1659

CILSS

PRORES

PROBLEMS RELATED TO PRODUCTION SYSTEMS IN THE SAHEL

SYNTHESIS OF NATIONAL BALANCES/EVALUATIONS

OUAGADOUGOU, March 1997

FOREWORD

This paper results from the synthesis of the national studies on production systems in the CILSS member countries. In the said studies, the countries regrettably provided extremely heterogenous data. This is due, on the one hand, to differing definitions of production systems and, on the other hand, to the methodologies used in the studies and to the level of information availability in each country.

As regards the methodologies in particular, we should note that:

- five countries (Burkina Faso, Cape Verde, Chad, Mauritania and Senegal) worked according to agro-ecological zones;
- two countries (Mali and Niger) did not take into account agro-ecological zones, yet defined in their reports;
- two countries (The Gambia and Guinea-Bissau) worked according to soil series.

These differing approaches resulted in the production of documents with different contents. As a result, it was extremely difficult to make a synthesis.

Classification of the different zones of the countries in the various production systems was done on the basis of information provided in the national studies. Such classification might not be accurate in some countries like Guinea-Bissau, The Gambia and Niger, because of the low level of information available in the national studies.

SUMMARY

The main characteristic of the Sahel boils down to the peculiarity of its climate which explains its status of agro-sylvo-pastoral space par excellence. The Sahel is marked by the successive periods of drought it has been experiencing since the middle of the 17th century at least.

The 1973 drought, one of the most obvious signs of desertification in the Sahel, has been marked by the disappearance of pastures, the drying up of watering points and the loss of 25% of large cattle and 13% of small cattle. This was the landmark year for the establishment of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS).

The Sahel has numerous natural resources:

- a population of about 47 million inhabitants (1994), 47 to 50% of which are youth aged under 15;
- an area of 5.5 million square kilometers, a vast field for agro-sylvo pastoral activities;
- abundant surface and groundwater resources;
- 2,968,000 ha of irrigable land with total or partial water management;
- considerable mining resources; etc.

These considerable resources are the productive basis of agricultural production systems.

The national studies on production systems show that it is possible to define various types of production systems in the Sahel. However, despite such diversity, it is possible to organize the Sahelian production systems into five major types.

1. Pastoral production systems which are mainly characterized by exclusive cattle-breeding. This production system is localized in the most arid areas of the Sahel.
2. The agro-pastoral production system where pastoralism is predominant: cattle-breeding is the main activity in this system. (400 to 500 mm rainfall). Agriculture is a marginal activity for the agro-pastoralists. The pattern of cattle-breeding is transhumance.
3. The agro-pastoral system where dry-farming is predominant (500 to 900 mm rainfall): agriculture is the people's main activity. Because of erratic rainfall, cattle-breeding is a way of saving which protects the agro-pastoralists against climatic hazards;

4. The agro-pastoral system where humid agriculture is predominant (more than 900 mm rainfall): the difference with the previous system lies in the fact that rainfall as well as agricultural potentials are higher. Generally, the system includes commercial and export crops.
5. The irrigated production system: it is not localized in a specific area and irrigated perimeters are scattered all over a given country.

These production systems are faced with numerous physical , socio-economic and institutional constraints while having tremendous potentials.

The physical constraints identified by the national studies relate to decreasing rainfall, increasing population pressure which results in pressure on agricultural lands, increasing animal pressure on pasturelands, inappropriate farming systems... The severity of these constraints varies from one agro-ecological zone to another.

The socio-economic and institutional constraints are shared by all agro-ecological zones. They relate to the improvement of productivity in production systems and to the performance of institutions in charge of agricultural extension.

The national studies allowed to highlight the potentials of the various production systems. These potentials also vary from one agro-ecological zone with a North-South gradient in terms of plant production to another one with a South-North gradient in terms of livestock production.

Some production systems are pregnant with positive developments. Most of the promising systems are shared by all countries. This is the case for irrigated production systems, peri-urban cattle-breeding, cattle-breeding integrated to agriculture.

Therefore, the various development partners should put special emphasis on the promising systems so as to increase the productivity of production systems.

Indeed,despite the efforts that have been made over several decades, the Sahelian countries' food balance is characterized by a virtually structural deficit, especially in years of poor rainfall. The promising sectors that were identified in the national studies could be an avenue for increasing the rural people's incomes as well as the productivity of resources. Indeed, food security should be aimed at without jeopardizing natural resources.

The agricultural and food policy of the CILSS countries should be based on the two parameters of food security and sustainability.

INTRODUCTION

In the wake of an institutional and technical reorganization, the Permanent Interstate Committe for Drought Contol in the Sahel (CILSS) has developed a plan built around six Major Programmes, including one entitled "Food Security Policies".

This programme designed a Strategic Reflection Project which aims at improving knowledge so as to better coordinate the interventions of CILSS in terms of agricultural and food policy formulation. One direction determined for the interventions of PRORES aims at better understanding trends in production systems.

In this framework, the project commissioned studies on production systems in the nine CILSS member countries from July to September 1996. These studies were validated by national workshops. This report is a comparative synthesis of the aforementioned national studies.

Each national consultant had his/her own understanding of the concept of production systems, which thus made regional synthesis difficult. The first consequence has been a multiplicity of production systems as per country.

In some extreme cases, each crop is referred to as a unique production system; e.g. the corn or rice production system.

So as to iron out all these difficulties due to the profusion of production systems, our methodology consisted in making an inventory of rural activities (farming, cattle-breeding and fishing) in agro-ecological spaces characterized by natural resources and specific productions which stand as the productive basis of the adopted production systems.

Thus, all production systems covered by the nine national reports are classified into five systems, the charactristics of which are depicted in the chapter on the features of production systems in this report. The systems are the following:

- the pastoral production system;
- the agro-pastoral production system where pastoralism is predominant;
- the agro-pastoral production system where dry-farming is predominant;
- the agro-pastoral production system where humid agriculture is predominant;
- the irrigated production system.

Then we carried out the tasks under the terms of reference of this synthesis with regard to the five systems. These tasks consisted in highlighting the following aspects in a comparative synthesis of the national studies on production systms:

- the common and distinctive features of production systems in the Sahelian countries;
- the major constraints and prospects for improvement in the systems;
- the role of production system;
- poorly known and/or promising systems;
- the role of various local, national and regional development partners;
- the need for further action with a view to formulating project documents and plans of action.

Finally, the analysis of the nine national studies and one of the observations made by the manager of PRORES converged towards the need to isolate fish production in a distinct production system. Indeed, five CILSS countries out of nine (Mauritania, Senegal, The Gambia, Guinea-Bissau and Cape Verde) are coastal countries on the one hand and, on the other hand, all nine countries practise continental fishing to various degrees. As the national reports did not address fishing in very specific terms, the issue has been dealt with in the framework of needed further actions mentioned in the report.

As regards the bulk of production systems depicted in the nine studies, they are summarized in Annex I.

1 FUNDAMENTAL CHARACTERISTICS OF THE SAHELIAN COUNTRIES

Basically located between isohyets 0 and 900 mm, the Sahel is a buffer zone between the Sahara desert and the humid tropical forest.

Located in West Africa between latitudes 7 and 20 degrees North, the region covers an area of 5.5 million sq.km and stretches on 4,500 km from East to West.

1.1 Climate

The main characteristic of the Sahel boils down to its special climate which explains the fact that it is an agro-sylvo-pastoral space par excellence, but unfortunately with fragile ecosystems.

Rainfall is low and variable from two standpoints: poor frequent distribution in time and space over the same year on the one hand, and repeated periods of drought , sometimes lasting for several years on the other hand. In addition to these variations, the isohyets are sliding from North to South, resulting in uncertain plant production in the sub-Sahelian and Sahelian parts of the region.

The variability of rainfall as occasionally recorded in meteorological stations is quite expressive: 15% variation in rainfall in humid zones and 50% in northern arid zones.

It seems that, for a long time, Sahelian history has been rythmically marked by periods of drought that "fell" on the region in the following years: 1640; 1680; 1710; 1770; 1790; 1810; 1820 and 1840.

Some historical studies (Sharon and Nicholson, 1982) show that the recent drought in the Sahel was not a unique event. Periods of drought of the same magnitude and lenght recurrently mark the climatology of this region. These climatic fluctuations go hand in hand with more extended geographic patterns of rainfall variability.

As regards the 1973 drought, it opened several wounds: famine, malnutrition and diseases. This drought was one of the most obvious signs of desertification in the Sahel and was marked by the disappearance of pastures, the drying up of watering points and the loss of 25% of large cattle and 13% of small cattle. This was the landmark year for the establishment of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS).

1.2 Water Resources

The Sahel covers an arid and semi-arid zone. It is criss-crossed by many rivers, and also has considerable quantities of groundwater of various origins.

1.2.1 Surface water resources

The Niger is a river which runs through arid and semi-arid regions and, with the Bani, its tributary, is at least 2,000 km long.

The Senegal and its tributaries are some 1,700 km long. Two dams have been built in the framework of the OMVS (Organisation for the development of River Senegal).

Chad is crossed by the Chari and its tributary , the Logone.

The black Volta (Mouhoun) and its tributary, the Sourou.

River Gambia and River Casamance (Senegal and the Gambia) consist of salt water over most of their course.

In addition to these permanent rivers, there are temporary ones including the Ferlo in Senegal, the white Volta (Nazinon) in Burkina Faso and the Batha in Chad.

1.2.2 Lakes

There are lakes scattered all over the Sahel because of its flat relief. They are vast perennial watering points which are not subject to drying up by serious periods of drought. We can mention Lake Guiers in Senegal, Lake Rkiz in Mauritania, Lakes Faguibine, Niangay, Do, Garou and Haribongo in Mali, Lake Chad, the greatest in the Sahel, and Lake Fitri. There are

also several ponds, the perennial nature of which is due to the fact that they communicate with watertables.

1.2.3 Groundwater Resources

An advantage of the Sahel is the fact that the region has groundwater resources of various origins and is characterized by the absence of impermeable strata between them and the earth surface (groundwater tables), and others which are under several strata that are impermeable, deep and subject to some pressure.

1.2.3.1 Groundwater tables

- tables under wind sands can be found at 20-30 m below the sand stratum (Mauritania, Mali, Chad...)

- alluvial tables can be found in fossil valleys such as the Dallols in Niger.

1.2.3.2 Deep tables

They ar often located at more than 40 metres down.

