Crop residues and agro-industrial by-products in West Africa

Situation and way forward for livestock production

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Preface

Major changes have been brought about in the livestock production systems in West Africa by climate change, and increased demand for livestock products is being driven by rapid population growth, urbanization and policy changes. Changes are driving an increase in demand for foods of animal origin that will stretch the capacity of existing production and distribution systems. Access to feed in quantity and quality is therefore a key strategic priority for livestock development in West Africa.

In order to better monitor the regional livestock sector and promote appropriate livestock strategies, it has become essential to develop systematic approaches for accurately assessing livestock feed supplies in both quality and quantity. Assessments will provide information on feed resource availabilities that could enable optimal policy decisions regarding the use of these resources.

Feed assessments are therefore a component of an overall strategy or options that will integrate technical (genetics, health and nutrition), policy and institutional interventions, aiming to use resources more efficiently to produce more food and feed in pastoral and agro-pastoral, mixed and intensive systems.

The FAO Regional Office for Africa is contributing to regional initiatives in order to support feed assessments and their use for livestock development.

The present publication focuses on the availability, access and utilization of crop residues and agro-industrial products in West Africa. It contributes to the efforts to strengthen mechanisms to establish and maintain feed assessments in West Africa. It is a first regional assessment attempt, based on literature review and fieldwork in a selected sample of seven countries from the Union économique et monétaire ouest-africaine (UEMOA), and utilizing databases available at the regional level in 2011–2012.

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Abbreviations used in the text

ECOWAS	Economic Community of West African States [English version of CEDEAO]
CEDEAO	Communauté Economique Des Etats de l'Afrique de l'Ouest [French version of ECOWAS]
TLU	Tropical Livestock Unit
UEMOA	Union économique et monétaire ouest-africaine [West African Economic and Monetary Union]

The Members of the West African Economic and Monetary Union (known by its French acronym, UEMOA) are Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo.

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Summary

Among the obstacles to the development of the livestock sector in West Africa, feed availability remains a constant factor contributing to the poor performance of livestock, especially in the arid and semi-arid agro-ecological zones with the highest potential.

Irrespective of location, crop residues management is a known and common practice. However, there is an increasing demand for agro-industrial by-products, with the aim of intensifying animal production to meet the increasing demand generated by high population and urbanization growth rates.

Naturally, crop residue supplies vary according to agro-ecological zone and crop type. Arid and semi-arid zones thus have more cereal and legume residues than wetlands, where roots and tubers thrive. Most importantly, as a whole, despite some variations across countries, cereal residues supplies have increased significantly over the past five years, with a preponderance of sorghum and millet, while legumes and root and tubers peel supplies are significantly less. However, cereal residues supplies per animal are declining, while those of legumes are increasing.

The main constraints to the use of these residues are technical in the sense that well-known technologies designed to improve their nutritional value are still not commonly applied in West Africa.

As for agro-industrial by-products, there is a need to discern between those generated from industrial processing (cotton, groundnut, soybean, wheat, rice and sugar cane) and those generated by small-scale processing (major local cereals: millets, sorghum and maize).

Among crop residues, the use of grains and cottonseed cake largely predominates, followed by wheat bran and groundnut cake. The quantities of residues for these by-products obviously depend on agroclimatic conditions, but most of all on the price of the original product. This is especially true for cotton.

While the role of agro-industrial by-products in the livestock feeding industry is well known, it is more difficult to monitor quantities, an already unreliable endeavour in the case of crop residues. With respect to marketing, while crop residues are usually marketed locally, agricultural by-products generated by modern agro-industries are marketed at national, intra-regional and extra-regional levels. The top cotton producing countries (Burkina Faso, Mali and Benin) actually export not only to countries in the sub-region and African countries outside the Union économique et monétaire ouest-africaine (UEMOA) zone, but also outside the continent. However, according to available data, it appears that the quantities exported are much less than the quantities used at national level.

In general, marketing channels are subjected to little or no control at national as well as extra-national levels, and prices experience fluctuations that certainly meet the demand but mostly in proportions justified only by the absence of a legal and economic monitoring system from public authorities. Although the use of by-products is a concern for both technical services and producers, it appears that research focuses even less on them than it used to.

Finally the obstacles to a widespread use of by-products in livestock production can be summarized as follows:

For crop residues:

- poor control of development techniques;
- difficulty in transferring existing technologies; and
- lack of control of supplies.

For agro-industrial by-products:

- difficult access to available supplies and to marketing channels;
- lack of legislation on their trade and use; and
- extensive fluctuations in supply.

Research as well as public authorities should and can take action to eliminate such constraints in order to promote livestock production development at regional level. To achieve this, it is necessary, among other solutions, to promote the harmonious, fair and controlled trade of these feeds between the countries of the UEMOA zone.

Based on the situation, a draft action plan is suggested in order to enable coordinated and sustainable action in the region, while involving the various stakeholder categories.

INTRODUCTION

In West Africa, livestock production is the only activity for over 38 percent of the population in the Sahel, an agro-ecological space characterized by arid and semi-arid zones. In Sahelian countries, livestock production accounts for almost 40 percent of the GDP and ranks either first or second in terms of exports. Moreover, this activity is the first sector, followed by the cereal sector, for which the economy is based on integrating intra-community markets. In effect, regional trade links production basins in Sahelian surplus countries, to consumption areas in coastal countries. Even though trade flows are quite recent for agricultural produce such as cereals, fruits, vegetables and tubers, they are age-old for livestock products. It is therefore a particularly important sector, both socially and economically, for the sub-region.

However, it should be noted that in many respects, livestock production has not really satisfied West African populations, and its economic development has not met the expectations of livestock producers or States. Actually, even though the region carries almost 25 percent of the cattle in sub-Saharan African, its performance remains weak. Thus, in the area of food, the animal protein deficit is especially acute. While nutritionists recommend a daily supply of 20 g of animal protein per person, the actual consumption varies between 8.5 and 5.9 g in the region.

One outcome has been, for example, a doubling of milk and dairy products over 20 years, from an absolute value of US$ 223.7 million in 1984, to US$ 529.4 million in 2004, to meet ever-growing needs. Moreover, the demand for animal products in the sub-region is forecast to experience a 25 percent increase by 2025, and in spite of 2 percent annual growth in supply, it remains lower than the demand; a worsening of the imbalance between supply and demand by 2020 has even been projected.

Thus, the various development projects for the sector, including one on the control of epizootics that enabled a significant increase in cattle numbers, were not enough to bring livestock production to the fore, even though it still has a definite potential for countries in the sub-region. Most of the challenges facing the sector have not been met, including that of feed supply, the relevance of which has been proven by the fluctuations in production levels and rainfall from one season to the other over the years. The latter is especially relevant in Sahelian countries since they are the main providers of animal products and regularly experience tragic cattle losses during years of drought.

Hence, cattle feeding is a major technical and economic challenge for livestock production in West Africa since the feed item accounts for over 50 percent of production costs. It is therefore necessary to find alternatives to usual feeding practices. One of these alternatives which is widely used across the world, is the use of crop residues. Although well known in West Africa, it appears it has not been effectively streamlined. To achieve this, it is necessary to have a thorough knowledge of supplies, of accessibility and technical and economic constraints which vary according to the agro-ecological zones, and hence according to countries. These countries being generally agriculturally interdependent, it is also worth considering the possibility of integration beyond the farm and the country, and mixed farming at sub-regional level.

The study involved five countries (Niger, Burkina Faso, Mali, Benin and Senegal) surveyed during field visits. These countries were selected based on their potential in terms of agricultural and animal production. This potential was determined by agroclimatic conditions and the development of agro-processing industries. Globally, the specificities of the targeted countries represent the diversity of West Africa. Thus, the study includes Sahelian countries and other more or less humid countries, with or without a coastline.

PART 1. AGROCLIMATIC CONTEXT

1.1 SPATIAL VARIATION IN ECOSYSTEMS

In West Africa, the four major agroclimatic zones spread from the west and overlap on a north-south rainfall gradient based on annual precipitation and the growth period of grasses (Table 1).

The coverage of the four zones is uneven at both regional and national levels. A relatively large portion of the entire area is arid to semi-arid (over 50 percent) while the proportion of humid zone is quite low. The countries are grouped in three ecosystems, based on the importance of the four agroclimatic zones:

- the Sahelian ecosystem (Burkina Faso, Mali, Niger, Mauritania, Senegal, The Gambia and Cape Verde);
- the savannah ecosystem (The Gambia, Guinea Bissau, Ghana, Côte d'Ivoire, Benin, Nigeria and Togo); and
- the forest ecosystem (Liberia and Sierra Leone).

Some Sahelian countries have a relatively large savannah ecosystem (Burkina Faso, Mali and Senegal), while Niger and Mauritania are the archetypal Sahelian countries, since they have primarily arid and semi-arid climates. Another distinctive difference between countries is their access to the sea. While coastal countries are often considered forest zones, it should be noted that there are Sahelian countries with a coast, such as Senegal and Mauritania.

For this study, the choice of countries to be visited was guided by the diversity of ecosystems that determine agricultural potential, and by the presence or absence of a coastline, which determines the nature and importance of commercial activities. Thus, the following countries were selected:

Table 1. Characteristics of the four major agro-ecological zones in West Africa

Zone	Rainfall (mm)	Plant growth period (days)
Arid	≤ 500	0–90
Semi-arid	500–1000	90–180
Sub-humid	1000–1500	180–270
Humid	> 1500	270–365

SOURCE: OECD, 2008.

- an exclusively Sahelian country: Niger;
- a Sahelian country with a coast: Senegal;
- two landlocked Sahelian countries with a sub-humid zone: Burkina Faso and Mali; and
- an exclusively sub-humid country with a coast: Benin.

1.2 TEMPORAL VARIATION IN RAINFALL

In addition to the spatial and seasonal rainfall variations in West Africa, between-year variations determine 'good' or 'bad' rainy seasons. However, beyond these 'normal' variations, there are now longer-term variations, to the extent that they are now considered to be associated with climate change. Several expert reports note that climate change threats are more severe in West Africa, with floods, storms, heat waves and droughts, and that these could halve crop yields and modify livestock production practices and performance by the year 2020.

