Médiég (Northern villages) the interval between seeding and weeding is about 31 days; in Oussouye it is 45 days. Low groundnut yields can also be attributed to the use of local, low-yielding varieties (which do have the advantage of competing relatively well against weeds because of their semi-upright growth habit).

Rice yields differ basically according to the type of rice cultivated (phreatic rice in the North and aquatic rice in the South). The shortage of water in the rice fields greatly delays transplanting, and it is often necessary to wait until the end of the first third of September when the rainfall level reaches 700 mm. (see figure 3). By this time the rainy season is almost over and the average 300 to 400 mm. rainfall that can be collected is hardly sufficient to complete the rice cycle. Thus, during grain-filling the plants are under increasing water stress. Phreatic rice, since it is direct seeded, benefits from rainfall accumulated throughout the season, and yields of about 1,800 kg. per hectare are common. At Boulom, for example, near Ziguinchor, the rice-growing system is in a transitional phase. Farmers are beginning to direct seed their paddies, which were until recently, transplanted. The direct seeded rice shows slightly higher yields than transplanted rice (1,112 kg./ha. and 940 kg./ha.), but it requires much more labor (264 person days compared with 187 person days for transplanted rice).

Finally, the relative importance of off-farm household income is significantly different between farms to the North and South of the river. In the South, the proportion is 60% in comparison to 20% in the North.

THE RESEARCH PROBLEM

This paper has focused on farmer adaptation strategies to drought, a study started by the Production Systems Research Team in 1982. With some exceptions, the systems approach has enabled the PSR Team to understand the farmers' approach and to identify the potential of his environment. After the exploratory surveys and the first agronomic monitoring of cultivated plots, the team identified four main research themes which reflected the

principal concerns of farmers in the Lower Casamance and of the regional agricultural development agency (PIDAC). These themes are illustrated in figure 5.

The Intensification of Production on Productive Land

Because of the present drought cycle, the intensification effort has been concentrated on good land: newly cleared fields, those enriched by manuring; and humid rice fields that benefit from run-off. Two complementary approaches are used: (1) improving the productivity of the land; and (2) increasing labor productivity.

Upland Zone

In the North, farmers prefer to cultivate the rainfed fields and to use animal traction which reduces their labor time. With respect to improving land productivity, fertilization trials for maize, groundnuts and phreatic rice have been started. In general, the doses used correspond to the "light recommendations" (100 kg. of 8:18:27 and 100 kg. of urea per hectare for cereals and 75 kg. of 8:18:27 per hectare for groundnuts), which seem profitable in view of the farmer's scant technical knowledge and the present climatic risks. Improved varieties of rainfed rice tested under farmer conditions have proved successful because of their short cycle, their tolerance to rice blast and the farmer's appreciation of the grain orgaleptic quality. For example, varietal trails with DJ-12-519 and IRAT 133 have given on-farm yields of 3,550 and 2,700 kg./ha. respectively. In large scale demonstrations these varieties have produced at least 20% higher than local varieties (8 out of 13 times) under local, low-input conditions.

With respect to labor productivity, the agronomic study and trials under farmer conditions show that the interval between seeding and weeding is a main constraint to increased yields. In the absence of appropriate weeding equipment the moldboard plow has been successfully used to weed plots and has resulted in a 60% time saving compared to manual weeding for the same yield.