- the Chadian sedimentary watershed (continental, terminal, eocene and cretaceous, intercalary continental, lower pliocene);
- the Malian sedimentary watersheds (continental, terminal,cretaceous, dolomotic limestone);
- the Senegalese sedimentary watersheds (continental, terminal, eocene, maëstrichian);
- the Mauritanian sedimentary watersheds (continental, terminal, eocene, deep maëstrichian, the Hodh and Aouker tables);

1.3. Soils

The useful agricultural area (UAA) varies from 0.2% of the total area of Mauritania to 57% of the total area of The Gambia, and the percentage of cultivated areas in relation to the useful agricultural area varies from 5% in Chad to a minimum of 90% in Cape Verde, against 63% in Senegal and 50% in Niger. In the light of these facts, it could be said that the issue of saturation of arable lands is looming but for the last three countries.

However, there are very serious constraints to the development of most of these lands (see chapter on the physical constraints). Low rainfall, poor agricultural techniques and the rural people's low investment capacity are some of the causes of degradation of natural resources in general, and of the soil capital in particular.

1.4. Population

Population and development are interdependent. Therefore, any development strategy should take into account the importance of demographic factors. This was how the Sahelian countries expressed the importance they attach to the human potential.

The Sahelian population is growing very fast in the like of all poor countries. From 20,359,000 inhabitants in 1960, it went up to 46,939,000 in 1994 , and will reach 67,652,000 by the year 2015 according some estimates.

Population density varies tremendously within the zone going from 5 inhabitants/sq.km in Chad up to 97 inhabitants/sq.km in Guinea-Bissau. The least populated countries (in terms of population density) are those whose territories expand into the Sahara desert: Chad, Mali, Mauritania and Niger have each more than one million square kilometres.

Table 1.1 General Data on Areas and Population

	Burkina Faso	Chad	Cape Verde	The Gambia	Guinea Bissau	Mali	Maurita-nia	Niger	Senegal
Total area (1,000)	274	1,284	4	10	36	1,240	1,036	1,267	197
Useful Agricultural area (1,000ha)	8,900	39,000	42	590	1,260	26,770		15,000	3,800
%UAA/total area	32	30	10	57	35	22	0.2	12	19
UAA/inh (ha/inh)	0.88	6.09	0.11	0.57	1.26	2.97	0.2	1.76	0.46
Cultivated area (1,000ha)	3,500	2,000	42	180	163	3,730	228	10,141	2,400
% cultivated/arable	39	5	90/100	30	13	14	981	50	63
Population (1,000) in 1960	4,279		200	374	540	4,636	2,400	3,234	3,051
Population (1,000) in 1994	10,100	6,400	380	1,025	1,000	9,013		8,493	8,128
Density 1994	37	5	93	97	28	7	2.4	7	41.3
Distribution % men			48		51	49	49	49	48
women			52		49	51	51	51	52
under 15 years				47	49	44	49.5	47	47
Life expectancy at birth	47.5	47.5	65	45	44	55	46	47	49.5
Rural population		79	50	63.6	67	73	50	85	59
Urban pop		21	50	36.4	33	27	50	15	41
average illiteracy rate	81	81	30	61	45	83	61	86	67
illiterate women		92				89	70		
Total active pop.	54	49	35	50	48	50	46.5	31	45
Rural sector (%)	90	83	31	80	84	86	54	78	77
GNP/inh 1994 FCFA	90,000	220*		537D	220*	134,000	193,500	76,300	780*
Agricultural GNP/rural inh. FCFA	31,0000			372D		65,000	45,000	27,500	

*** The actual cultivated area of Niger is about 7,500,000 ha after deduction of the double accounting of inter-croping (mostly cowpeas)

* GNP in dollars (1992)

Source: National studies

The fundamental characteristics of the Sahelian population boils down to:

- a mainly female population: with the exception of Guinea-Bissau (49% of women), in the nine CILSS countries, the female component of the population is higher than 50% and varies between 51 and 52%. It should be noted that women play a very important role in the general activities of life, especially in rural areas. They take part in the production process in all systems; they are mostly present in traditional rice-growing and market-gardening. For example, in the agro-pastoral production system where humid agriculture is predominant, in the Gambia, Senegal and Guinea-Bissau, they produce most of bottom-land rice. Besides, women are responsible for preparing agricultural produce for consumption (domestic processing of produce and cooking).

- A very young population: one of the consequences of high population growth is the predominance of the youth. In the Sahel, young people aged under 15 represent 44 to 50% of the total population.
  This phenomenon, especially in urban centres, raises problems in terms of education, health and food in the current economic context. These valid hands are lost labour for parents living in rural areas on the one hand and, on the other hand, they are a source of social problems for the city.

- A low active population: the percentage of the active population in the Sahel varies from 30% in Niger to 54% in Burkina Faso. The high proportion of young people, plus the elderly and the disabled, results in the fact that the number of dependents per active person remains high.

- A mostly rural population: the majority of the population are farmers, pastoralists and fishermen (although some fishermen are urban dwellers). With the exception of Mauritania (54%), the rural population varies from 77% in Senegal to 90% in Burkina Faso. However, it should be underscored that, in the 1960s, only 7% of the population lived in town; in 1984, urban dwellers represented 20%. Rural people are extremely poor as compared to urban dwellers: GNP per rural inhabitant varies from F CFA

27,500 to F CFA 65,000 while GNP per capita (national) ranges from F CFA 76,300 to 193,000.

Therefore, it is easy to understand the high migration rate of rural people. Their main destinations are the Soudanian and African regions in general where climatic conditions are more lenient, and Europe.

Life expectancy remains very low despite the progress made by health services; it varies from 44 years in Guinea-Bissau to 65 years in Cape Verde.

1.5 Infrastructure

Table 1.2 Infrastructure

Countries	Telephone lines/inhabitant	Asphalted roads km/million inhabitants
Burkina Faso	2	158
Chad	1	56
Cape Verde	-	-
The Gambia	14	772
Guinea-Bissau	6	-
Mali	1	308
Mauritania	3	804
Niger	1	400
Senegal	8	542

Source: National studies

While telephone communication is less accessible, road networks have been the target of appreciable effort. This might have contributed to the development of rural markets as mentioned in the national studies.

There are storage facilities for produce in the Sahelian countries taken as a whole. Agro-industries exist depending on the concentration of commercial crops: cotton, groundnut, sugar cane.

In the field of hydro-agricultural developments, and although the acreage of irrigated areas is still low, important works have been built such as the Diama and Manantali dams in the framework of the OMVS which is a common organization to Mali, Mauritania and Senegal. There are other dams within Senegal: the Guidel and Afiniam anti-salt dams and two dams in the Anambé watershed. In Mali, the Office du Niger dam can be mentioned, and in Burkina Faso the Bagré and Kompienga dams.

II COMMON AND DISTINCTIVE FEATURES OF THE PRODUCTION SYSTEMS

In the national studies, three different definitions were adopted as regard production system.

The first such definition is that of Burkina Faso and Mauritania (and which is the definition proposed by Norman and Winch, 1980) which considers the production system as a series of elements or interdependent components with a reciprocal action. Consequently, the production system is the result of interactions between several interdependent components. There are three such components: the exploitation system, the farming system and how production factors are used.

The second one, that of Senegal (which is the definition by Ph. Lost), relates the production system to a set of techniques and practices used by producers to tap the potentials of a zone with a view to obtaining plant or livestock production.

The third one, that of Niger, Chad and Mali (which is the defintion given by Ph. Jouve) considers the production system as a combination of plant and livestock productions as well as production factors that are managed by the farmer so as to meet socio-economic and cultural objectives.

From these three definitions, we can say that the production system is the result of the operative and dynamic relations which unite the following sets:

- a set of plant, animal, fauna and fish production;
- a set of production factors (land, water, labour, capital); and
- a set of techniques and practices.

2.1 The various production systems

The various production systems depicted in the national studies are summarized in the tables in Annex I.

From the above definition, (the three sets defined above) production systems in the Sahel can be gathered under five major types (Table 2.1):

- the pastoral production system which is mainly characterized by exclusive cattle-breeding. This production system is localized in the most arid areas of the Sahel.
- The agro-pastoral production system where pastoralism is predominant: cattle-breeding is the main activity in this system. (400 to 500 mm rainfall). Agriculture is a marginal activity for the agro-pastoralists. The pattern of cattle-breeding is transhumance.
- The agro-pastoral system where dry-farming is predominant (500 to 900 mm rainfall): agriculture is the people's main activity. Because of erratic rainfall, cattle-breeding is a way of saving which protects the agro-pastoralists against climatic hazards;
- The agro-pastoral system where humid agriculture is predominant (more than 900 mm rainfall): the difference with the previous system lies in the fact that rainfall as well as agricultural potentials are higher. Generally, the system includes commercial and export crops.
- The irrigated production system: it is perceived here as a production system because of its peculiarity and of the importance of water in the Sahel. Indeed, given increased security in production as well as the important role that irrigation plays in the Sahel, we deemed it necessary to isolate it as a system. This system is not localized in a specific area and irrigated perimeters are scattered all over a given country. Here, the centre of interest is irrigated perimeters. Oasis irrigation: its peculiarity lies in total or partial water management. This system covers plant production as well as livestock production.

Table 2.1 Production Systems

COUNTRIES	PASTORAL PRODUCTION SYSTEM	AGRO-PASTORAL PRODUCTION EMPHASIS:PASTORALISM	AGRO-PASTORAL PRODUCTION EMPHASIS:DRY FARMING	AGRO-PASTORAL PRODUCTION EMPHASIS:HUMID AGRIC.	IRRIGATED PRODUCTION SYSTEM
Burkina Faso		System used in the Sahelian agricultural region where rainfall is under 500 mm	System used in Central, north-western and eastern agricultural regions	Used in western agricultural region	Irrigated areas
Chad	System used in the Saharan part of country	System used in Sahelian part of country		System used in Soudanian part of country	Irrigated areas
Cape Verde	System used in arid zone	System used in semi-arid zone	System used in sub-humid and humid zones		Irrigated areas
The Gambia			System used in the plateau region	System used in the mangrove area	
Guinea-Bissau			System used in the plateau region	System used in the mangrove area	
Mali	Pastoral production system (Kayes Timbuctu, Ségou)	Evolutionary pastoral production system (Mopti, Ségou, Koulikoro)	North Sahelian South Sahelian	South Soudanian North Guinean	Irrigated areas (active Delta)
Mauritania	Used in arid and maritime agro-ecological zones 0 to 100 mm	Used in West and east Sahelian agro-ecological zones			Irrigated areas
		Used in North Sahelian zone	Used in South Sahelian and North Soudanian zones		Irrigated areas
Senegal		Used in the sylvo-pastoral zone	Used in groundnut basin	Used in South-east and upper Casamance Lower and mid Casamance	Used in Senegal Valley The Niayes production system

2.2 Common and distinctive features of production systems (Table 2.2)

The pastoral production system: as already mentioned, the pastoral production system is to be found in the most arid zones where rainfall is less than 300 mm. Cattle-breeding is extensive, nomadic in general. Livestock consist of camels and goats. Because of the great variability in water resources and natural pastures, herds graze over expanded areas.