Globally, over a period of 30 years, the long-term annual rainfall average of 150 mm has been infrequently reached in the dry Sahelian zone. During the same period, the semi-humid Sudanian zone was subject to increasingly long dry seasons. In the forest zone, which usually has four seasons (2 dry and 2 rainy), the second rainy season has been disappearing in the northern part (between 7° and 8°N), with the dry seasons getting longer. Thus, there is a variation in the duration of wet periods. These temporal and spatial variations, which imply decreased rain and a reduction in wet zones, alter the agro-ecological profile of West Africa (L'Hôte and Mahé, 1996). Combined with exponential population growth, these trends severely endanger food security and a host of other social aspects of West Africans' existence.

1.3 CROP DISTRIBUTION BY AGRO-ECOLOGICAL ZONE AND INCREASE IN PRODUCTION

1.3.1 Production basins

The diversity of ecosystems related to the diversity of rainfall in West Africa leads to

yet an additional diversity: that of production types that reflect the opportunities for crop profitability. In Sahelian dry zones, where cereal production is dominant, sorghum and millet are cultivated using rainfed farming systems. Rice and wheat, the production of which remain low and lower, respectively, are also cultivated using irrigation, though they are rainfed in a few limited areas.

In the sub-humid zone, the diversity of crops is more pronounced as the climate is more diverse. In addition to sorghum, millet, wheat and rice, maize is also cultivated. Roots and tubers (cassava and yam) as well as legumes (groundnut and cowpea) are also grown. In the agricultural humid zone, the cultivation of other roots and tubers such as cassava, taro and sweet potato dominates.

1.3.2 Production

The main food cereals are millet, sorghum and rice. Wheat has a marginal position. Generally, there was a boost in plant production between 1980 and the 2000s in West Africa (Annex 1), with annual growth rates of 4.5% for maize, 1.6% for sorghum, 1.8% for millet and 1.8% for rice. However, as family production systems remain extensive, where a large part of the harvest is home-consumed, the increased production has come not from an increase in yields, but from extension of cultivated areas to meet the needs of an ever-increasing population in the sub-region. This has led to culture of zones considered marginal due to their low rainfall.

The share of the various cereals in total cereal production varies, with millet supplying over one-third. However, this is rapidly changing, with the share of millet reducing in favour of maize and particularly rice (Annex 2). Cereals are cultivated in all the agro-ecological zones, although very unevenly distributed by country and ecosystem (Annex 3). Thus, in the region under study, it appears that the Sahelian countries (Niger, Mali, Burkina Faso and Mali) are the main producers of millet and sorghum. The differences are smaller for maize although its dominance in sub-humid or Sahelian countries (Mali) with a sub-humid zone is perceptible.

The most cultivated legumes, cowpea and groundnut, had similar yields in 2010 (2 730 000 tonne) and are essentially produced by the same Sahelian countries, headed by Niger for cowpea and Senegal for groundnut. In spite of the increase in production, there was a significant drop in Niger in 2009, leading to a decline in the entire zone (Annexes 4 and 5).

The major cultivated roots and tubers are cassava and yam, and their residues are the most used in feeding domestic animals in the Union économique et monétaire ouest-africaine (UEMOA) region. The main producing countries are Benin, followed by Côte d'Ivoire and then Togo. As for the other crops, roots and tubers production has significantly increased (Annexes 6 and 7).

Among the cash crops, cotton and sugar cane have the most known by-products due to their use in animal feed.

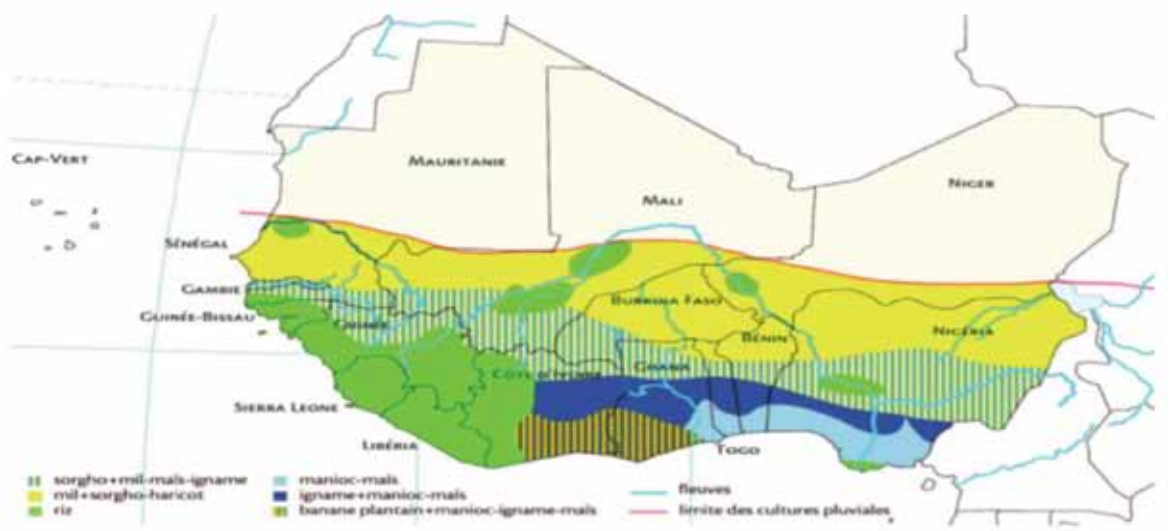

Figure 1. Crop production basins in West Africa
Source: CEDEAO, 2008

Until 2000, West Africa was a leader in cotton production. Its annual production had increased from a few tens of thousands of tonnes in 1960, to over 1 400 000 tonne. In the UEMOA region, this production is dominated by Burkina Faso and Mali, and to a lesser degree by Benin (Annex 8). Due to policies related to the international economic crisis and to climate, production has been declining since 2006.

The production of sugar cane in West Africa reached about 430 000 tonne in 2005, having increased only slightly over the previous 25 years to cover local needs. Within the UEMOA region, there was a drop in production due to low sugar prices on international markets. In that region, the main producers are Côte d'Ivoire (40%), Senegal (32%) and Burkina Faso (15%). The link with favourable ecosystems is apparent, since even in Burkina Faso and Senegal (Sahelian countries), sugar cane is produced in the sub-humid zones.

PART 2. LIVESTOCK

2.1. INCREASE IN LIVESTOCK POPULATION IN ALL THE AGRO-ECOLOGICAL ZONES

The UEMOA share in cattle numbers in West Africa makes it a typical livestock production region, especially for ruminants (Table 2), although within the UEMOA region the distribution by species is not uniform (Table 3).

The steady increase in West African cattle numbers heads is real, even though the rate of increase has not reached that of crops (Annex 9). The growth observed is not uniform across countries or species. Over the past 10 years, a higher annual growth rate was recorded for ruminants compared with monogastric animals (Annex 10). Even though the growth rate is higher in Sahelian countries, it is significant in the other countries. This is certainly due to livestock development projects in the various countries, in order to meet local needs in a context of high population growth, especially in urban areas.

Among monogastric animals, the gap between Sahelian and sub-humid countries is clearly smaller. This reflects the recent increasing importance of short-cycle animal species in sub-humid countries in meeting ever-increasing human needs.

Thus, it can be noted that the distribution of the poultry in sub-humid countries is at par with that of Sahelian countries (Table 3). In sub-humid countries, the urbanization rate is greater due to high population growth and to immigration, and has prompted these countries to develop short-cycle animal species production, for which the environment is conducive. Regarding pigs, similar considerations come into play, with religious factors favourable in sub-humid countries and unfavourable in Sahelian countries.

2.2 LIVESTOCK SYSTEMS DIVERSIFICATION AND MIXED FARMING

There are typically three main types of livestock production.

- Pastoral systems are typical in arid and sub-arid zones and are based on the use of natural food resources, especially in landlocked countries. They cover large pastoral areas where cropping is random. In this situation, the cattle and their owner have to move frequently and could end up in sub-humid zones during the dry season, or in humid zones, where the plant growth period is longer and where fodder supplies are permanent. The supply source is natural fodder or crop residues in the context of exchange of fertilizer for food

Table 2. Livestock production in the UEMOA region – number and share in the ECOWAS total

	Cattle	Sheep	Goats	Camels	Pigs	Chicken
UEMOA country	31 794 050	38 936 550	45 189 620	2 825 290	4 159 210	196 050 000
Share in ECOWAS	54.45%	43.96%	39.71%	65.11%	33.28%	42.26%

SOURCE: FAO, 2009.

Table 3. Distribution (percent) of animal species per country in the UEMOA region

Country	Camels	Cattle	Sheep	Goats	Pigs	Poultry
Benin	0	6	2	3	8	8
Burkina Faso	1	27	21	27	48	19
Côte d'Ivoire	0	4	4	3	8	17
Guinea-Bissau	0	2	1	1	10	1
Mali	41	25	26	18	2	18
Niger	57	26	27	6	1	6
Senegal	1	9	14	22	8	22
Togo	0	1	5	9	15	9

SOURCE: FAO, 2009.

with farmers during seasonal migrations. Their presence in these wealthier zones lasts up to the beginning of the next rainy season.

- Agro-pastoral systems are less mobile and combine livestock production on natural range with use of crop residues. The practices are typical for farmers who also breed animals in order to diversify their economic activities. This type of livestock production is especially important in cotton producing zones, where the cattle also double as draught animals while providing manure. This is typical mixed farming, and also involves livestock keepers who have settled, especially after the great droughts in the 1970s and 1980s.
- Off-soil systems are characterized by the non-availability of space; more precisely, land that enables the use of the aforementioned systems and where the land is insufficient, only pure livestock farming is practicable. In this case, food resources are obtained at the local market and/or imported, with concentrates usually imported.

Wherever land is limited, generally in or around cities, less space-consuming livestock farming systems have developed during the past decades, especially for poultry and pig farming. However, there are also a few sheep fattening units, and units with cattle for fattening and milk. Such livestock farming is essentially, or even exclusively, market-driven, intensive and owned by families and collective businesses. Their modern mode of operation has stimulated the development of animal feed production industries in their vicinity, as is the case in cities such as Dakar and Abidjan. Even though off-soil systems are booming in West Africa, pastoral and agro-pastoral systems are by far the main suppliers (80%) of animal products in West Africa (PROCORDEL, 2004).

All these livestock farming systems are changing towards more established systems. With the ever increasing need for animal products (4 percent more between 2000 and 2015, 25 percent by 2025, 27–28 percent by 2030), the result has been to diversify mixed farming in all the agro-ecological zones. Thus, livestock farming is now associated with all the farming systems.