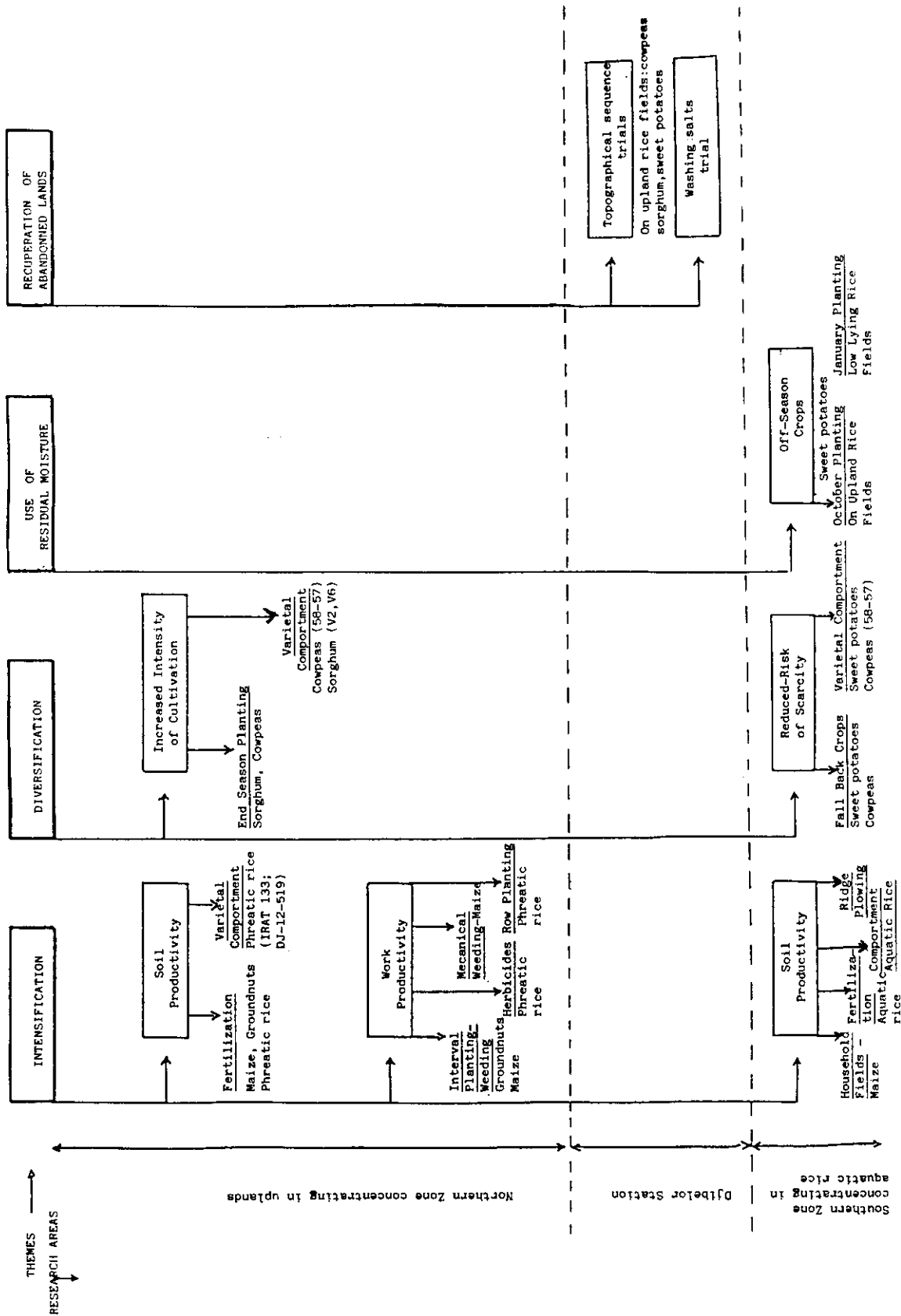


FIGURE 5. DJIBELOR PRODUCTION SYSTEMS TEAM RESEARCH THEMES (SCHEMATIC PRESENTATION)

In the phreatic rice paddies the emphasis is on weed control by means of herbicides and on row seeding. Herbicides can reduce by a third the time required in comparison to nontreated plots. The introduction of seeders and row seeding in these fields (in Boulandor for example) reduces weeding time by half compared with broadcast seeding.

Aquatic Rice Zone

In the rice production zone South of the river intensification through the improved productivity per unit is possible primarily on the "household plots" near the compound where the gardens are manured with household waste and where fruit trees are planted.¹⁶ The results of tests over the last two years on these fields show that, given the right conditions, maize yields can be increased to 2,000 kg./ha. The high humidity and temporary soil flooding in July, however, tends to reduce yields. Some orientation trials of new Cassava varieties which are tolerant to cochenilles (*Phanacocus manihoti*) and to the mosaic virus are also underway.

For the regularly flooded rice fields (without problems of salinity or ferric toxicity) intensification involves fertilization and varietal trials. Recent results show that the variety DJ-684D has an average yield of 2,600 kg./ha.; this represents an increase of 54% compared with the yields of local varieties.

In the absence of animal traction, labor productivity can be improved by adopting more efficient manual techniques. Contrary to common belief, many traditional practices are efficient and justify the farmer's adherence to them. Tests on phreatic rice fields and for maize reveal that ridge plowing, for example, is quicker and provides better weed control than the research-proposed flat plowing.