Agriculture is of the oasis type. The major crop is date. Market-gardening is also practised under the palm groves as well as recessional agriculture around dams and watering points.

The agro-pastoral production system where pastoralism is predominant: it is localized between isohyets 400 and 500 mm, and it corresponds to the cattle-breeding zone par excellence. Livestock mostly consist of large cattle, sheep/goats, donkeys and camels. Utilization of pastoral resources is still based on herd mobility.

The basis of animal feed is natural pasturelands where woody species play an important role. High degradation of pasturelands is noticeable around watering points while fodder resources are relatively available where water resources are limited or virtually inexistant. The dominant pattern of cattle-breeding is transhumance both in terms of number of heads and space used.

Agriculture is a marginal activity. More often than not, it is practised by cattle-breeders who turned poor following successive periods of drouhgt in the region. The major crops are millet and cowpeas, either as single crop or companion crop. The agro-pastoral production system differs from country to country, depending on the types of crops: in Chad, recessional crops are wheat, corn and market-gardening, while in Mauritania, they are sorghum, cowpeas, wheat and corn. As regards tree-planting, the species are mango, citrus trees, coco and cashew trees in Cape Verde, date palm and gum tree in Niger.

The agro-pastoral production system where agriculture is predominant: this sytem is found in areas above isohyet 500 mm where cattle-breeding coexists with agriculture, the latter being the

dominant activity. In this system, the various activities may be juxtaposed or integrated; the dominant feature is sedentary cattle-breeding.

In the dry area (500 to900 mm), cultivated lands are degraded because of poor farming techniques; this is all the more so as soils are inadequately protected by the crops during the rainy season and they are submitted to wind erosion during the dry season.

The major crops are cereals (sorghum, millet, corn) in association with some legumes (especially cowpeas).

Livestock is both a factor of soil fertility (manure), a factor of labour (animal traction), a source of food and capital.

Crop residues are used to feed the cattle during the dry season.

The agro-pastoral production system where agriculture is predominant differs from country to country, depending on the types of crops and the existence of maritime or continental fishing. In Senegal, groundnut is the major export crop.

In the humid zone (above 900 mm), cultivated lands are generally fertile and human pressure is low. The system is characterized by rainfed agriculture, although there are irrigated crops such as rice. In Burkina Faso, Mali and Chad, cotton is the driving crop under this system. The integration of agriculture and livestock is materialized by the use of animal traction, the production and utilization of manure.

The irrigated production system: in the Sahelian countries, agricultural production is high dependent on rainfall. So as to increase security in food production, the States undertook to develop irrigated perimeters following the drought in the 1970s. These perimeters are either downstream of dams or alongside rivers. Irrigation is by gravity or by pumping. In addition to

these modern perimeters, there are traditional ones, plus the exploitation of groundwater in oases.

Table 2.2 Common and distinctive features of production systems (plant production)

PRODUCTION SYSTEM	ISOHYET	COMMON FEATURES	DISTINCTIVE FEATURES	COUNTRIES
Pastoral production system	0 to 300 mm	⇒ Oasis type agriculture ⇒ main activity: dates and market-gardening under palm groves (carrot, cauliflower, tomato, onion) ⇒ recessional crop: sorghum and cowpeas. Often barley and wheat ⇒ gum tree		Mali, Niger, Cape Verde, Mauritania
Agro-pastoral production system emphasis: pastoralism	400 to 500 mm	⇒ marginal agriculture but rainfed crops: millet, sorghum often in association with cowpeas ⇒ recessional and bottom land crops	⇒ recessional agriculture: * Chad: wheat, corn, market-gardening * Cape Verde: cassava, sweet potato, market-gardening * Mauritania: sorghum, cowpeas, wheat, corn ⇒ Tree-planting * Cape Verde: mango, papaya tree, cashew, coco, citrus, forest trees * Niger: market-gardening and dates in oases ⇒ Continental fishing in Senegal	Burkina Faso, Mali, Niger, Cape Verde, Mauritania, Senegal Chad
Agro-pastoral production system emphasis: dry farming	500 to 900 mm	⇒ Rainfed agriculture, emphasis cereals ⇒ main crops: sorghum, millet often in association with cowpeas. ⇒ inter crop: groundnut ⇒ market-gardening around dams and watering points ⇒ fruit tree: mango, citrus, cashew ⇒ degraded agro-forestry, degraded plant forest ⇒ integration agriculture/livestock	Rainfed crops: Niger: rice and cotton in the river area Senegal: groundnut, cotton The Gambia: fonio and cotton Senegal: maritime and continental fishing	Burkina Faso, Chad, Senegal, Mali, Niger, The Gambia, Guinea-Bissau

Source: Adapted from national studies, CILSS/PMSA/PRORES studies, 1996

Table 2.2 Common and distinctive features of production systems (plant production)

PRODUCTION SYSTEM	ISOHYET	COMMON FEATURES	DISTINCTIVE FEATURES	COUNTRIES
Agro-pastoral production system emphaisis: humid agriculture	Above 900mm	⇒ very much diversified rainfed agriculture, often in association ⇒ main crops: sorghum, millet, corn, rainfed rice ⇒ inter crops: sesame, sugar cane, tobacco, groundnut ⇒ fruit trees and market-gardening very much developed ⇒ very dense agro-forestry ⇒ integration agriculture/livestock with development of animal traction ⇒ irrigated and bottomland rice	⇒ Guinea-Bissau: mangrove crops ⇒ The Gambia, Guinea-Bissau, Senegal: timber and service wood, continental and maritime fishing ⇒ Senegal: little developed animal traction	Burkina Faso, The Gambia, Guinea-Bissau, Senegal, Mali, Chad
Irrigated production system	All isohyets	⇒ Agriculture made secure because of water availability: modern and traditional hydro-agricultural developments ⇒ single or double cropping ⇒ main crops: rice, market-gardening, traditional cereals (sorghum, corn) and sugar cane	⇒ Mali, Mauritania, Senegal: exploitation of river and dams ⇒ Same countries belonging to OMVS	Burkina Faso, Mali, Niger, Cape Verde, The Gambia Mauritania, Senegal Chad

Source: Adapted from national studies, CILSS/PMSA/PRORES studies, 1996

Table 2.2 Common and distinctive features of production systems (plant production)

PRODUCTION SYSTEM	ISOHYET	COMMON FEATURES	DISTINCTIVE FEATURES	COUNTRIES
Pastoral production system	0 to 300 mm	⇒ cattle-breeding is the main activity ⇒ dominant pattern is nomadic because of scarcity of natural pasturelands ⇒ breeding of sheep, goats and camels oriented towards milk and meat production	⇒ difference is at level of species ⇒ Chad, Mauritania: majority of camels ⇒ Niger and Mali: majority of large cattle ⇒ Cape Verde: majority of goats ⇒ Mauritania: maritime fishing in addition	Mali, Niger, Cape Verde, Mauritania, Chad
Agro-pastoral production system emphasis: pastoralism	400 to 500 mm	⇒ Transhumance is dominant activity ⇒ Extensive utilization of pasturelands. Intensive utilization of woody species and pressure around watring points ⇒ Breeding of large cattle, sheep and goats	⇒ Cape Verde: majority of goats ⇒ Mauritania, Senegal: majority of camels ⇒ Senegal: continental fishing	Burkina Faso, Mali, Niger, Cape Verde, Mauritania, Senegal Chad
Agro-pastoral production system emphasis: dry farming	500 to 900 mm	⇒ sedentary breeding of large cattle, goats and sheep ⇒ intensive peri-urban cattle-breeding oriented towards production of meat, milk and eggs	⇒ Senegal: maritime and continental fishing	Burkina Faso, Chad, Senegal, Mali, Niger, The Gambia
Agro-pastoral production system emphasis: humid farming	above 900 mm	⇒ sedentary breeding of large cattle, goats and sheep ⇒ Fulani transhument cattle-breeding ⇒ intensive peri-urban cattle-breeding oriented towards production of meat, milk and eggs		Burkina Faso, Chad, Senegal, Mali, Niger, The Gambia, Guinea-Bissau

Source: Adapted from national studies, CILSS/PMSA/PRORES studies, 1996

III MAJOR PHYSICAL CONSTRAINTS AND PROSPECTS FOR IMPROVEMENT

The annexed Table 2 provides a synthesis of the major physical constraints and prospects for improvement.

3.1 Major Constraints

The low performance of the Sahelian production systems is due to a combination of constraints.

Three types of constraints are highlighted in the national studies:

- physical or agro-ecological constraints;
- socio-economic constraints; and
- institutional constraints

3.1.1 Physical or agro-ecological constraints

They relate to:

- decreasing rainfall;
- increasing demographic pressure resulting in pressure on agricultural lands;
- increasing animal pressure on pasturelands;
- inappropriate farming practices (mineral agriculture, without inputs or with low levels of inputs);
- pests which destroy crops.

Table 3.1 gives a synthesis of physical constraints in relation to production systems.

In the pastoral production system and agro-pastoral production system where pastoralism is predominant, the major constraints are decreasing rainfall and lack of water, the degradation of ecosystems, wind erosion, high level of degradation of pasturelands around watering points.

In the agro-pastoral production system where dry farming is predominant, the major constraints are decreasing rainfall, soil degradation, degradation of the plant cover. Given the fact that more often than not these are production systems with a high human concentration, the result is an increase in cultivated areas, continuous exploitation of lands without organic or mineral

restoration. Fallow that was once the main method used to restore soil fertility is about to disappear, thus depriving animals from fodder resources. The result of the above is decreasing soil fertility, low yields and soil erosion.