There is therefore need to use as much as possible of all the food resources derived from crops in the form of residues to support a sector that has become essential due to ever increasing market demands.

PART 3. INDUSTRIAL BACKGROUND

The by-products considered in this study originate from the textile industry (cottonseed) and the food-processing industry (cakes, bran and grain).

3.1 A HIGH-POTENTIAL FOOD-PROCESSING INDUSTRY WITH MIXED PERFORMANCE

West Africa, and especially the countries studied, which form a large part of the UEMOA region, present good potential for industrial development due to the importance of their raw materials. Actually, the Sahelian zone and the sub-humid zone suitable for livestock farming and diversified cropping make it a preferred space, since farming contributes up to 38 percent of the sub-region's GDP. Thus, UEMOA countries have a great number of food-processing industries in diversified sectors. This study focuses on the sectors of oilseeds, cereals and sugar cane. Other crops, such as barley, provide highly marginal by-products, in largely insufficient amounts reserved for a few very wealthy producers in peri-urban zones.

3.2 A HIGHLY DIVERSIFIED OILSEEDS INDUSTRY IN TERMS OF CAPACITY AND STAKEHOLDERS

The oilseeds industry is involved in livestock farming through the production of cakes. This industry dominates the other sectors due to its greater supply of raw materials, mainly cotton, groundnuts and, to a lesser extent, soybean. All UEMOA countries, to varying extents, have an oilseeds processing industry, and the three types of processing (artisanal, semi-industrial and industrial) co-exist (Table 4).

Table 5. Characteristics of major oil mills in the UEMOA region

Country	Number	Production capacity (tonne/year)	Products processed
Benin	4	70 000	Cottonseed, palm nut
Burkina Faso	6	103 000	Cottonseed
Côte d'Ivoire	6	950 000	Cottonseed, palm nut
Guinea-Bissau	—	—	—
Mali	2	371 000	Cottonseed, groundnut
Niger	1	—	Groundnut
Senegal	1	300 000	Groundnut
Togo	1	90 000	Cottonseed

As data on the number of employees in artisanal and semi-industrial businesses, as well as their production, could not be obtained, this study focuses only on modern businesses and their production. Côte d'Ivoire, followed by Senegal and Burkina Faso, have the highest capacity (Table 5). The main cakes supplied by these modern industries originate from groundnut, cotton and palm nut.

3.3 MAIN ARTISANAL OR SEMI-MODERN MILLS

Rice-mills and other mills process raw materials into grain and bran, although local cereals such as millet and sorghum are mainly processed using traditional methods. Industrial plants process wheat, and to a lesser extent rice, as it is mainly semi-industrially processed. Few data exist on rice mills. In fact, the small amount of rice produced locally is often processed using artisanal methods, and so data on by-products is not available. Nevertheless, there are some

Table 4. Characteristics of oilseed processing units

Characteristic	Artisanal	Semi-artisanal	Modern industrial
Labour	Family	Small and medium enterprise	Large enterprise
Investments	Very low/nil	Few machines	Large and modern
Operations	Manual	Manual	Automatic
Productions	Very low	National	National, sub-regional
Type of market	Local	National or regional	National and regional
Distribution	Direct sale	Sale through middlemen	Extensive and professionalized

Table 6. Characteristics of the major mills in the UEMOA region

Country	Name	Capacity
Benin	Grands Moulins du Bénin	65 000 t/year
Burkina Faso	Grands Moulins du Faso	50 000 t/year
Côte d'Ivoire	Grands Moulins Abidjan	—
Mali	Grands Moulins Mali	70 000 t/year
Niger	Grands Moulins du sahel	—
Senegal	Nouvelle Minoterie Africaine	200 t/day
Senegal	Moulin SENTAC	7 000 t/month

SOURCE: UEMOA, 2008.

Table 7. Ginning factories in the UEMOA region

Country	Number	Ginning capacity (tonne/yr)	Cottonseed production (tonne; 2009)	%	Oil mills
Benin	20	650 000	415 000	64	2
Burkina Faso	15	535 000	432 000	81	1
Côte d'Ivoire	12	420 000	346 000	82	1
Guinea-Bissau	1	na	4 000		
Mali	17	600 000	515 000	86	3
Niger	2	60 000	10 000	17	
Senegal	5	65 000	41 000	63	
Togo	6	200 000	162 000	81	1
Total	79	2 530 000	1 925 000	76	

NOTES: na = data not available. % column indicates capacity in use.

very-low-capacity modern rice mills. An elaborate system exists (Table 6).

3.4 A STRUGGLING TEXTILE INDUSTRY

The relevance of cotton for the livestock sector resides in the defibered cottonseed that has not been crushed or prepared for seeding. Relatively modern ginning mills with significant production capacity produce cottonseed. Even though the sector is diversified in the various countries through integration and a diversity of stakeholders, there exist common points, related mainly to the supply of often insufficient raw materials.

The cotton industry developed in West Africa in the early 1960s. The then highly aggressive national policies heralded a promising period, which was followed by difficult times starting at the end of the 1980s. These policies involved not only structural adjustment policies, public enterprises crises, the devaluation of the CFAF, but also the competition created by second-hand clothes from western countries. Thus, of the 41 industrial units in the UEMOA region in 1980, half have closed down. Production capacities of the various factories are always below 90 percent of their ginning capacity (Table 7).

PART 4. CROP RESIDUES

In the agricultural literature, and especially research jargon, 'crop residues' refer to the fibrous parts of cereals, sugar cane, roots and tubers, dried fruits, etc. Their common features include the fact that they comprise the parts that are not consumed by humans after the harvest, and also that they have low feed value for animals and a very low or non-existent feed value for monogastric animals. Yet they are used as feed, since these creatures are able to digest them. In this study, the focus will be on crop residues generally used in animal feeding within the area studied. These are the post-harvest residues from cereals, legumes, and roots and tubers (cassava and yam peel).

4.1 GLOBAL CROP RESIDUE SUPPLIES

To assess the quantity of available crop residues in West Africa, factors for conversion of grains into residues were used. For countries where the conversion factors are readily available, they were applied to estimate the crop residues available. For those countries where they are not available, the factors generally applied to Africa have been used for the other countries (Kossila, 1988) (Annex 11).

4.1.1 Cereal residues

In 2010, the total quantity of cereal straws was estimated at about 80 million tonne for all UEMOA countries. Millet ranked first, followed by sorghum, with about half of the cereal residues. As for grains, there has been an increase of their residues over the past five years (Figures 2 and 3).

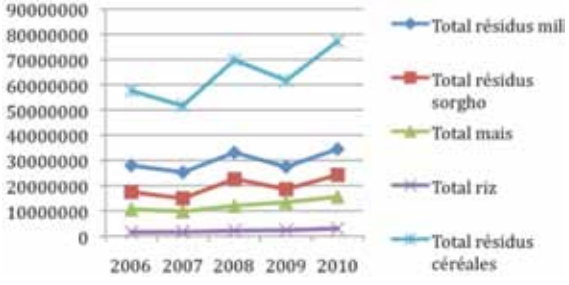

Figure 2. Trend in the quantity of cereal residues in the UEMOA region (tonne)

Sahelian countries (Niger, Burkina Faso, Mali and Senegal) have the largest share of crop residues, especially cereal residues, in the UEMOA region (90%). This advantage is essentially due to millet and sorghum cultivation. In all the countries, there is a trend toward increase in these residues over the past five years, and certainly over the past 10 years, as grain production has increased in the last decade.

4.1.2 Leguminous haulms

In spite of fluctuations essentially due to changes in the production of groundnut in Senegal and of cowpea in Niger and Burkina Faso, the production of leguminous haulms has doubled in the past five years.

In general, production is dominated by the four Sahelian countries, led by Senegal for groundnut, and Niger for cowpea (Figure 5).

4.1.3 Roots and tubers

The main crops are mainly cassava and yam, and their peels are used in animal feed in sub-

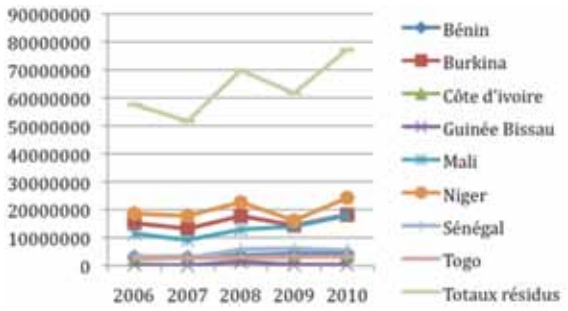

Figure 3. Trend in the supply of cereal residues by country (tonne)

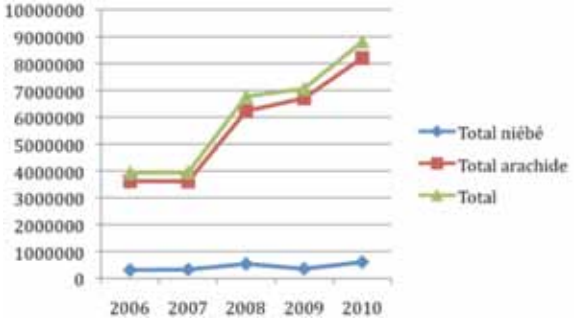

Figure 4. Development of cowpea and groundnut residues in the UEMOA region (tonne)

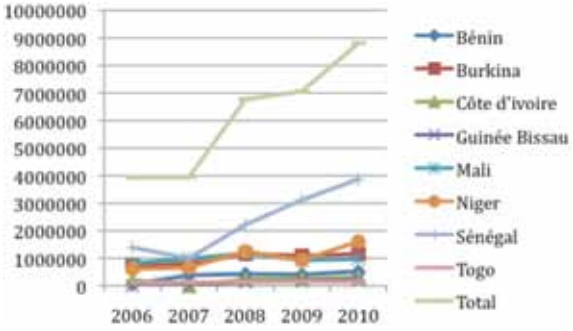

Figure 5. Trend in the quantity of leguminous residues (cowpea and groundnut) (tonne)

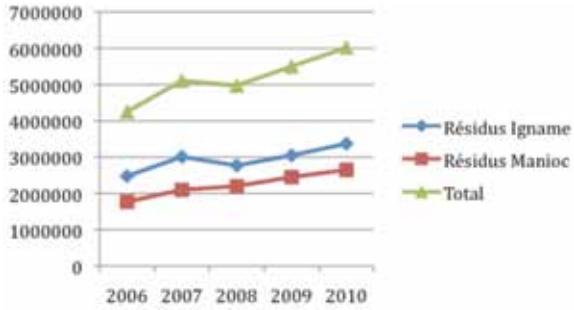

Figure 6. Change in estimated cassava and yam peel production (tonne) in the UEMOA region, 2006–2011

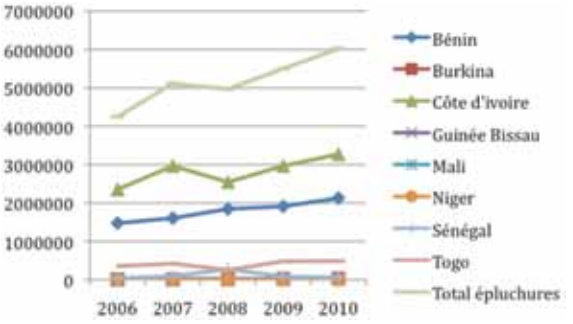

Figure 7. Trend in the production of cassava and yam peel in the UEMOA region (tonne)

humid countries, essentially in the southern part of Benin and in Côte d'Ivoire. Their production levels are quite close, and their steady increase yielded about 6 million tonne of peel in 2010 (Figure 6).