¹⁶A research program on village arboriculture will soon be started.

Diversification of Cultivation

This theme concerns introducing crops that can be seeded towards the end of the rainy season without overloading the peasant farmers' schedule. In the zones where the upland strategy dominates (Northern villages), this can be achieved by staggering agricultural activities with crops such as sorghum and cowpeas that can be seeded immediately after groundnut seeding and weeding (see figure 4). Three years of sorghum varietal tests with the varieties V2 and V6 have given an average yield of 950 kg./ha.--three times greater than the average yield of local varieties (315 kg./ha.).

In full scale tests, these improved varieties, seeded between the 1st and 10th of August, have maintained high yields. Varietal tests of cowpeas (Variety 58-57) seeded between the 15th of August and the 1st of September, show similar high relative yields with 775 kg./ha. compared with 248 kg./ha. for the local variety.

Diversification in the Southern rice production zone seeks to reduce the risk of food shortages during dry years, when aquatic rice is unsuccessful. As described above, transplanting only takes place at the end of August or the beginning of September. If the rainfall is inadequate at this stage, it is often too late to seed another cereal crop to compensate for the failure of transplanted rice. Cowpeas and sweet potatoes have been tested as "fall back crops." Cowpea varieties (especially 58-57) have given an average yield of 496 kg./ha. compared with 103 kg./ha. for the local variety; sweet potato trials have shown that the NDargu variety sown on upland fields between the 15th of August and the 15th of September can produce a yield of around 5,000 kg./ha. compared with an average of 1,911 kg./ha. for the local variety.

The Use of Residual Moisture in Rice Fields

This theme, applied especially in the Southern zone, includes many of the same activities under the intensification and diversification themes. Sweet potatoes are being tested in villages around Oussouye as an off-season crop planted immediately after the rice harvest. It is set out in the phreatic rice fields in mid-October and relies on morning dew and capillary

action for its water requirements (average yield is 2,500 kg./ha.). In the aquatic rice polders, however, sweet potatoes can be transplanted only at the beginning of January. The crop requires watering during the first two weeks in order for the cuttings to take root; subsequent water requirements are met from capillary action (average yield is 4,200 kg./ha.).

The Recuperation of Abandoned Land

A substantial proportion of upper rice fields both to the North and South of the river have been abandoned because of insufficient flooding due to the marked drop in the water table. Some low-lying rice fields are now excessively saline because of the ocean tides. It is estimated that more than two-thirds of the former rice fields have been abandoned.¹⁷

On-station trials with sweet potatoes and cowpeas seek to identify how these crops can be used to bring the abandoned upper rice fields back into production with crops that require little water and weeding. On these abandoned rice fields, maize has not only given higher yields than rice, but is more labor-saving at weeding time. Sorghum and sweet potatoes also perform well with yields of 1,000 and 3,300 kg./ha. respectively, higher than the rice yields of 800 kg./ha. on a sample plot.

In collaboration with a hydrologist, those working in saline rice fields are seeking to improve techniques for plowing and spacing the drains. Such techniques should facilitate the leaching of the salt from the soil.

CONCLUSION

The Lower Casamance has greater agricultural production potential than most other regions of Senegal. But the drought conditions since the 1970s--decreased rainfall and a shorter rainy season--have made profound changes in the local production systems. Deteriorating production conditions have put the smallholders' cereal situation in jeopardy in many villages. In the last twenty years, there has been a 50% decline in the

¹⁷Information collected during PSR team exploratory surveys in 1982.

total area cultivated. For rice, the drop is even greater, as much as 77% in the Bignona district.

The Djibélor ISRA PSR Team has defined five agricultural situations or zones in the Lower Casamance. Each has advantages which facilitate adjustments to the present cycle of drought; they also reflect specific constraints which require specific solutions. This paper has discussed two agricultural situations representing two geographical extremes: the Sindian-Kalounayes zone to the Northeast of the Casamance River and the Oussouye zone to the Southwest. There is a marked difference between their agricultural systems, their agricultural calendars, the structure of their production units, and consequently their adaptive strategies to the present climatic situation. Agricultural researchers and the regional agricultural development agency must take these variations and different production systems into account in order to respond to the requirements of rural development. There is no single solution to the agricultural problems in the Lower Casamance.

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