Table 3.1 Physical Constraints

Pastoral system	Agro-pastoral system, emphasis:pastoralism	Agro-pastoral system, emphasis: dry farming	Agro-pastoral system, emphasis: humid agriculture	Irrigated system
⇒ high rainfall ⇒ poor soils ⇒ extremely extensive cattle-breeding ⇒ marginal agriculture ⇒ low plant cover ⇒ lack of water ⇒ degradation of ecosystems ⇒ overgrazing ⇒ wind erosion ⇒ problem of transhumance with long distances to cover	In addition to the constraints faced by the pastoral production system, the following could be added: ⇒ pressure of agriculture on pasturelands ⇒ excessive degradation	⇒ rainfall often in a deficit ⇒ high concentration of commercial crops ⇒ decrease in fallows ⇒ high fall in soil fertility ⇒ overexploitation of vegetation which is seriously degraded ⇒ contribution of poor agricultural practices to soil degradation ⇒ high pressure on forests ⇒ highly mineral agriculture ⇒ wind erosion ⇒ water erosion ⇒ overexploitation of pasturelands ⇒ soil acidity and salinity ⇒ fall and salination of water tables ⇒ constant cereal deficit ⇒ high dependence of varieties on rainfall	⇒ shallow soils based on a crust ⇒ pronounced water erosion ⇒ indiscriminate exploitation of forests ⇒ introduction of new commercial crops leading to the need to clear new lands ⇒ soil acidification ⇒ soil salination especially in estuaries ⇒ malaria ⇒ onchocerciasis ⇒ trypanosomiasis ⇒ progressive use of marginal lands ⇒ fall in soil fertility ⇒ degradation of the plant cover	⇒ salination of poorly drained heavy soils ⇒ threat of chimical products through drainage water ⇒ reduction in pasturelands ⇒ fall in fish resources ⇒ change in ecology with the emergence of new diseases ⇒ slow pace of developments for lack of financial resources ⇒ low agricultural intensity (low level of double cropping) ⇒ lack of maintenance of infrastrucutre (obsolete) ⇒ prohibitive costs of investments (developments) ⇒ precarious management of infrastructure network by producers ⇒ inadequacy of water distribution system ⇒ accumulation of sand in agricultural zones ⇒ land-lockedness

Source: Adapted from national studies, CILSS/PMSA/PRORES studies, 1996

In the agro-pastoral system where humid agriculture is predominant, the major constraints are: fall in soil fertility, indiscriminate clearing leading to destruction of the plant cover and salination of lands, endemic diseases which hamper the development of lands and pressure on

pasturelands mostly because of the considerable number of heads of cattle coming from other production systems.

The irrigated production system: the major constraints are: fall in soil fertility, salination of lands, mechanical failure of irrigation networks, ecological changes, threat of chimical products and prohibitive cost of some development facilities.

3.1.2 Socio-economic and institutional constraints

These are common to all production systems. Table 3.2 summarizes the constraints identified in the national studies.

Table 3.2 Socio-economic and institutional constraints

Socio-economic constraints	Institutional constraints
Plant production ⇒ Land tenure system or access to land ⇒ Inadequacy of processing and storage facilities ⇒ Supply/marketing ⇒ Lack of credit ⇒ high cost of production factors ⇒ Low integration of agriculture/cattle-breeding ⇒ Rural exodus ⇒ under-equipment ⇒ Slow adoption of technological packages ⇒ rudimentary production means ⇒ Conflicts between farmers and cattle-breeders	⇒ Inadequacy of extension activities (1) ⇒ Privatization (2) ⇒ R & D linkage ⇒ Low performance of credit-providing institutions (banks) ⇒ Weakness of Peasant-farmer Organizations* ⇒ Inappropriate agricultural policies* ⇒ Inappropriate regulations
Animal production ⇒ Feed ⇒ Water ⇒ Supply/marketing ⇒ Credit ⇒ Animal health	⇒ Inadequacy of extension activities ⇒ Privatization ⇒ R & D linkage ⇒ Low performance of credit-providing institutions (banks) ⇒ Weakness of Peasant-farmer Organizations* ⇒ Inappropriate agricultural policies* ⇒ Inappropriate regulations
Fish production ⇒ Supply in fishing equipment ⇒ Outlets ⇒ Overexploitation of some species	⇒ Inadequacy of extension activities ⇒ Low performance of credit-providing institutions (banks)

Source: Adapted from national studies, CILSS/PMSA/PRORES studies, 1996

* As proposed by regional consultants

(1) The inadequacy of extension activities is the result of the structural adjustment policies in the agricultural sectors in the various countries and which materialized in drastic reduction in the number of extension workers.

(2) Privatization is mentioned as a constraint in the sense that, in parallel with the policy of state divestiture, the prive sector has not been prepared to replace the state bodies.

(3) R & D linkage. In this linkage, there appears a low level of upgrading research output one the one hand and, on the other hand, inadequate taking into account of development requirements.

3.2. Expansion and improvement prospects

Table 3.3 provides a synthesis of prospects and avenues for improvement in the various production systems.

Pastoral production system and agro-pastoral production system where pastoralism is predominant: the national studies underscore the fact that avenues for the expansion of strict rainfed crops are extremely limited. Agriculture is a very risky activity because of very unfavourable climatic conditions. Thus, the expansion of crops could lead to competition between agriculture and cattle-breeding. Conversely, oasis areas have considerable potentials that deserve to be tapped. Agricultural activities in these zones provides the main sources of food and incomes for the people. It is possible to expand cultivated areas, with the proviso that pumping equipments are improved.

Agro-pastoral production system where dry farming is predominant: there are possibilities for expansion, albeit limited. In Mali, for example, 60 to 80 % of arable lands are exploited while in Chad only marginal lands are still available. However, there are possibilities to improve the production system owing to the integration of agriculture and cattle-breeding. The development of mixed cattle-breeding is a factor of intensification. The high preponderance of single-crop

farming is also an obstacle to the improvement of the production system. Efforts should concentrate on the search of avenues for diversifying agricultural productions.

As regards cattle-breeding, the expansion of cultivated lands led to reduction in the pastoral estate. Among other things, the improvement of livestock production will require an increase in fodder production, whether natural pastures managed in a rational manner or fodder crops introduced in the farming systems or agricultural by-products.

The agro-pastoral production system where humid agriculture is predominant: this production system still has tremendous untapped agricultural, pastoral and fishing potentials. Rainfall and soil quality offer interesting prospects for development in agriculture and cattle-breeding. However the pace of exploitation and the current production level can only be sustained in the long term through the protection of natural resources and soil fertility. As regards cattle-breeding, the quality of natural pasturelands is good and animal feed should be improved through the emergence of agro-industries in these areas.

The irrigated production system: the national studies underscore the importance of the areas that could be developed in the various countries. Burkina Faso: 140,000 ha; Mauritania: 135,000 ha; Senegal: 240,000 ha in the River valley; Chad: 5,600,000 ha; Niger: 240,000 ha; Mali: 1,000,000ha. The CILSS/Club du Sahel report on the development of irrigated crops in the Sahel (1991) show that, with the exception of Cape Verde's negligeable potential, the CILSS countries exploit but 20 to 30% (it seems that this is too high than is the case in actual facts) of their potentials, apart from Burkina Faso and Guinea-Bissau who exploit but 13% and 9% respectively. The same report also emphasizes that, for Guinea-Bissau, the irrigable area is higher than irrigation requirements by very far.

Table 3.3. Prospects for expansion and improvement of plant production systems

Systems	Pastoral production system	Agro-pastoral production system, emphasis: pastoralism	Agro-pastoral production system, emphasis: dry farming	Agro-pastoral production system, emphasis: humid agriculture	Irrigated production system
Possibilities for expansion	Very limited possibilities for expansion in agriculture	⇒ Senegal: expansion not recommended outside irrigable areas ⇒ Mali: 60 to 80% of arable lands are under cultivation ⇒ Chad: not possible: only marginal lands available ⇒ Burkina Faso:limited and risky possibilites ⇒ Mauritania: limited possibility	⇒ Senegal: virtually impossible ⇒ Mali: 60 to 80% of arable lands are under cultivation ⇒ Burkina Faso: limited possibilities, exploitation of marginal lands	⇒Senegal: expansion still possible but with caution in the South-east ⇒ Mali: 60 to 80% of arable lands are under cultivation ⇒ Chad: expansion not recommended so as to better protect soil fertility; cultivated areas must represent 1/4 of fallows ⇒ Burkina Faso: possible; only 13 to 30% of arable lands under cultivation	⇒ Senegal: expansion possible with 240,000 irrigable ha in the north ⇒ Mauritania: possible River and oasis zones ⇒ Mauritania: possible in oasis zone if improved pumping facilities. Possible in irrigable zone ⇒ Burkina Faso: expansion possible

Table 3.3. Prospects for expansion and improvement of plant production systems

Systems	Pastoral production system	Agro-pastoral production system, emphasis: pastoralism	Agro-pastoral production system, emphasis: dry farming	Agro-pastoral production system, emphasis: humid agriculture	Irrigated production system
Prospects for improvement	⇒ Protection of environment ⇒ development of alternative activities ⇒ Responsibility-building among the people as regards protection of natural resources against bush fires ⇒ Bush fire control ⇒ protection of cultivated areas against cattle ⇒ increase rural incomes ⇒ provide watering points	⇒ Provide water in fossil valleys ⇒ introduce irrigated crops ⇒ introduce mixed farming ⇒ better management of natural resources ⇒ improvement of productive capacity ⇒ increase incomes	⇒ Agricultural intensification and diversification ⇒ Reafforestation and soil conservation programme ⇒ Development of agro-forestry ⇒ Natural resource management ⇒ Integration agriculture/cattle-breeding ⇒ Early varieties ⇒ Reinforce food security ⇒Improvement of marketing channels for cereals ⇒Boost commercial crops ⇒ Crop diversification ⇒ Water and soil conservation	⇒ Diversification and increase in production, especially cereals ⇒ Introduction and promotion of new crops ⇒ Development of fruit-tree planting ⇒ Production of vegetables for agro-industry (flowers for export) ⇒ Rational exploitation of forests ⇒ Identification and development of irrigable areas ⇒ Maintenance of soil fertility ⇒ Soil-improving fallow ⇒ Development of agro-forestry ⇒ Development of valleys ⇒ Better management of natural resources through appropriate technologies ⇒ Integration agriculture/cattle-breeding ⇒ Combat salination and acidification ⇒ Improvement of production techniques ⇒ Better dissemination of research output ⇒ Development of markets and processing of products, especially cereals	⇒ Double-crop farming ⇒ Increase in yields ⇒ Development cost distribution between State and beneficiaries ⇒ Promotion of horticulture for export ⇒ Land tenure legislation enabling ownership ⇒ Distribution of good seeds ⇒ Plant health ⇒ improvement of production techniques ⇒ Adapted credit system ⇒ Protection of environment ⇒ Combat sand accumulation in farming areas ⇒ Increase profitability of farms ⇒ Improve productive capacity ⇒ Improve pumping equipment in oases ⇒ Management of land-related conflicts ⇒ Rehabilitation of watering points for palm groves ⇒ Improve labour productivity ⇒ Rehabilitation and reorganization of developed perimeters ⇒ Improve efficiency of investments

LIVESTOCK PRODUCTION

	Introduce small cattle through fodder crops	⇒ Combat bush fires ⇒ Improve load capacity of pasturelands ⇒ Introduce fodder crop at watering points ⇒ Drill pastoral wells ⇒ Improve pastureland management through community participation ⇒ Better monitoring of cattle health ⇒ Genetic improvement of local stocks ⇒ Development of early stocks ⇒ Take into account the concerns of cattle-breeders in research programmes	⇒ Improve cattle-breeding methods ⇒ Upgrade livestock by-products ⇒Improve animal feed ⇒ Improve major natural potentials for animal feed	⇒ Integration agriculture/cattle-breeding ⇒ Agricultural development projects should have livestock component ⇒ pest control	⇒ Rationalization and intensification of cattle-breeding ⇒ Corridors for cattle ⇒ Define terms for cattle access to water ⇒ Define rules for pastures ⇒ Develop fodder crops ⇒ Take cattle-breeding into account when designing hydro-agricultural developments

Source: Adapted from national studies, CILSS/PMSA/PRORES studies, 1996

IV ROLE OF PRODUCTION SYSTEMS

The Sahelian agriculture is essentially rainfed. It is based on traditional farming of cereals such as millet and sorghum, often in association with cowpeas. Table 3A provides the main rainfed crops as per country. Conditions permitting, farmers grow some commercial crops (cotton, groundnut) which, in some cases, are means for introducing modern inputs in the production system, thus benefiting cereals crops. Annexed Table 3B shows the importance of cattle in the various countries.