Naturally, the producing countries (Benin, Côte d'Ivoire) provide a large share of these residues.

Generally, crop residues are increasing in the sub-region and amounted to over 95 million tonne in the UEMOA region in 2010.

4.2 SUPPLIES PER ANIMAL

To estimate the supply per animal, the various animal categories have been converted into Tropical Livestock Units (TLU) with the equivalencies: Camelidae = 1 TLU; Cattle = 0.73 TLU; Sheep and goats = 0.16 TLU; and Chicken = 0.04 TLU.

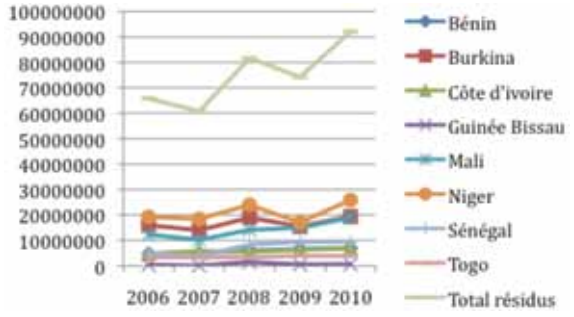

Figure 8. Trend in the quantity of cassava and yam peel in the UEMOA region (tonne)

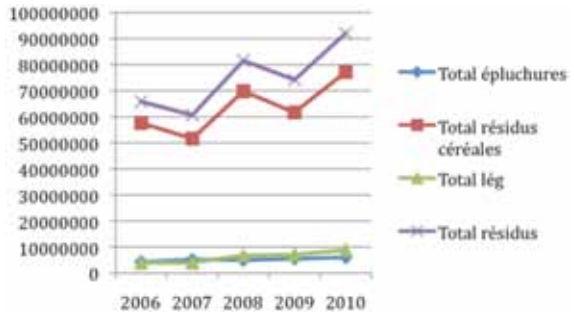

Figure 9. Comparison of trends in quantities of various crop residues in the UEMOA region

At regional level, it could be concluded that:

- straw supplies per animal are larger than haulm or peel supplies;
- a reduction in the quantity of available cereal residues per animal has been observed for the past four years in favour of legume haulm, while peel remains constant, albeit the conversion factor of legumes into residues is more precise at 1.77 than the 5 for peels. This reflects increased legume production, with over 45 percent increase in haulms, while straw had only a 26 percent increase. The great increase in groundnut production has contributed to this situation;
- the contribution of cereals to total residue supplies per animal dropped from 91 percent to 88 percent in 2009, while that of legumes rose from 6 to 9 percent;
- the quantity of straw per animal has increased in all the sub-humid countries (except for Guinea Bissau), while it decreased in most Sahelian countries. This could be explained by clearly higher numbers of cattle and annual cattle growth rate in Sahelian countries; and
- in countries producing yam and cassava, the quantity of peel has increased.

Table 8. Trend in supply of crop residues in the UEMOA region (tonne per TLU)

Country	Residue											
	Cereal straw				Legume haulm				Cassava and yam peel			
	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009
Benin	1.88	1.73	2.02	2.26	0.03	0.21	0.23	0.22	0.48	0.50	0.59	0.63
Burkina Faso	1.67	1.40	1.81	1.43	0.08	0.08	0.12	0.11	0	0	0	0
Côte d'Ivoire	1.36	1.96	1.56	1.80	0.12	0	0.14	0.15	0.42	0.61	0.45	0.52
Guinea-Bissau	0.64	0.15	2.10	0.51	0	0	0.23	0.27	0	0	0.04	0.03
Mali	1.31	0.99	1.30	1.34	0.13	0.15	0.17	0.17	0	0	0	0
Niger	1.84	1.68	2.05	1.39	0.06	0.06	0.11	0.08	0	0	0	0
Senegal	0.97	0.71	1.53	1.56	0.38	0.27	0.58	0.79	0.01	0.02	0.07	0.02
Togo	3.54	3.38	3.45	3.72	0.13	0.15	0.17	0.17	0.23	0.28	0.07	0.30
Total per TLU	1.58	1.37	1.76	1.50	0.11	0.10	0.17	0.17	0.05	0.06	0.06	0.06

Table 9. Trend in straw supplies (tonne per TLU) in the UEMOA region

Country	Millet residues				Sorghum residues				Maize residues				Rice residues			
	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009
Benin	0.09	0.12	0.09	0.07	0.37	0.37	0.36	0.31	1.38	1.22	1.52	1.83	0.03	0.03	0.04	0.05
Burkina Faso	0.61	0.48	0.60	0.45	0.78	0.75	0.90	0.71	0.27	0.16	0.30	0.25	0.01	0	0.01	0.01
Côte d'Ivore	0.11	0.16	0.12	0.14	0.10	0.14	0.11	0.13	0.91	1.35	1.06	1.24	0.24	0.31	0.26	0.29
Guinea-Bissau	0.29	0	1.79	0.20	0.16	0	0.10	0.11	0.07	0	0.05	0.05	0.12	0.15	0.16	0.16
Mali	0.61	0.59	0.60	0.55	0.39	0.10	0.46	0.47	0.23	0.21	0.16	0.23	0.08	0.08	0.09	0.10
Niger	1.40	1.24	1.48	1.09	0.43	0.43	0.56	0.30	0.01	0.01	0	0	0.01	0	0.01	0.01
Senegal	0.63	0.40	0.83	0.97	0.15	0.12	0.31	0.27	0.14	0.13	0.30	0.24	0.04	0.05	0.09	0.08
Togo	0.25	0.26	0.26	0.26	1.30	1.18	1.15	1.26	1.92	1.88	1.97	2.11	0.06	0.06	0.07	0.09
Total per TLU	0.77	0.67	0.84	0.67	0.48	0.40	0.57	0.45	0.29	0.26	0.30	0.33	0.04	0.04	0.05	0.06

Table 10. Trend in haulms and peels supplies (tonne per TLU)

Country	Haulm								Peel							
	Groundnut				Cowpea				Cassava				Yam			
	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009
Benin	0.02	0.20	0.22	0.21	0.01	0.01	0.01	0.01	0.48	0.50	0.59	0.63	0.36	0.40	0.41	0.38
Burkina Faso	0.07	0.08	0.11	0.10	0.01	0.01	0.01	0.01	0	0	0	0	0	0	0	0
Côte d'Ivoire	0.11	0	0.14	0.15	0	0	0	0	0.42	0.61	0.45	0.52	0.99	1.43	1.05	1.22
Guinea-Bissau	0	0	0.22	0.09	0	0	0		0	0	0.04	0.03	0	0	0	0
Mali	0.09	0.10	0.12	0.09	0	0	0	0	0	0	0	0	0	0	0	0
Niger	0.05	0.04	0.08	0.07	0.02	0.02	0.03	0.01	0	0	0	0	0	0	0	0
Senegal	0.38	0.27	0.57	0.79	0	0	0.01	0	0.01	0.02	0.07	0.20	0	0	0	0
Togo	0.12	0.13	0.15	0.15	0.01	0.02	0.02	0.02	0.23	0.28	0.07	0.30	0.20	0.22	0.23	0.24
Total per TLU	0.10	0.10	0.16	0.16	0.01	0.01	0.01	0.01	0.05	0.06	0.06	0.06	0.07	0.08	0.07	0.07

Millet straw accounts for the largest quantity of residues; however its share in the total of residues considered has diminished as the other straws tend to stagnate. Generally, this decrease is found in the supply of this cereal per country. Except for Côte d'Ivoire and Togo, the trend is the same for sorghum residues, for which the supply per animal has almost been halved in the zone under study. At the same time, for maize and rice, the quantity of straw supply per TLU has slightly increased. For maize, this increase is significant in most of the sub-humid countries.

Regarding haulms, supply per animal has increased for groundnut at regional level, especially

in Senegal and Niger. Cowpea supply has remained constant at regional and national levels.

Finally, the increase in peel supply per animal is especially remarkable in sub-humid countries, while relatively steady at regional level. This same constancy was observed for yam, even though there has been a definite increase in Côte d'Ivoire.

4.3 DEVELOPMENT TRENDS OF CROP RESIDUES IN THE SUB-REGION

The basis for estimation of trends was largely derived from the study on "Food crops production and consumption basins in West and Central Africa" (AFD/CIRAD/CILSS/FIDA, 2010), which provides estimates of possible production in 2025 and 2050. The results indicate a possible improvement in supplies by those dates. The conversion coefficients used were applied to estimate cattle supplies per TLU.

4.4 PRODUCTION, CONSERVATION AND MARKETING

4.4.1 Cereal straws (millet, maize, rice, sorghum) production and conservation

Straws are standing cereals stems and leaves which are left on the farm after the harvest and are dry. They are either consumed directly on farm by animals or collected and distributed in the trough. When the straw is not left in the field, such as for millet, maize and sorghum, it is collected at the beginning of the dry season (October-November). Depending on local practices, it is either immediately cut after harvesting the grain, or later when the plant is dry. In Sahelian countries, it is common to chop straw before storing. In all cases, the harvest leaves stubble, which is the stump of these plants and which can be grazed by animals. Straw conservation for later consumption by the animals is done on rooftops, in trees, on a small plot of farmland, or directly on the floor.

In the countries studied, rice straw remains after cutting the spike or the whole plant while it is still green and flooded. The reaped plant is then dried, its grains threshed either on a stone or using a thresher, depending on the size of the farm, leaving the stems and leaves. Often, only the panicle is reaped first. In this case, it is recommended to immediately cut the rest of the plant.

Drying rice straw is a real challenge in regions with high rainfall since the drying process requires extra labour for spreading. The fodder is often left near the rice farm for draught animals or for cattle producing milk or meat. It can happen that rice straw is stored on tree branches or stacked to protect it against animals, especially during long fodder shortages.

4.4.2 Production and conservation of other crop residues

In West Africa, other crop residues include mainly groundnut and cowpea haulms, and their production is relatively important, especially in Sahelian countries. The plants are uprooted two to three days after the harvest, arranged in 1 to 2-kg bundles and dried in the shade. The feed is then stored in the same way as cereal straw: on a roof, in a fold or on a tree. The objective is to protect it from wandering animals or termites. In contrast to straw, leguminous haulms are almost entirely intended for domestic animal feeding and they are systematically collected, reflecting their market value. Their use is not affected by constraints associated with the use of straw. However, some constraints persist, mainly those related to transport, which is still less daunting due to the possibility of less voluminous packaging, the constraints and risks related to supply storage, conservation

Table 11. Projections for crop residue availability in 2025 (tonne per TLU)

Country	Millet	Maize	Sorghum	Rice	Yam	Cassava	Cowpea	Groundnut	Total/TLU
Benin	0.07	2.03	0.36	0.07	0.30	0.48	0.01	0.27	3.59
Burkina	0.62	0.36	1.07	0.02	0.00	0.00	0.01	0.11	2.20
Côte d'Ivoire	0.17	1.39	0.15	0.37	0.87	0.37	0.00	0.18	3.49
Guinea Bissau	0.24	0.06	0.15	0.26	0.00	0.03	0.00	0.36	1.11
Senegal	0.46	0.06	0.09	0.11	0.00	0.00	0.00	0.44	1.17
Togo	0.02	0.19	0.12	0.01	0.01	0.02	0.00	0.01	0.38
Niger	3.79	0.01	1.29	0.02	0.00	0.00	0.10	0.32	5.52
Mali	6.51	2.50	4.47	7.66	0.02	0.01	0.03	1.12	2.32
Total	0.82	0.38	0.58	0.24	0.06	0.05	0.02	0.22	2.36

and seasonality. Haulms are, however, more expensive.

Cassava and yam peel are produced by the local processing of these tubers for use as human food. First, they are reduced, then dried. It is necessary to dry them for storage. In the case of cassava, drying rids the peel of the hydrocyanic acid concentrate found in bitter cassava. Yam peel is produced using the same process. In both cases, they are sundried. However they can also be ensiled. In fact, the main problem in using peels is the hydrocyanic acid content in cassava, even though it falls considerably when dried. Even though the use of these by-products has been extensively studied in Nigeria, and a lot less in Benin, Côte d'Ivoire and Ghana, it is not generally practiced in livestock farming. It is therefore easy to imagine that the constraints can be related to the drying time in humid countries, to storage, labour need and transport. However, it is possible that packaging in sacks, as is done for charcoal, could be envisaged to facilitate transportation.

4.4.3 Crop residues marketing

Straw is virtually never traded, especially in sub-arid zones, where it is left on the field unless used by the household (fuel, construction, etc.). Cowpea and groundnut haulms are traded in the cities. In this case, production sites are usually within a 20 km radius of the cities. Transporting straw from the farm to the cities is rarely done by vehicle. Haulm is hauled on the back of camels, donkeys, in carts or on bicycles. There are very few middlemen, although there could be producers who transport the residues themselves to the city, or city dwellers who go and find them in the rural areas, using the services of carters or camel riders and reselling them as retail items along the roads.

The prices vary based on the period, and increase as the dry season progresses, and decrease with the first rains. They vary from CFAF 250 to 500/kg on average. Prices can soar when events such as the *Tabaski* are getting closer during the dry season.

Root and tuber residues are not extensively traded. They are sold by women in small heaps and in baskets for CFAF 250 to 300/kg. The quantities traded are low because these residues are often intended for use by the households to feed their domestic animals. However, at the outskirts of some urban centres such as Cotonou or Lomé, pig farmers obtain their supplies from the women who process roots and tubers.

Table 12. Challenges in harvesting crop residues in Nigeria

Challenge	Relative importance (percent)
Overcrowding of harvesting equipment	13.5
High transport costs	12.5
Road condition	13
Lack of storage and conservation facilities	8
Fires	6
Termites infestation	9
High prices	8
Inclement climate	5.5

Source: Onyeonagu and Njoku, 2010.

4.5. CHALLENGES

4.5.1 Accessibility

Collecting and transporting straw presents a major challenge to its wide utilization. In practice, it is not easy, and definitely not profitable, to convey large quantities over long distances in a short time as they become available. This explains their wide local utilization on production sites. Activities conducted in the sub-humid zone in Nigeria typify the main difficulties encountered by producers in harvesting crop residues (Table 12).

4.5.2 Alternative uses

On the production sites, straw has been used for purposes other than animal feeding (Table 13) and there has been variation in the importance of the various utilization modes for residues according to their origin (Table 14).

4.5.3 Land issues

Access to crop residues is closely related to land tenure. Conflicts between farmers and pastoralists within a country, or between two or more countries, is a perfect illustration of the importance of this factor. In semi-arid zones, where the population density is quite low, crop residues are used by animal owners free of charge. However, as the population grows, as is the case in sub-humid and humid zones, crop residues are used on a contractual basis between pastoralists and farmers.

4.5.4 Seasonal supply

For some crops, the availability of residues is seasonal (Table 15). Generally, in semi-

Table 13. Importance of the various residue uses in Mali (percent)

Uses	Groundnut	Maize	Millet	Cowpea	Sorghum
Burning	0	0	34	0	28
Mulching	9	9	3	0	1
Fodder in the field	15	36	48	15	48
Fodder at the farm	65	44	2	83	2
Litter	10	11	11	0	20
Other	1	0	2	2	1
Total	100	100	100	100	100

Source: Kaasschieter, Attema and Coulibaly, 1995.

Table 14. Proportion of residues per mode of utilization in Niger (percent)

Use	Stubble		Straw			Haulm	
	Millet	Sorghum	Maize	Rice	Wheat	Cowpea	Groundnut
Left in the field	53.3	19.2	68.0	26.2	71.3	13.7	3.9
Construction	13.6	1.1	0.3	1.5	9.3	—	—
Combustion	2.1	0.1	—	—	—	—	—
Supplement	30.0	79.5	30.4	65.1	30.0	86.3	96.1
Other	1.0	0.1	1.3	7.2	3.1	—	—

Source: Karimou and Atikou, 1998.

Table 15. Seasonal availability of crop residues

Residue	Arid to sub-arid zone	Humid to sub-humid zone
Sorghum residues	October-April	September-April
Millet residues	September-May	September-April
Maize residues	September-May	July-March
Rice residues	January-December	January-December
Cowpea haulm	October-April	August-January
Groundnut haulm	October-April	November-April
Yam peel	n.a.	January -December
Cassava peel	n.a.	January -December

Notes: n.a. = Not applicable

arid zones, seeding or transplanting occurs in May-June, and harvesting is carried out from September to October. The availability of straw is at its maximum in December-January, and reduces considerably towards April. However, in zones such as the semi-arid regions in Niger, since the harvest of early millet occurs in August, this cereal is quickly replaced by the late sorghum, which leads to the non-availability of the unharvested millet straw. In sub-humid and humid zones, where producers have more flexibility to seed, straw can be available all year round. The availability of rice straw depends on agro-ecological zones, but also on whether the rice is rainfed or irrigated.

4.5.5 Technical challenges

In addition to harvesting and transporting the residues, some technical factors restrict the use of cereal residues (Table 16).

Table 16. The main technical factors potentially restricting the use of straw in animal feed

Factor	Impact
Pesticides	Health risks for cattle
Storage techniques	Insect infestation Nutrient losses Dry matter losses
Palatability	Lack of consumption
Urea treatment	Health risks Cost of water Investment in equipment
Ammonia treatment	Cost Requires the availability of chemicals
Soda treatment	No nitrogen supply Hazardous handling
Urea blocks	Cost of equipment Cost of various block components
Transport	Cost Loss of leaves
Genetics	Leaf : stem ratio
Residues collection	Soil impoverishment

PART 5: AGRO-INDUSTRIAL BY-PRODUCTS

5.1 AGRO-INDUSTRIAL BY-PRODUCTS SUPPLIES

5.1.1 Cotton by-products

Cottonseed has been the most used. However, it has been observed that availability is dwindling. There has been a significant drop in production of this by-product, directly related to cotton production in West Africa. After starting in 2004, this decline worsened in 2007 and the trend seems to persist. Global cottonseed supplies amounted to over 2 million tonne for the sub-region in 2005, and dropped to only 1.134 million tonne in 2009. Between 75 and 83 percent of the annual output comes from Burkina Faso, Mali and Benin, the leading cotton producers in the sub-region, followed by Côte d'Ivoire.

Cakes are the solid residues obtained after extracting oil from the seeds or oilseed fruits (rich in fat). These are the co-products of crushing, that is, the industry of oil manufacturing. At global level, the availability of cakes follows the same trend as cottonseeds. The same countries lead, with Burkina Faso clearly ranked first with between 37 and 50 percent of the total supply, depending on the year (Table 17).

Nevertheless, in absolute terms, these figures should be treated with caution since the production data for some traditional ginning and seed crushing units are not known. Moreover, oil yields, and consequently cake yields, vary considerably. While in modern factories they reach 16–20 percent, they are only 8–10 percent in traditional oil mills. Finally, in some traditional oil mills, the mode of extraction is far from efficient, but could be carried out without separating the shell from the seed.

5.1.2 Soybean cake

Even though soybean is a recent and still marginal crop, it is gaining in importance in West Africa. It seems that in most cotton producing countries, farmers are turning to soybean since it provides them with increased autonomy in their commercial exchanges compared with cotton. As can be seen in Burkina Faso and Benin, production has increased exponentially in reaction to (or as a consequence of) the decline in cotton production.