In several cases, the introduction of commercial crops amounts to deforestation because of indiscriminate land-clearing and farming techniques which do not respect soil regeneration: this is the case of groundnut in Senegal, cotton in Mali and Burkina Faso.

The contribution of the primary sector (agriculture, livestock, forests, fishing) to GDP formation varies tremendously from country to country, ranging from 22.2% in Senegal to 50% in Guinea-Bissau.

Conversely, the sector occupies a prime place in exports in most CILSS member countries.

Table 4.1 Contribution of the primary sector to GDP formation

Countries	Burkina Faso	Chad	Cape Verde	Gambia	Guinea Bissau	Mali	Mauritania	Niger	Senegal
Contribution to GDP	1992	91/95	1994	94/95			1992	1993	
Total GDP (FCFA 1,000 M)	817		11.3 ME	550M2D			99.7 M3 UM	651	
Agricultural GDP (FCFA1,000M)	252			113M2D			29.1M3 UM	244	
Primary (%)	31	47	20	21	50	42	30	38	11
Agriculture	17			14			3	22	
Livestock	8	11		5			20	12	
Forest	6				0.6			4	
Fishing	with forest			1.7			6	with forest	
Contribution to exports (FCFA1,000M)	1991							1993	
Total exports (FCFA1,000M)	30							62.5	
Primary (% total exports)	80	89			93			22	
Agriculture	66	54						2	
Cotton	63	35						20	
Livestock	14								
Forest									
Fishing									
Share in investments		91/95				87/91			
Total investments (FCFA1,000M)		311				570			
Primary (%)						32			
Agriculture		17				19.2			
Livestock		3.6				8			
Forest						4.2			

The Sahel is also a major cattle-breeding region. The existence of vast areas unsuitable for agricultural production, low rainfall unfavourable for the development of trypanosomiasis are assets for livestock development. The number of heads of cattle is considerable in virtually all countries with the exception of Cape Verde, Guinea-Bissau and The Gambia.

Cattle-breeding is transhumant in the pastoral and agro-pastoral production systems where pastoralism is predomiant, and sedentary in the agro-pastoral production system where agriculture is predominant. Table 4.2 presents the role of production systems

4.1 The role of pastoral production systems

Pastoral production systems are found in the Sahelian part which borders the desert (sub-saharan and north-sahelian zone) in Mauritania, Chad, Mali and Niger.

In this zone, plant production is virtually inexistent, with the exception oasis production made possible through oases scattered over the desert. Rainfall varies between 0 and 300 mm per annum. The main production is dates.

In Mauritania, this type of production provides 2,310 tons of vegetables and 4,175 tons of wheat and barley.

In Niger, cattle-breeding in this zone is for milk production and livestock for export.

4.2 The role of the agro-pastoral system where pastoralism is predominant

This is the production system in the typically Sahelian zone (annual rainfall under 500 mm) which is found in all CILSS member countries with the exception of The Gambia and Guinea-Bissau.

Plant production is marginal except in Chad where this zone provides 40% of cereal production and 15% of oil and vegetable production.

This production system provides arabic gum in the sub-region (Chad, Senegal and Niger). In Senegal, the production of arabic gum reaches 200 tons per annum and is for export. In Mali, the system provides 24% of food crops.

The major characteristic is livestock production. The zone is host to more than 70% of livestock in Chad, 38% of large cattle in Mali. In Senegal, cattle-breeding accounts for 60% in the

monetary incomes of cattle-breeders living in this zone. This is also where all the camel livestock is to be found.

In Burkina Faso, the agro-pastoral production system where pastoralism is predominant is host to 12.5% of large cattle, 11.5% of sheep, 21% of goats and 100% of camels. In Niger, the zone is host to cattle meant for export.

4.3 The role of the agro-pastoral system where dry farming is predominant

This is the cereal production system par excellence: 47% of food crops in Mali, 57% of agricultural production in Mauritania, 63% of cereal production in Senegal, 95% of cereal production in Niger, 84% in The Gambia and 50% of rural incomes in this zone in Burkina Faso.

For some countries such as Senegal, it provides most of groundnut production.

Cattle-breeding remains an important activity.

4.4 The role of the agro-pastoral system where humid agriculture is predominant

From all points of view, this zone is complementary to the previous one, but agriculture is more diversified because of climatic conditions that are favourable to several varieties and species. In the field of cattle-breeding, the importance of the plant cover as well as greater quantities of water resources allow sedentary cattle-breeding.

In Chad, the zone provides 40% of cereal production and most of commercial crops (cotton, sugar cane). In Burkina Faso, it produces 29% of cereals, 80% of cotton. 35 to 50% of the country's export earnings are derived from the zone owing to the concentration of commercial crops.

The space devoted to this production system contains the highest potential in woody species in the Sahelian countries.

4.5 The role of the irrigated production system

The irrigated production system is not localized in a given zone, but rather scattered, depending on possibilities for irrigation. This is the system where production is secured at a high level. The system provides a considerable part of rice and market-gardening crops.

In Chad, it provides 40% of fish products and the entire rice production; in Senegal it produces 86% of rice.

Table 4.2 The role of the various production systems (% of national production)

Role of systems	Pastoral production system	Agro-pastoral production system; emphasis: pastoralism	Agro-pastoral production system; emphasis: dry farming	Agro-pastoral production system; emphasis: humid agriculture	Irrigated production system
Burkina Faso: agriculture: 36% of GDP		⇒livestock: domestic consumption and export: ⇒12.5% of large cattle ⇒11.5% of sheep ⇒21% of goats ⇒100% of camels	⇒agriculture:50% of incomes ⇒export market-gardening crops ⇒export sheep & goats	⇒cereal production:50% ⇒cotton production:80% ⇒export earnings: 30 to 50%	⇒fishing ⇒rice ⇒market-gardening
Chad ⇒ agriculture: 40 to 50% of GDP ⇒ food crops:33% ⇒ livestock:18%	⇒ date production ⇒ camels: 13.34%	⇒ 40% of cereal production ⇒ 15% of oil and vegetable production ⇒ arabic gum ⇒ 70% of country's livestock		⇒ 40% of cereal production ⇒ 85% of cotton ⇒ 100% of sugar cane ⇒ 18% of livestock	⇒ Fishing: 40% of national production ⇒ 10% of GDP ⇒ overall rice production ⇒ market-gardening
Cape Verde: agriculture: 45% of GDP	⇒goats	⇒goats and large cattle	⇒60% of the people's food requirements ⇒milk cows and goats		
The Gambia: agriculture: 28% of GDP			⇒cereal production:84% ⇒livestock:64% of large cattle ⇒majority of horses & donkeys	⇒cereal production:16% ⇒groundnut ⇒cotton ⇒horticulture	
Guinea-Bissau Agriculture				80% of lands for cereals, of which 54% for rice	

Role of systems	Pastoral production system	Agro-pastoral production system; emphasis: pastoralism	Agro-pastoral production system; emphasis: dry farming	Agro-pastoral production system; emphasis: humid agriculture	Irrigated production system
Mali ⇒43% of GDP ⇒food crop:17% of GDP ⇒agro-industry:9.4% ⇒livestock:10.5% ⇒fishing:1% ⇒fish-farming:5%	⇒7% of large cattle	⇒24% of food crops ⇒38% of large cattle	⇒47% of food crops ⇒27% of large cattle	⇒28.7% of food crops ⇒38% of large cattle, fruit trees and forestry	⇒fishing:2.4% of GDP
Mauritania	Production of dates and milk ⇒milk ⇒vegetables: 2,310 tons ⇒wheat & barley:4,175 tons		⇒Agriculture:57 % of national total ⇒livestock:50% of potentials ⇒98% of rice production ⇒milk production		
Niger ⇒agriculture:46% of GDP ⇒export earnings:16% ⇒livestock:15%	⇒livestock for milk and export ⇒milk production	⇒livestock for export	⇒almost 95% of cereal production ⇒livestock: poultry, eggs, meat		Meat, milk, rice ⇒rice:30 to 45% of production ⇒cotton:4,500 tons ⇒market-gardening
Senegal		⇒Cereal production:7% ⇒groundnut:10% ⇒arabic gum:200 tons ⇒wood and charcoal ⇒livestock provides more than 60% of incomes	⇒cereal production:63% ⇒groundnut for oil:79% ⇒groundnut for eating:100% ⇒cattle, sheep, goats, horses ⇒peri-urban cattle-breeding:poultry & milk cows ⇒major fishing areas	⇒cereal production:17.8% ⇒cotton ⇒woody potential:43.5% ⇒fish:14.4% ⇒rice:8% ⇒groundnut:16.5% ⇒value of agricultural production:20.8%	⇒cereal production:9.8% ⇒rice:86% ⇒market-gardening: ⇒fish ⇒firewood

Source: Adapted from national studies, CILSS/PMSA/PRORES studies, 1996

V POORLY KNOWN AND/OR PROMISING PRODUCTION SECTORS

A promising production sector is one with increasing outlets, which generates attractive incomes and allow productive investments in the system. It is emerging when new, little developed and still poorly known. It is identified with a view to facilitating its development, but this does not mean all other systems will no longer be supported. This concern was often an obstacle in the national studies which preferred to put to the forefront the existing fundamental systems (R. Rochette).

Table 5.1 provides a summary of these promising sectors

5.1 The irrigated production system

Out of the nine CILSS member countries, seven identified promising systems under irrigation conditions and which relate to two groups:

- Cereals and companion crops
- Fruit and vegetables

It is also a revelation to note that the seven countries that identified these systems are those which are closest to the Sahara.

The reaction illustrates the concern those countries have as regards the need to secure food crops (cereals and companion crops) and to ensure a certain level of incomes (fruit and vegetables) by upgrading water resources under any form: total water management, traditional irrigation, recessional agriculture, oasis farming.