5.1.3 Groundnut cake

A sharp recovery in groundnut production in Senegal boosted UEMOA production to

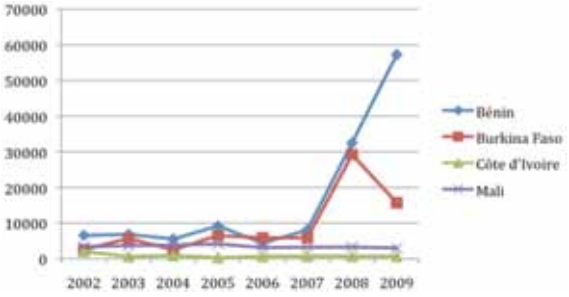

Figure 10. Trend in soybean cake production in the UEMOA region (tonne)

Table 17. Cottonseed and cotton cake production (thousand tonne)

Country	2005		2006		2007		2008		2009	
	S	C	S	C	S	C	S	C	S	C
Benin	341	190	250	124	268.62	148	244.56	135	229	126
Burkina Faso	713	370	760	373	377.36	190	720.67	315	484	270
Côte d'Ivoire	321	145	268	100	278	75	135	65	125	63
Guinea-Bissau	5	—	5	—	6	—	6	—	5	—
Mali (1)	534	240	432	195	248	111	203	91	236	106
Niger (1)	10	5	11	5	12	5	15	7	5	2
Senegal	45	—	52	—	45.138	—	38.81	—	2	—
Togo (1)	65	29	40	18	49	22	33	15	29	13
Total	2035	979	1818	814	1283	552	1395	627	1135	581

Notes: S = Cottonseed; C = Cotton cake. (1) The data being unavailable for cakes in these countries, a coefficient of 45 percent corresponding to an average cake yield, was applied to the seeds. Source: FAO, 2009.

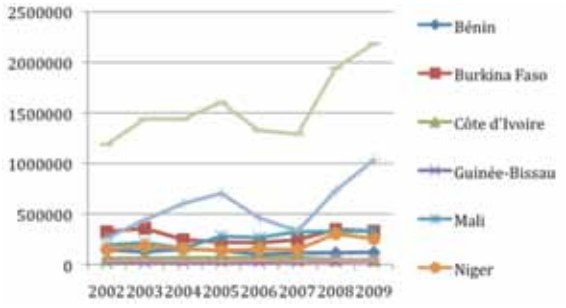

Figure 11. Trend in groundnut cake production in the UEMOA region (tonne)

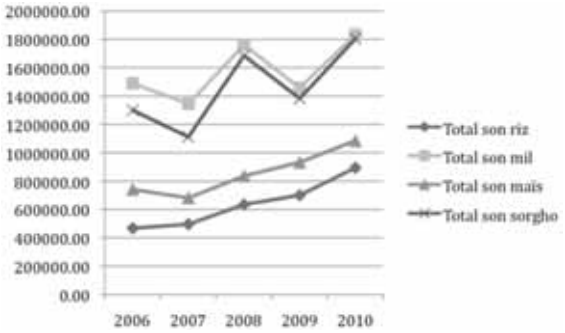

Figure 12. Trend in the production of local bran cereals in the UEMOA region (tonne)

about 2.5 million tonne of groundnut cake in 2009. However, that increase is virtually attributable to Senegal alone within UEMOA. In comparison, Niger, a former leading groundnut producer, currently produces only 250 000 tonne, compared with the more than 1 million tonne produced by Senegal. In fact, in Niger, groundnut oil production is mainly done using traditional methods, and to a lesser extent using semi-modern methods. Consequently the by-product obtained is marketed in the form of groundnut paste intended for human consumption. A similar situation can be observed in Mali and Burkina Faso. Thus, these by-products are not traditionally fed to animals in those countries, even though this practice can be observed here and there among individuals.

5.1.4 Local cereal bran

It is very difficult to obtain figures for local cereal brans due to the key role played by artisanal units in their processing, the number and capacity of which are difficult to obtain. Moreover, it was not possible to obtain similar data for rice and other grain mills. Consequently, the quantity of bran was estimated based on the conversion factors of the quantities of seeds provided (Kossila, 1988).

It is not surprising that sorghum and millet provide the highest quantities of bran: 1.3 million tonne of sorghum bran, and between 1.5 and 1.8 million tonne of millet bran, with trends that are naturally similar to those of seed production. Obviously, the ranking per country remains the same for seeds, and Sahelian countries are still the largest producers of bran cereals (Figure 12).

To estimate the production of wheat bran, a 0.35 percent coefficient was applied to the quantities of wheat imported in view of the

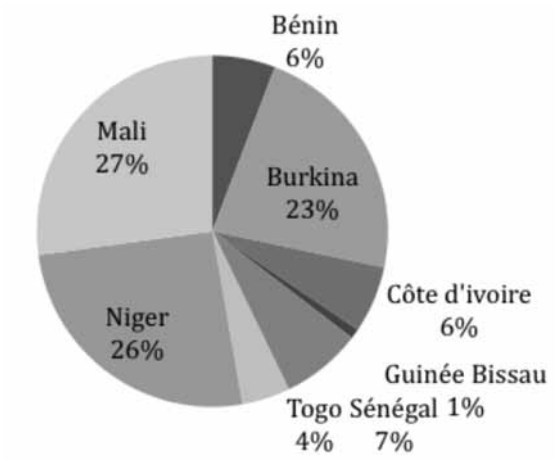

Figure 13. Distribution of total bran production per country

difficulty in obtaining reliable and complete data and since the quasi-totality of processed wheat is imported (sub-regional production is very low). The results of this estimation are shown in Table 18, where it can be observed that Senegal and Côte d'Ivoire produce between 75 and 80 percent of the total production of wheat bran in the sub-region, and that this production has been increasing over the past years. Burkina Faso and Niger have the lowest production. Their supplies vary from 5 to 7 kg/TLU/year, depending on size of production.

5.1.5 Molasses

The production of molasses was estimated based on the production of sugar cane, knowing that during processing, molasses accounts for 3 percent of sugar cane. The UEMOA region produces approximately 100 000 tonne of molasses yearly, and this production has been stable (Table 19). Within West Africa, Côte d'Ivoire produces about 45 percent and Senegal 15 percent of the total molasses production. Mali and Burkina Faso share almost equally the

Table 18. Trend in wheat bran production in the UEMOA region (tonne)

Country	2005	2006	2007	2008	2009
Benin	0	9 848	7 423	0	0
Burkina	0	12 565.00	18 725	19 930	25 060
Côte d'Ivoire	88 091	102 360	94 705	85 712	157 917
Guinea Bissau	0	0	0	0	0
Mali	29 500	39 942	210439	14 659	14 659
Niger	5 949	2 561	5 658	0	3 587
Senegal	114 200	124 794	138 510	127 292	146 515
Togo	35 272	31 570	24 400	19 076	26 313
Total	273 012	323 640	310 860	266 670	374 051

Table 19. Trend in molasses production in the UEMOA region (tonne)

Country	2005	2006	2007	2008	2009
Benin	30	1 133	1 211	1 228	1 228
Burkina Faso	13 500	13 500	13 650	13 650	13 650
Côte d'Ivoire	43 688	43 440	49 090	48 900	48 900
Guinea-Bissau	165	165	165	180	180
Mali	10 329	9 586	10 255	10 800	11 310
Niger	6 600	7 200	7 200	5 633	6 356
Senegal	24 870	24 885	25 080	25 080	25 080
Togo	0	0	0	0	0
Total	101 083	99 909	10 6652	105 470	106 704

remaining 15 percent. The supplies per TLU are negligible: from 0.5 kg/TLU/year in low producing countries, to 25–30 kg/TLU/year in countries such as Côte d'Ivoire and Senegal.

5.2 AGRO-INDUSTRIAL BY-PRODUCT EXPORTS

5.2.1 Cottonseeds

At global level, there is a reducing trend in cottonseed exports in the sub-region (Table 20). There are two possible reasons: the decline in cotton production in the countries and the ban on agricultural by-product exports. It appears that Côte d'Ivoire is not under this ban since it is the leading exporter of these by-products and the quantities are increasing. The second exporter is Burkina Faso, with rather irregular quantities. Noteworthy is that across the entire region, the share of extra-community exports has been declining (except in 2009), even if Côte d'Ivoire exported only outside the UEMOA region. Togo and Niger have also preferentially exported outside the region, albeit in smaller quantities.

Table 20 presents global seeds exports per country. There is a clear difference between intra-community export prices and extra-community export prices. The latter are obviously more profitable (Table 21) and this could explain the mass exports outside the UEMOA region. It can also be observed that the countries do not export at the same price

Table 20. Trends in total cottonseed exports per UEMOA country (tonne)

Country	2005		2006		2007		2008		2009	
	T	%	T	%	T	%	T	%	T	%
Benin	69 032	100	21 224	100	1 310	4.5	299.75	4.5	7 390	100
Burkina Faso	24 490	41.9	38 378	11.7	200 512		273.21		1 213	3.4
Côte d'Ivoire	154 252	100	157 168	99.0	104 214	100	136 549	100	24 517	100
Guinea-Bissau	—		—							
Mali	65 703	63.0	55 791	35.9	1 690	39.1		39.1		
Niger	1	100	344	100			327		176	100
Senegal	—	—	32 233	99.9	5				4	70.5
Togo	97 200	100	446	100			56		182	
Total	562 058	70.4	629 764	40.3	306 420	34.2	137 205	34.2	260 92	94.8

Notes: T = tonne; % = Share of extra-community exports in total exports.

Table 21. Export prices of cottonseeds (CFAF/tonne)

Country	2005		2006		2007		2008		2009	
	IntraC	ExtraC	IntraC	ExtraC	IntraC	ExtraC	IntraC	ExtraC	IntraC	ExtraC
Benin		39 654		46 466	7 949	13 130	2 500	16 399	37 686	45 917
Burkina Faso	24 871	27 298	19 990	21 973	30 107		15 136	132 033		135 517
Côte d'Ivoire		51 378		625 565		47 373		82 267		94 083
Mali	48 838	20 009		37 745		18 589				
Niger		150 000	113 297	78 237	20 262		20 000	144 987		231 709
Senegal				50 009	139 149				101 667	83 674
Togo		39 521	15 088	44 475				20 834	20 000	
Average	28 367	38 932	49 458	52 505	30 089	47 191	68 885	82 426	36 070	95 204

Notes: ExtraC = extra-community; IntraC = intra-community. Source: UEMOA, no date.

and that the inter-annual variations are rather high. However, generally, a trend towards an increase in prices has been observed, probably due to the national bans.