This way of upgrading water resources so as to secure production is also anxious to reduce costs to reasonable proportions in some cases. This explains why, alongside major hydro-agricultural developments, there are small village irrigated perimeters which are maintained by farmers with quite limited financial resources.

There also simple and inexpensive developments in bottom-lands or manual pumps or animal traction as often practised in oasis agriculture.

The system which develops rice-growing in association with traditional cereals such as irrigated sorghum and corn or even some fodder crops such as alfalfa is particularly targeted by countries which experience extremely harsh cilmatic conditions in their northern region (e.g. Mauritania).

Adoption of this system is strategic in the sense that it allows to ensure a certain level of food security which varies from country to country, depending on their possibilities and which often highly contributes to fodder resources.

As regards the upgrading of water resources through market-gardening and fruit trees, countries who chose it aim at income improvement. The Sahel certainly has assets in the field of horticulture for both export and domestic consumption.

5.2 The agro-pastoral production system where pastoralism is predominant

Here again, the choice by countries bordering the Sahara desert somewhat reveals the effort made by the Sahelians to tap their limited natural resources under precarious climatic conditions: pastoralism in Mauritania, ranching in Niger, gum-tree planting in Chad.
Ranching aims at a three-fold objective: economic, ecological and social.

On the economic plane, the objective is to tap vast areas of lands and enable considerable milk and meat production.

On the ecological plane, ranching helps better manage the balance between pastures/cattle/water when it is known that the pastoral zone has a fragile ecosystem.

From a social stanpoint, the system could help out many people forced into transhumance.
The production of arabic gum also leads to improvement in incomes.

5.3 The agro-pastoral production system where agriculture (dry and humid) is predominant

This is the most valued system, but also the most common to all countries in the region. It mainly relates to rainfed crops (cereals and agro-forestry) intensive cattle-breeding (modern peri-urban) and semi-intensive cattle-breeding (cattle-breeding integrated to agriculture, any type of poultry-farming, fishing/fish-farming).

Corn certainly has a productive capacity in this system because of good rainfall in its humid part. The existence of early varieties of corn provides an acknowledged opportunity to fill the food gap during the hungry season.

But corn is mostly mentioned here because of its nutritional values, multiple avenues for processing and also as a component in animal feed and mostly poultry in peri-urban husbandry.

Here, agro-forestry relates to cereal crops cultivated under shea nut trees and rainfed association of cashew trees and market-gardening (rainy season market-gardening), especially vegetables of African origin.

Selection of this system also aims at rehabilitating natural resources such as the soil and plant cover which are seriously degraded.

5.1 Poorly known and/or promising production systems

Production systems	Burkina Faso	Chad	Cape Verde	Gambia	Guinea Bissau	Mali	Mauri tania	Niger	Sene gal
Irrigated production system									
⇒cereals and companion crops	x	x				x	x	x	x
⇒fruit and vegetables	x	x			*	x	x	x	x
Agro-pastoral production system emphasis: pastoralism	x								
⇒pastoralism							x		
⇒ranching								x	
⇒agro-forestry: arabic gum		x							x
Agro-pastoral production system emphasis:dry& humid farming									
⇒rainfed crops:				*					
corn	x		x			x			
cereal + sorrel	x								
⇒agro-forestry									
farming under shea nut trees									
cashew trees +rainy season market-gardening	x				*				
⇒modern peri-urban cattle-breeding (meat & milk)	x	x		*		x	x	x	*
⇒cattle-breeding integrated to agriculture	x		x	*		x	x	x	*
⇒any type of poultry-farming	x	x				x			
⇒fishing/fish-farming	x	x				x			

* Proposal made by authors of the report Source: adapted from national studies and CILSS/PMSA/PRORES studies,1996

VI ROLES OF VARIOUS NATIONAL AND REGIONAL DEVELOPMENT PARTNERS

The national studies did not provide a detailed analysis of the roles that could be played by development partners. The proposals that were made can be summarized at both the national and sub-regional levels.

6.1 National level

Development partners could play an important role in:

6.1.1 **Cattle-breeding**, through

- support to a census of cattle so as to have reliable data;
- support to development of small cattle and poultry.

6.1.2 **Improvement of natural resource production/management systems**, through:

- developement of solar energy so as to combat environmental degradation;
- support to policies aimed at removing taxes on inputs and agricultural equipment so as to allow intensification of production and conservation of the environment; and
- natural resource management and desertification control through the promotion of water and soil conservation technologies, of agro-forestry and renewable energies.

6.1.3 **Food security**, through:

- the provision of facilities for storage and processing of local products, especially in land-locked areas;
- the search of working capital so as to improve the marketing of surplus production;
- improving the conditions for the recovery of agricultural production;
- development of farm-produce sectors;
- higher integration of agriculture/cattle-breeding; and
- strenghtening national extension and research programmes.

6.1.4 **Training-information**, through

- the promotion of peasant-farmer organizations;
- greater promotion of women;
- improving the flow of information; and
- local capacity-building.

6.2 Sub-regional level

At the sub-regional level, their role could consist, inter alia, in:

- promoting sub-regional expertise;
- producing reliable statistics in the agricultural field and establishing sub-regional information system on agricultural markets;
- helping coordinate research programmes towards food security;
- organizing inter-Sahelian trade;
- organizing a commodity stock exchange; and
- developing the road network to open up the region.

VII NEED FOR FURTHER REFLECTION

The formulation of a common approach to further deepen the national studies on production systems appeared as a necessity.

The synthesis of the national documents on production systems which culminated with this report was an extremely difficult task, mostly because of the difference in methodologies used on the one hand and, on the other hand, owing to divergence in understanding some concepts such as production system and farming system. In several cases, the farming system is merged with the production system while the former is an element of the latter. Thus, in some countries, it is possible to find the corn production system, the rainfed rice production system or the bottom-land rice production system etc.

So as to better understand production systems and their (internal and overall) dynamics, CILSS should summon all the national teams for a discussion on a common approach with a view to further deepening the national studies on production systems.

Such further reflection should allow to refine the constraints that were identified as regards the systems so as to understand the major constraints and prioritize them. Projects and programmes as well as plans of action will be in a position to integrate these constraints in order to remove them progressively according to a precise schedule.

Most of the national documents addressed the role of production systems in the national economy without however showing quantitatively their contribution to the said economy. Further studies should help understand the quantitative contribution of each system to the national economy, to the people's nutrition, and help know the area and people that are represented by each production system.

In the light of this synthesis, all countries should , through further study of production systems, be able to integrate the five identified systems:

- Pastoral production system;
- Agro-pastoral production system where pastoralism is predominant;
- Agro-pastoral production system where humid agriculture is predominant;
- Agro-pastoral production system where dry farming is predominant;
- Irrigated production system.

At the same time, each country will have to look further into these five systems, to localize them and to quantify them, giving accurate acreages, population, number of heads of cattle, cultivated areas, performance (yields, food balance...)

Thus, the synthesis will provide a better vision of production systems, the promotion of which is certain in the sub-region (intra-regional trade) as well as outside. This will aslo help participate in the evaluation of the CILSS zone in other major African groupings.

The synoptic vision of all five systems in the sub-region will be possible only if each country uses the geographic information system so as to help CILSS characterize and localize the homogenous agro-ecological zones in the Sahel.

Fish production is a special aspect in agricultural and food production in the Sahel. Five out of the nine CILSS member countries are coastal nations on the one hand and, all nine countries practise continental fishing to some degree on the other hand. Thus, all countries are requested to further study the maritime and continental fish production system.

The above explanations and need for further reflection will help better understand the emerging and/or promising systems in the sub-region so as to generate promising sectors within the CILSS countries and/or outside.

Thus, further study of the emerging systems will have to address the quantification of these systems, while precising acreages and the market that they could represent at both national and sub-regional levels.

But the propulsion of emerging systems must be done in the framework of natural resource conservation and, better still, it should take into account, in designing development programmes for these systems, components related to the rehabilitation and sound management of natural resources. This is a tangible principle of sustainable development: development of emerging systems should not be tantamount to the degradation of the ecosystems which host them.

Consideration and synthesis of the national studies were made even more difficult by the reports of the Gambia and Guinea-Bissau.

In these countries, it seems that the study on production systems does not exist. It can be noted for both countries that studies are made in relation to soil series, which makes their classification difficult in production systems. In this connexion, there is a need to improve these national studies.

In all countries where there is no research programme on production systems, it becomes an imperious necessity for CILSS to approach the said countries with a view to finding financial, human and institutional resources to establish such programmes. These countries are Mauritania, The Gambia, Cape Verde, Chad and Guinea-Bissau.

Finally, on the sub-regional plane, the various national studies reveal that the CILSS countries are a space for the production of dry cereals and that, overall, food balances are in a chronic deficit.

From this standpoint, it is urgent to define coherent research programmes towards food security in the CILSS zone. In this connexion, a regional meeting of research and development workers

should be organized to launch the foundations for the definition of a research framework towards food security in the Sahel.

Table 7.1 Need for further reflection

Fields	Countries	Short term	Medium term	Long term
1. Adoption of a common approach to further deepen the national studies on production systems:	All	+		
1.1 To deepen, localize and quantify the five systems defined in this report	All	+	+	+
To deepen the continental fish production system	All	+		
To deepen the maritime fish production system	Cape Verde, Gambia, Guinea-Bissau, Mauritania, Senegal	+		
1.3 To use the geographic information system so as to characterize and localize homogenous agro-ecological zones in the sub-region			+	
1.4 To refine and prioritize the constraints as per production system so as to better understand the major ones	All			
1.5 To accurately determine the contribution of each system in the national economy	All	+	+	+
1.6 To further deepen studies on emerging systems	All	+		
2. To improve the national studies on production systems	Gambia, Guinea-Bissau, Cape Verde	+		
3. To find ways of designing research programmes on production systems where such programmes do not exist	Mauritania, Gambia, Cape Verde, Chad, Guinea-Bissau			+
4. To define research programmes towards food security				+

VIII FRAMEWORK FOR THE FORMULATION OF PROJECTS AND PLANS OF ACTION

The Sahel is a vast space for cereal production in particular, but also groundnut and cotton as export crops. It is also a an expanded area for extensive cattle-breeding.

However, the fundamental characteristic of the region is chronic cereal deficit because of low agricultural productivity. Natural resources are not properly managed and, in general, soils and ecosystems are seriously degraded.

In order to remedy such a situation, the CILSS countries are obliged to adopt food security as the cornerstone of their agricultural policies.

Achievement of food security can be done only in the framework sound natural resource management and implementation of appropriate policies.

The degradation of natural resources which are the productive basis accounts for the low level of productivity. The Sahelians must adopt intensive agriculture , mostly using local and modern inputs without destroying natural resources. Therefore, rational management of natural resources is the means to ensure food security and the sustainability of production systems. As a prerequisite, there is a need to improve rural incomes and keep the people on their village lands.

The improvement of rural incomes and living conditions is based on the following points aimed at transforming the production systems (Table 8.1):

- participation of the people as partners in the management of resources and decision-making , and not as eternal beneficiaries of assistance;
- promotion of democratic peasant-farmer organizations capable of ensuring the supply of agricultural inputs and equipment, marketing and processing of products;
- modernization of production systems through intensification and crop diversification, while respecting the integrity of natural resources;
- Restoration of a performing credit system for the procurement of equipment and inputs so as to support intensification and diversification;

- support to and promotion of emerging and/or promising production systems which are the best at upgrading natural resources such as water and pastoral resources (better livestock and plant production);
- development of a type of agro-forestry capable of regenerating soils and contributing to increasing rural incomes;
- promotion of reafforestation according to programmes that are specific to the spaces which are host to production systems;
- promotion of private initiative, especially the creation of agricultural SMEs;
- Tax reduction and trade and price liberalization so as to boost private initiative in rural areas;
- improvement of the rural road network for better movement of products, especially the most perishable ones.

Table 8.1 Transformation of production systems

	Burkina Faso	Chad	Cape Verde	Gambia	Guinea Bissau	Mali	Mauri tania	Niger	Sene gal
1. Fundamental objectives									
⇒Food security	x	x	x		x	x	x	x	x
⇒Natural resource management	x	x	x		x	x	x	x	x
⇒Improvement of incomes**	x	x	x		x	x	x	x	x
⇒Divestiture of State (SAP)	x	x	x		?	x	x	x	x
2. Strategic options									
⇒ Promotion, participation, partnership and organization of the rural world	x	x	?			x	x	x	
⇒ Modernization of production systems	x	x	X		x	x	x	x	x
diversification	x	x	x		x	x	x	x	x
intensification	x	x	x		x	x	x	x	x
⇒ Restoration of credit for inputs and equipment	?	x	x		x	x	x	x	x
⇒ Support to emerging systems (including water and pastoral resources)	X	x	x		x	x	x	x	x
⇒ Support to promising and basic (cereals) sectors			x			x	x	x	x
⇒ Reduced taxation and liberalization of trade and prices, and improvement of rural road network	x	x	x		x	x	x	x	x
⇒ Promotion of private initiative	x	x	x		x	x	x	x	
3. Support expected from CILSS									
⇒ Information, training, exchange of views	x				x	x		x	
⇒ Monitoring/information on NRM									
⇒ and on firewood and renewable energies	x				x	x		x	
⇒ Promotion of regional trade	x				x	x			
⇒ Promotion of peasant-farmer organizations					x	x			

CONCLUSION

The Sahel is characterized by a series of successive periods of drought, high population growth and serious degradation of ecosystems which resulted in counter-performance of the production systems.

This situation raises a productivity problem in the Sahelian agriculture, especially in terms of cereal production.

The national studies have shown a structural food deficit in the zone.

Now, rural production basically depends on the state of natural resources and efficiency of policies. The degradation of resources leads to a fall in agricultural productivity. The sustainability of growth in productivity in the sector can therefore but rely on the rehabilitatio and sound management of natural resources.

In this framework, so as to remove this food deficit, the Sahel must be aware of the fact that production activities, agriculture, cattle-breeding, fishing and forestry are never isolated but integrated in a balanced agro-sylvo-pastoral space. This is the rationale behind the national studies commissioned by PRORES in all CILSS member countries.

These studies helped characterize production systems, identify their constraints, analyze their role in the national economies and, at the same time, determine the advisable fields of co-operation with the Sahel's development partners.

This process should be consolidated through further reflection around the said national studies (see Part VII of this report).

Summary of production systems per agro-ecological zone and per country

BURKINA FASO

Agro-ecological zone: Centre, Soudanian region

1. Plant production system: Rainfed agriculture: sorghum, millet (75 to 80% of cultivated area).

* groundnut, cowpeas associated with sorghum and millet.
* irrigated rice
* market-gardening
* forest species: A. Seyal, A. Radiana, P. Biglobosa, B. Parkii

2. Livestock production system: Mixed system integrating agriculture/livestock based on large cattle, donkeys and especially small cattle for meat production (goat , mutton), and poultry.

* Peri-urban breeding of goats, sheep and pigs for meat , and poulty-farming for meat and eggs.

3. Fish production system:

4. Rainfall: 600 to 900 mm

5. Soils: Tropical ferruginous soils, washed on sandy, sandy-clayey or clayey-sandy material. Crude mineral soils. Vertisols

6. Major activities: Agriculture

Agro-ecological zone: North-west, Soudano-sahelian region

1. Plant production system: Rainfed agriculture: sorghum, millet (75 to 80% of cultivated area).

* groundnut, cowpeas associated with dry cereals.
* irrigated rice

* market-gardening, including green beans for export (43% of national production)

* forest species: A. Seyal, A. Radiana, P. Biglobosa, B. Parkii

2. Livestock production system: * Agro-pastoral system oriented towards fattening and cow goat milk production: transfer of cattle from the Fulani breeders to farmers

* Mixed system integrating agriculture/livestock towards meat production (goat , mutton), and poultry; fattening of large cattle.

* Peri-urban breeding: fattening of large cattle, goats, sheep.

3. Fish production system:

4. Rainfall: 500 to 600 mm

5. Soils: Little evolved erosion soils, gravel

6. Major activities: Agriculture

Agro-ecological zone: West, Soudano-guinean region

1. Plant production system: Rainfed agriculture: sorghum, millet, rainfed rice, cowpeas in association with cereals, yam, fonio, voandzou, cotton as cash crop.

* market-gardening (tomato, cabbage, onion)

* irrigated and bottom-land rice

* fruit (mango, papaya, citrus fruits, banana)

2. Livestock production system: * Sedentary cattle-breeding by agro-pastoralists (draught animals raised in stable for manure production).

* Transhumant breeding in search of better pastures

* Peri-urban breeding

3. Fish production system:

4. Rainfall: 900 to 1,200 mm

5. Soils: Hydromorphic soils; ferralitic soils; tropical ferruginous soils, entrophic brown soils

6. Major activities: Agriculture

Agro-ecological zone: East, Soudanian region

1. Plant production system: Rainfed agriculture: sorghum, millet, yam, cassava, sweet potato, cotton .

* irrigated and bottom-land rice

* Forest species: A. Albida, B. Paradoxum, P. Biglobosa, A. Digitata

2. Livestock production system: Pastoralism evolving towards agro-pastoralism

3. Fish production system:

4. Rainfall: 600 to 900 mm

5. Soils: tropical ferruginous soils, entrophic brown soils, alluvion vertisols, little evolved erosion soils

6. Major activities: Agriculture

Agro-ecological zone: Sahel, Sahelian region

1. Plant production system: Rainfed agriculture: millet, sorghum

* Forest species: A. Albida, A. Radiana, C. Glutinosum, B. Aegyptiaca, P. Reticulatum

2. Livestock production system: Pastoral and agro-pastoral system

3. Fish production system:

4. Rainfall: < 500 mm

5. Soils: ferruginous soils, little evolved soils, entrophic brown soils, sodic soils

6. Major activities: Livestock

Annex 1 Summary of production systems per agro-ecological zone and per country

CAPE VERDE

Agro-ecological zone: Arid, 2,652 sq.km

1. **Plant production system:**
2. **Livestock production system:** * Sylvo-pastoral extensive breeding of goats; animal feed is derived from forest species such as P. Jubiflora, P. Aculeata and other fodder species: grass and rainfed crops (corn, fava)
3. **Fish production system:**
4. **Rainfall:** 300 mm
5. **Soils:** Young, little evolved, poor in organic matter and sensitive to erosion
6. **Major activities:** Livestock

Agro-ecological zone: semi-arid, 631 sq.km

1. **Plant production system:** * Rainfed crops
   * Irrigated crops in valleys: sugar cane, banana, cassava, sweet potato, potato, onion.
   * fruit-trees: mango, cashew, papaya tree, coco tree, citrus trees.
   * forestry: P. Jubiflora, A. Albida, C. Canescens, A. Funiculada.
2. **Livestock production system:** Breeding of goats; agro-sylvo-pastoral system
3. **Fish production system:**
4. **Rainfall:** 300 to 400 mm
5. **Soils:** Magmatic rocks.
6. **Major activities:** Agro-pastoralism

Agro-ecological zone: humid

1. **Plant production system:** * Rainfed crops: corn, beans, cassava

   * irrigated crops: tomato, onion, potato

   * Fruit-trees: mango, cashew, citrus

2. **Livestock production system:** * **Agro-pastoralism:** large cattle, but mostly goats for milk production; cattle raised on animal feed and agricultural residues
3. **Fish production system:**
4. **Rainfall:** 400 to 600 mm
5. **Soils:**
6. **Major activities:** Agro-pastoralism

Agro-ecological zone: humid, highlands

1. **Plant production system:**

   * Rainfed crops: tubers, corn, beans, coffee

   * market-gardening

   * Eucalyptus and Pinnus SP plantation

2. **Livestock production system:** * Stabling or semi-stabling of large cattle; cattle raised on cultural residues
3. **Fish production system:**
4. **Rainfall:** > 600 mm
5. **Soils:**
6. **Major activities:** Agro-pastoralism
7. **Activities not related to an agro-ecological zone:** artisanal and industrial fishing. Four small processing plants.

THE GAMBIA **Agro-ecological zones**: not determined

1. Plant production system: * Production system on highlands: millet, corn and vegetables on lands around villages.

* groundnut, millet, sorghum, cotton on peripheral lands

*Intensive type: utilization of inputs and animal traction (total mechanization)

* semi-intensive type: limited utilization of animal traction and inputs; involves women

* extensive type: poor weeding, low utilization of animal traction, very low utilization of inputs;

* production on lowlands: rice-growing; fruit and vegetables on a small scale.

2. Livestock production system: * Traditional livestock-raising; collective herds of 10 to 150 heads. Small cattle remain on the farm and generally belong to women.

* Improved traditional cattle-breeding: feed, water supply and health are improved.

* Modern (peri-urban): market-oriented, especially poultry. It is expanding to cover large cattle, sheep and pigs.

3. Fish production system: * Artisanal fishing: 1,653 pirogues, of which 500 go to sea; remainder for continental fishing

* industrial fishing: Gambian and foreign companies varying in capacity. Production for export.

4. Rainfall:

5. Soils: * Alluvium, hydromorphic. Low organic contents, drained, low fertility. Slightly acid.

* colluvial dominance. Little drained soils with fine texture on surface. Low fertility here and there because of degradation: erosion, destruction of vegetation, acidity, salinity.

6. Major activities:

GUINEA-BISSAU

Agro-ecological zones

1. Plant production system: * Production system on plateaus.

- bush farms: extensive (rainfed rice, corn, millet, groudnut, cowpeas, cocoyam) and fruit trees. Farms are 5 km away from villages.