5.2.2 Cakes

Between 2005 and 2009, the quantities of cottonseed cake exported outside the UEMOA region have varied between 76 600 and 21 400 tonne (Annex 12). There is thus a clear decrease, possibly related to a decline in cotton production in the zone. Moreover, producing countries (Benin, Burkina Faso and Mali) often issue ministerial decrees to ban the exportation of this by-product in order to cover their own needs.

During that period, Benin proved to be the top exporter, with over 60 percent or even 85 percent of extra-community exports per year in the sub-region. Moreover, Benin is the only country to export over 20 percent of its cake production outside the Community during that same period, except in 2009, when its share dropped to 13 percent. Nevertheless, this country remains the leader in terms of exports while the other countries export very little outside the UEMOA community.

Regarding exports to other countries within the same economic community, Senegal is the largest seller since between 10 and 18 percent of its production is intended for UEMOA member countries. Côte d'Ivoire followed in its footsteps during the past few years.

Generally, exports are not large and do not justify the shortages observed in the countries. Thus, it is important to assume that the largest part of cottonseed cakes is consumed locally, unless exports are not totally controlled by the relevant services at borders. Consequently the data is not reliable.

The following points should be highlighted regarding exports:

- cottonseed cake is the most sold in terms of quantity;
- extra- and intra-community exports are relatively low;
- countries seem to use the largest part of their cottonseed cakes locally;
- Benin is the top exporter to outside the UEMOA region;
- extra-community exports are far larger than intra-community exports; and
- Senegal is the top intra-community exporter.

Finally, producing countries either export cottonseed cakes towards countries outside the UEMOA region, or consume them locally. In other words, the lowest producing countries are deprived of regional production.

Only Senegal (Annex 13) exports its groundnut cake on a regular basis to countries outside the UEMOA region, although in highly variable quantities, from 1 to 10 percent of its total production. When they exist, intra-community exports vary between 0.02 and 0.04 percent of national production. Niger exported only 0.86 percent of its production in 2005 and Togo exported 1.02 and 1.45 percent of its production in 2008 and 2009, respectively. These two countries have exported only outside the community. As for cottonseed, groundnut cake exports by producing countries are relatively low and in all cases intended for countries outside the Community.

Regarding soybean cake, from 2005 to 2009 only Benin exported outside the community on a regular basis, providing between 92 and 96 percent of the total exports in the sub-region. In 2005 and 2006, Togo exported

between 190 and 230 tonne, equal to between 3 and 6 percent of total exports. The only intra-community exports were from Senegal, with 100 tonne of soybean cake in 2006.

Finally, for all the cakes considered and on the basis of the literature obtained, countries actually consume the largest part of their production. Moreover, exports to outside the Community are greater than those within the Community. However, according to the information collected from the countries visited, it appears that exports are apparently greater than the quantities available in theory in the countries.

The extra-community export prices for the various cakes (Annex 14) clearly increased between 2005 and 2009: over 4-fold for cotton, and almost 1.5-fold for soybean and 2-fold for groundnut. While the intra-community export price of cottonseed cake more than doubled, the most expensive cake remains soybean cake, followed by cotton. In 2009, the intra-community export price for a tonne was higher than the selling price outside the Community not only for cottonseed cake, but also for soybean cake. In other words, producing countries sell their produce at a higher price to Community members than to non-members. This is very surprising when transport costs are factored in. However, this could be explained by the fact that clients outside the UEMOA zone buy larger quantities. Actually, western countries import in bulk, with no packaging, in large cargo ships, and this reduces transport costs considerably. At the same time, it is also very possible that the clients are close neighbours to exporting countries such as Benin and Nigeria.

5.2.3 Bran

Wheat bran is the most exported by-product in the UEMOA zone (Annex 15): more than 170 000 tonne between 2005 and 2009, with an average of 34 000 tonne per year. The average annual rice bran exports were only 232 tonne and maize bran exports 8 tonne (Annex 16). While rice bran and maize bran are exported virtually only within the UEMOA zone, wheat bran is rather exported outside the Community. The share of wheat bran extra-community exports accounts for 55 to 93 percent of total exports of this by-product.

From 2005 to 2009, the total annual exports varied between 26 000 and 61 000 tonne, while annual production during that period varied between 10 000 and 16 000 tonne, that is between 25 and 57 percent of total annual exports. Therefore the wheat bran produced is not obtained from regional wheat production, but primarily from processing of imported wheat in mills. This is all the more noticeable because the top exporter, Côte d'Ivoire, with its quasi-exclusive exports outside the UEMOA zone, has never produced wheat. And for all the countries exporting this by-product, the quantities exported are clearly higher than the yield from domestic wheat production. It can also be observed that a producing country such as Mali has exported wheat only once and in low quantities within the UEMOA zone.

The following points emerge regarding production of bran:

- rice and maize bran are barely involved and very low quantities are exported within the UEMOA region by Niger and Senegal;
- the intra- and extra-community trade in rice and maize bran is negligible, while that of wheat bran is relatively important;
- extra-community cake exports, for example, are by far the largest commodity;
- bran exports are greater than national production; the only plausible explanation is that some imports might not be controlled in some of the countries who re-export it; and
- the top exporter by far is Côte d'Ivoire. The country does not produce wheat, but processes large quantities of imported wheat.

The prices of various bran categories vary considerably, without any obvious explanation. Extra-community export prices are largely higher than the current prices for the intra-community zone. Thus, in 2009, the price for wheat bran was CFAF 38 000/tonne for countries outside the Community, but was CFAF 76 000/tonne (double!) for UEMOA member countries (Annex 16).

5.3 AGRO-INDUSTRIAL BY-PRODUCT IMPORTS

5.3.1 Cottonseed

Extra-regional imports seem very low in terms of quantity (Table 22). However, it should be noted that in some years they are the largest part of total imports, particularly for landlocked

Table 22. Trend in total cottonseed import quantities per UEMOA country

Country	2005		2006		2007		2008		2009	
	T	%	T	%	T	%	T	%	T	%
Benin	0	0	0	0	0	0	3 479	0	<1	100
Burkina Faso	2 648	<0.1	1 361	0	6 033	11.8	7 624	42.7	510	94.1
Côte d'Ivoire	0		0	0	0		0		0	
Guinea-Bissau	0		0	0	4	100	0		0	
Mali	55	60.4	111	0	0		4 716	2.2	27 953	0.5
Niger	1 719	100	1 511	26.8	1 082	12.1	366	45.4	1586	30.2
Senegal	0.3	0	2	100	5	100	0.6	100	17.22	100
Togo	3 957	100	18 469	0	2 215	0	0		0	
Total	8 381	12.4	21 455	1.9	7 345	11.6	12 707	278	30 068	6.8

Notes: T = tonne; % (percent) = Share of extra-community imports in total imports.

Table 23. Import prices for cottonseed (CFAF/tonne)

Country	2005		2006		2007		2008		2009	
	IntraC	ExtraC	IntraC	ExtraC	IntraC	ExtraC	IntraC	ExtraC	IntraC	ExtraC
Benin						40 024				
Burkina Faso	5 842	89 561	5 048		3 721		3 628	39 877	16 666	30 750
Côte d'Ivoire										
Mali	28 472		39 444				23 930	383 106	25 075	506 084
Niger	61 764	78 553	37 728	62 783	49 848	50 000	67 800	62 955	50 318	65 087
Senegal		80 612		186 105		193 907		471 461	203 160	499 929
Togo	32 975		21 514		2 051					
Average	25 826	82 908	23 268	124 444	10 427	94 643	16 509	239 349	73 804	275 462

Notes: ExtraC = extra-community; IntraC = intra-community.

countries. Intra-community import prices are clearly lower than those of extra-community imports. However, over the past two or three years, extra-community import prices soared, sometimes three or four-fold (Table 23). In particular, extra-community import prices applied in Senegal seem exorbitant.

5.3.2 Other by-products

Of all the by-products, cottonseed cake appears to be the most imported within the Community (between 28 and 65 percent of agro-industrial by-products imports depending on the year), distantly followed by soybean cake (Annex 17). For the same by-products, extra-community imports are dominated by wheat bran (47 to 90 percent depending on the year) far ahead of soybean cake.

Compared with total imports, the share of intra-community imports vary, except for cottonseed cake, where intra-community imports largely dominate (95 to 100 percent of total imports). Between 2005 and 2009, there was a decrease in the share of rice and maize bran intra-community imports in total imports from 100 to 13.5 percent and from 83 to 49 percent respectively (Annex 18). The trend is similar for soybean cake (from 72 percent in 2005 to 4 percent in 2009). For groundnut cake, an increase in intra-community imports was observed (from 5 percent in 2005 to 94 percent in 2008) (Annex 18).

It should be noted that while the UEMOA region appears self-sufficient in cottonseed cake, it relies heavily on other countries for its wheat. The biggest UEMOA country clients for maize are Niger and Benin (Annex 19), even though the latter is paradoxically a large producer of maize and could export to neighbouring Togo.

In addition, it is also surprising to observe that Benin, a country that exports almost all its cottonseed cake outside the UEMOA zone, is the biggest client of member countries for this same by-product. Senegal, in contrast, imports no feed from the other member countries. In terms of extra-community imports, Niger seems to be interested in all the by-products (Annex 20) and is even the biggest client for maize bran and groundnut cake, probably originating from Nigeria.