* Valley production system: rice, banana, fruit trees. This system mostly being for women, it is difficult to solve the issue of developments which require high physical efforts

* Mangrove production system: development is time-consuming and hard to achieve (5 to 6 years): clearing and desalination. Rice is grown.

* "Ponteiro" system: mechanized riced_growing combined with cashew for export.

2. Livestock production system: * **Balante system**: agro-pastoralism, collective herd: large cattle, sheep, goats, pigs and poultry.

* Fulani system

3. Fish production system: not mentioned in country report although fishing exists

4. Rainfall:

5. Soils: Impoverished by monoculture of groudnut and farming practices which do allow for soil regeneration.

Water erosion and acidification

Highly salt lands in estuaries

6. Major activities:

MALI

Agro-ecological zones: *Mopti, Timbuctu, Kayes, Koulikoro, Sikasso and ** Timbuctu, Mopti, Ségou, Koulikoro, Kayes

1. Plant production system: * Agro-pastoral system where agriculture is predominant.

* Purely agricultural production system: very little represented , even in irrigated areas.

* agro-pastoral system where pastoralism is predominant: marginal agriculture, mostly rainfed. Transhumant herds

Sahelian zone: pastoral system; nomadic cattle-breeders (Tamachek, Maures, Fulani.

2. Livestock production system: Agro-pastoral system; in irrigated areas, low mobility; * associated with rainfed crops (millet and cash crops)

* Pastoral system:

- with high mobility (nomadic) (Bella, Touareg, Maures Arabs)

- associated with rainfed crops (Harratin, Bella, Touareg, Fulani, Maure) . Medium mobility

- associated with pastures and recessional agriculture Fulani) High mobility in rainy season

3. Fish production system:

4. Rainfall: * Heavy rainfall; plenty of water

* * 400 mm

Sahelian zone: 400 mm

5. Soils:

6. Major activities: * Agriculture

** Cattle-breeding

Sahelian zone: cattle-breeding

MAURITANIA

Agro-ecological zone: East Sahelian: 100,000 sq.km, 350,000 ha, 3.5 inh/sq km

1. Plant production system: Rainfed and recessional agriculture

2. Livestock production system: Transhumance

3. Fish production system:

4. Rainfall: - 400 mm

5. Soils: young or older isohumic soils allowing development of herbaceous pastures

6. Major activities: Livestock

Agro-ecological zone: River area: 22 sq.km, 370,000 ha, 17 inh/sq km

1. Plant production system: Rainfed crops: millet, sorghum, cowpeas

* recessional agriculture on alluvial lands: corn, plus okra, sorrel, watermelon, tomato, onion; sorghum

2. Livestock production system: Transhumance of large cattle, sheep, goats and decreasing number of camels

* sedentary breeding of large cattle, sheep, goats, donkeys

3. Fish production system: River fishing but falling sharply

4. Rainfall: 400 mm

5. Soils: Hydromorphic soils

6. Major activities: Agriculture

Agro-ecological zone: Arid: 810,000 sq.km, 300,000 ha, 0.37 inh/sq km

1. Plant production system: Oasis agriculture with dates as main crop (4,751 ha in 1993)

* cereals: wheat and barley
* vegetables: carrot, cabbage, tomato
* fodder: alfalfa
* recessional crops: sorghum, beans

2. Livestock production system: Transhumant dromedaries for meat and milk; sedentary goats for milk, meat and butter

3. Fish production system:

4. Rainfall: 0 to 100 mm

5. Soils: crude mineral soils without agricultural value because of low rainfall

6. Major activities: Livestock

Agro-ecological zone: maritime: 25,000 sq.km, 20 inh/sq km

1. Plant production system:

2. Livestock production system: camels and cows for milk; dairy goats

3. Fish production system: Industrial fishing and processing of fish products

4. Rainfall:

5. Soils: Halomorphic soils characterized by presence of sodium and potassium

6. Major activities: Livestock

Agro-ecological zone: West Sahelian: 75,000 sq.km, 360,000 ha, 4.8 inh/sq km

1. Plant production system: peri-urban market-gardening; alfalfa, rainfed crops (millet, sorghum, cowpeas, watermelon;

Bottom-land crops: sorghum, cowpeas

Recessional crops: sorghum, cowpeas, and, en passant, wheat and corn

2. Livestock production system: Sedentary agro-pastoralism

3. Fish production system:

4. Rainfall: 200 to 400 mm

5. Soils: young or older isohumic soils allowing development of herbaceous pastures

6. Major activities: Agriculture

NIGER

Agro-ecological zone: Pastoral

1. Plant production system:

2. Livestock production system: * Pastoral system: traditional extensive (nomadic or transhumant) occupies 15-20 % of the people. Ranching: 7 ranches totaling 330,000 ha belonging to the State

3. Fish production system:

4. Rainfall: Sub-Saharan and North-Sahelian zone

5. Soils:

6. Major activities:

Agro-ecological zone: Agro-pastoral

1. Plant production system: *Extensive rainfed agriculture (millet, sorghum, cowpeas).
* semi-intensive: animal traction, manure (millet, sorghum, cowpeas, groundnut)
* Oasis type: cereals, fodder, horticulture. Animals used for pumping water and for manure.
* Agro-sylvo-pastoral: dallol and goulbis areas: woody species for commercial purposes

2. Livestock production system: Extensive sedentary or transhumant cattle-breeding
*Sedentary; collective herds; fattening; poultry-farming
* semi-intensive breeding of sheep and goats

3. Fish production system:

4. Rainfall: Maradi-Zinder

5. Soils:

6. Major activities:

Agro-ecological zone: Agricultural

1. Plant production system:
* extensive in dune areas and eastern plains: millet and cowpeas; no inputs
* semi-intensive: rivers, lakes, oases; mostly recessional crops: rice, market-gardening, cotton, fruit-trees
* intensive: hydro-agricultural developments (13, 12 ha) good utilization of inputs: rice, sorghum, cotton, market-gardening
* agro+ fish-farming

2. Livestock production system:
3. Fish production system: Continental fishing on River Niger, Koumadougou, Lake Chad
4. Rainfall: Agadez
5. Soils:
6. Major activities:

SENEGAL

Agro-ecological zone: Groundnut belt (centre)

1. Plant production system:
* system based on groundnut as commercial crop; northern area: groundnut, millet, sorghum, cowpeas, cassava. Southern part: groundnut, millet, corn, cotton
* Forestry: firewood, charcoal, service wood, handicraft, fodder, fibers for ropes

2. Livestock production system:
* integrated agricultural, pastoral and forestry activities
* juxtaposition of activities

3. Fish production system: Artisanal and maritime fishing on Petite Côte
4. Rainfall: North: 300 to 400 mm; South: 500 to 800 mm
5. Soils: Degradation; poor farming practices; water and wind erosion; salinity and acidity
6. Major activities: Agriculture (groundnut, cereals)

Agro-ecological zone: Lower and Mid Casamance (south)

1. Plant production system:
* system based on : groundnut, millet, sorghum (often in association, corn and rainfed rice on highlands
* slope and bottom-land rice

* Forestry: timber, firewood, sub-guinean type of vegetation

2. Livestock production system: system with agricultural activites

3. Fish production system: river and sea
traditional fish-farming

4. Rainfall: 800 to 900 mm

5. Soils: shallow plateau soils, low fertility, water erosion; bottom-land soil acid or salt

6. Major activities: Agriculture

Agro-ecological zone: South-east and upper Casamance

1. Plant production system:
* system based on two commercial crops : groundnut and cotton, groundnut cotton, millet, sorghum , corn
* Forestry: main origin of firewood
* National protected park, classified as heritage of humanity (Niokolo Koba)

2. Livestock production system: system of reproduction and re-breeding; little transhumance because of fodder in large quantities

3. Fish production system:

4. Rainfall: 900 mm and more

5. Soils: vast plateaus made up of lateritic strata with soil. Water erosion: indiscrimate exploitation of forests and poor farming practices lead to degradation of plant cover and soil

6. Major activities: Agriculture

CHAD

Agro-ecological zone:Saharian zone: 600,000 sq.km, 73,185 ha, 0.12 inh/sq km, rural population: 53,059

1. Plant production system: Oasis agriculture with vegetable gardens under palm groves gravity irrigation, avarage area: 0.29 ha
* dates, wheat, millet; low yields
* market-gardening: tomato, melon, watermelon onion, garlic, salad, sweet potato, okra, capsicum
* fruit trees: vine, citrus, mango

2. Livestock production system: Absence of natural pasturelands because of desert: obstacle to cattle-breeding; species: camels, sheep, goats in oases around Faya

3. Fish production system:

4. Rainfall: low or even nil

5. Soils: sub-arid soils; eroded soils; very low agricultural productive capacity

6. Major activities: Agriculture and transhumance of camel

Agro-ecological zone:Sahelian zone: 554,000 sq.km, 3,232,586 ha, 6 inh/sq km, rural population: 2,448,777, arable lands: 27,300,000 ha; rural density: 9.2 inh/sq. km

1. Plant production system: agriculture around Lake; rainfed cultivation of millet hazardous; recessional agriculture depends on Lake: wheat, corn, tomato, melon, watermelon onion, okra, capsicum
Polder farming: 3 crops/annumm ; corn during rainy season and millet on dune lands, wheat during cold season, recessional corn

2. Livestock production system: Agro-pastoralism: cattle, sheep, goats, horses, donkeys, camels. Transhumance; Season-related movement: Batha to Salamt or mid Chari during dry season and back during rainy season; from Chari Baguirmi to Lake Chad

3. Fish production system:

4. Rainfall: 200 to 600 mm

5. Soils: sub-arid soils in northern part; eroded soils in north-eastern part ; vertisols in southern part

6. Major activities: Agriculture and transhumance

Agro-ecological zone:Soudanian zone: 130,000 sq.km, 2,914,160 ha, 23 inh/sq km, rural population: 2,443,692; arable lands: 11,700,000 ha; rural density: 21 inh/sq km

1. Plant production system: Rainfed: millet, sorghum groundnut, sesame, cowpeas, corn, cassava, yam, taro, sweet potato; cotton as cash crop, groundnut to lesser extent.
* Irrigated rice on modern perimeters of about 500 ha
* on traditional perimeter of about 26,000 ha
irrigated rice, by pumping, 272 ha

2. Livestock production system: Sedentary cattle in Mayo-Kebbi, draught cattle in the cotton belt. Small cattle in all region and poultry highly developed

3. Fish production system:

4. Rainfall: 600 to 1,200 mm

5. Soils: Vertisols, hydromorphic soils; ferruginous and ferralitic soils

6. Major activities: Agriculture with cotton as main crop