Senegal is the biggest buyer of imported and processed wheat bran outside the Community. Cottonseed cake is mainly imported by Burkina Faso and Niger, while Côte d'Ivoire

Table 24. Trend in intra- and extra-community agro-industrial by-product import prices (CFAF/tonne)

By-products	2005		2006		2007		2008		2009	
	IntraC	ExtraC	IntraC	ExtraC	IntraC	ExtraC	IntraC	ExtraC	IntraC	ExtraC
Maize bran	3 526	4 676	25 075	—	10 695	39 399	—	40 000	—	37 046
Wheat bran	88 170	55 161	33 385	60 460	55 454	67 729	145 471	103 332	37 312	50 173
Rice bran	54 667	82 440	12 701	49 309	72 796	24 056	18 360	45 719	57 422	51 211
Soybean cake	—	226 974	—	255 736	—	217 725	15 854	228 258	384 909	229 700
Groundnut cake	20 830	39 575	—	44 988	37 772	39 362	39 194	43 674	—	132 950
Cottonseed cake	89 040	41 474	99 403	—	74 870	21 176	152 566	22 265	117 231	56 027

Notes: ExtraC = extra-community; IntraC = intra-community.

and Senegal import soybean cake from outside the Community.

From Table 24 on the trend in intra- and extra-community import prices some conclusions can be drawn:

- there is great variation according to by-product and year, with maize bran being the cheapest irrespective of origin;
- the most expensive by-products are soybean cake, cottonseed cake and wheat bran, with relative price depending on the years, although wheat bran is cheapest while soybean cake is always by far the most expensive;
- soybean cake was traded within the Community only in the last two years, and is cheaper than when it is imported from outside the Community; and
- Except for rice, and not every year, extra-community imports are clearly cheaper than buying within the UEMOA region.

5.4 LOCAL SUPPLIES

5.4.1 Cottonseed

At national level, supply figures were obtained by deducting the total exports per country from national production data. The available quantities are higher than the exports (Table 25). However, it was not possible to determine whether all these quantities were intended for cattle feeding. Actually, these quantities could also include seeds, but also grains crushed to obtain cake.

5.4.2 Cakes

As already observed for all the cakes, national supplies are relatively large compared with exports. Considering these figures (Tables 26, 27 and 28), it is surprising to observe high costs for these by-products at national level, under the pretext of mass exports. While exports are a reality, available supplies are probably insufficient for an ever-growing livestock

Table 25. Trend in cottonseed product supplies (tonne) per country

Country	2005	2006	2007	2008	2009
Benin	271 968	228 775	267 316	244 263	221 610
Burkina Faso	467 806	376 077	176 852	720 402	482 652
Côte d'Ivoire	167 034	110 676	173 786	-1 549	100 483
Guinea-Bissau	45 326	5 122	5 500	5 848	4 509
Mali	468 440	376 675	245 893	202 696	236 000
Niger	10 399	10 356	12 000	14 341	4 824
Senegal	45 025	19 793	45 135	38 810	22 086
Togo	-31 833	39 544	48 800	32 444	28 844
Total	171 473 196	1 188 243	976 592	1 257 555	1 108 398

Table 26. Trend in groundnut cake quantities per country (tonne)

Country	2005	2006	2007	2008	2009
Benin	140 329	99 382	114 460	115 562	121 000
Burkina Faso	220 525	215 447	244 922	346 292	330 624
Côte d'Ivoire	67 239	69 239	69 256	49 885	44 000
Guinea-Bissau	20 458	22 000	24 709	29 651	31 793
Mali	279 503	265 549	324 187	325 000	334 698
Niger	137 902	152 600	147 676	304 969	253 497
Senegal	696 219	411 602	301 319	723 723	1 017 698
Togo	33 448	39 285	35 950	40 222	34 750
Total UEMOA	1 595 623	1 275 104	1 262 479	1 935 304	2 168 060

Table 27. Trend in soybean cake supplies (tonne) at national level

Country	2005	2006	2007	2008	2009
Benin	4 659	1 880	7 547	30 827	55 651
Burkina Faso	6 500	5 860	5 850	29 209	15 686
Côte d'Ivoire	300	632	705	580	183
Mali	2 124	2 004	5 188	4 000	2 625
Total	13 583	10 376	19 290	64 616	74 145

Table 28. Trend in cottonseed cake supplies (tonne) at national level

Country	2005	2006	2007	2008	2009
Benin	140 916.3	67 610.16	104 379.8	106 378.7	108 511.6
Burkina Faso	368 800	359 288.2	175 226	314 675	258 138.6
Côte d'Ivoire	141 969.5	99 706.78	72 803	55 871.36	57 251
Guinea-Bissau	5 326	5 122	5 500	5 848	4 509
Mali	527 343.4	431 646	246 908.8	198 362.1	233 911
Niger	10 140.75	10 700	11 970	14 418.8	5 000
Senegal	37 435.94	46 809.75	41 500.71	31 486.13	19 407.39
Togo	45 827.36	25 973.54	36 765.6	19 485.27	17 714.15
Local sales	1 277 759	1 046 856	695 053.9	746 525.4	704 442.7

sector in the sub-region. This is all the more true in most countries in the Community as, in addition to livestock keepers, there are animal feed manufacturing plants that use these by-products.

5.4.3 Bran

Only wheat and maize bran, the latter in very marginal quantities, are traded at regional level. Wheat bran is mainly produced by Senegal and Côte d'Ivoire.

5.4.4 Molasses

Molasses is not a highly traded commodity even at national level. Actually, it is often used as source of energy by factories, or as 'bitumen' on roads plied by these factories' trucks.

5.5 MARKETING CHAINS

5.5.1 National channels

Generally, the various stakeholders (livestock services, producers and even manufacturers) consider that the marketing channels are not transparent, a factor that could contribute to increasing product prices. Nonetheless, in the case of cottonseed for example, the product is sold by the ginning factory and not by the producer, as observed in the United States of America. Depending on the country and the factory, the seeds are sold direct to wholesalers or pastoralists. Often the grains are sold to the State, especially during drought years, and are in turn sold to livestock keepers, often at subsidized prices.

In Senegal, cottonseed is generally donated by SODEFITEX to organizations of pastoralists, who in turn handle their distribution to their members. This company is not involved in retailing. In Burkina Faso, to meet national needs, the seed is sold to wholesalers who sell it to semi-wholesalers who in turn sell it to retailers. Semi-wholesalers in this case can be pastoralists' cooperatives.

In Mali, the first wholesaler can be the State, who donates the seed to pastoralist organizations. However the first wholesalers can also be pastoralist organizations. In Niger, the State generally buys on the regional market and sells to pastoralist organizations, even though this is not the official rule.

Regarding cottonseed cake, there are generally two sectors in all the producer countries:

- direct wholesale to traders, who in some countries are also the wholesale buyers of oil (as in Burkina Faso); these retail or semi-wholesale generally to pastoralists in peri-urban areas; and
- direct sale to animal feed factories.

Groundnut cake is preferably sold wholesale to animal feed factories.

For all these products, retailing is very rare. Actually, often because of the high prices, the end users are producers in urban or peri-urban areas who practice relatively important market-oriented livestock production and who purchase relatively large quantities of supplies. Thus, smallholders or pastoralists with low

husbandry inputs do not have access to these apparently luxury feeds.

5.5.2. International channels

International channels are even less known, and data for destination countries could not be found for all the countries. Even though cottonseed products are sold wholesale in West Africa, they can also be sold direct by the factory to organizations outside the country. The National Directorate of Statistics in Senegal has provided the destination for some agro-industrial by-products in 2007 and 2010 (Table 29). According to the data collected on-site, Benin exports most of its cotton by-products to South Africa and Nigeria.

Table 29. Target countries for some agro-industrial by-products from Senegal

Product	Destination	Year
Groundnut and cottonseed cake	Mauritania	2010
	Mali	2010
	Togo	2010
	United Arab Emirates	2010
Molasses	France	2007
	Netherlands	2007
	United Kingdom	2007
	Portugal	2007
	Mauritania	2007
Cottonseed	Mauritania	2010
	France	2010

Source: Data from National Directorate of Statistics, 2011

5.6 CHALLENGES IN THE USE OF AGRO-INDUSTRIAL BY-PRODUCTS

5.6.1 Technical challenges

For all cotton by-products, the main technical challenge is gossypol, a polyphenolic pigment present in the kernel and coat of the seed. Depending on the variety, the gossypol content of the seed can reach between 4 500 to 10 000 ppm. Gossypol is found free in the seed and this form is harmful for most animal species, and particularly for monogastric and pre-ruminants, with tolerance thresholds between 50 and 100 ppm for layers and pigs.

For a long time, it was thought that ruminants tolerate gossypol because of their ruminal abilities to fix this substance on soluble proteins, thus rendering it innocuous. However, there exists the possibility of overloading this detoxification, especially if the dietary supply of soluble proteins is insufficient, and symptoms have been observed among milch cows in the United States of America when the distribution of cottonseed is excessive. It is recommended not to exceed 30 percent of cottonseed in rations.

In the case of cakes, heating often links gossypol to amino acids through the so-called Maillard reaction which, even though it makes gossypol harmless, also renders vital amino acids unavailable.

The constraints associated with gossypol have motivated researchers to develop glandless varieties without gossypol.

In addition to the gossypol issue, depending on the mode of conservation, cottonseed cake in particular can be contaminated by toxins, namely mycotoxins, the most common being aflatoxins produced by *Aspergillus flavus*. The most dangerous, albeit less frequent, mycotoxins are: ochratoxin, palutin, citrinin, tricothecenes and zearalenone. However, cakes in Burkina Faso almost never contain these harmful mycotoxins (Marichatou, 2011). This is not surprising because the conservation period is too short for mould to start developing. The origin from soil of groundnut seeds makes it easier for mould development, so it is more frequently contaminated by aflatoxins. The maximum content allowed in this crop is 20 micrograms per kg.

One of the main issues with bran is its relatively low nitrogen content, even though, according to the process, some proteins can be found, namely in rice or wheat bran. Another issue is the risks associated with mould and therefore of fungal contamination during conservation. Finally, in their powdered form they are easily wasted by animals and this is why they are often produced as pellets, especially for poultry.

5.6.2. Economic constraints

The supplies for the most important products in the sub-region were calculated based on total production without taking into account post-export supplies. These supplies are therefore "potentially available". It should be noted that even though these supplies have been applied to cattle, they are relatively low in general. Yet these by-products are not intended for that species alone. There is a need to select the mode of distribution based on: the type of livestock production, the livestock zone, the other feed supplies and the markets. It seems easier to consider the distribution of these by-products in the areas

Table 30. Trend in agro-industrial by-product supplies for cattle (kg/head/year)

Country	2006			2007			2008			2009		
	CS	CC	GC	CS	CC	GC	CS	CC	GC	CS	CC	GC
Benin	140	70	50	140	80	60	130	70	60	120	60	60
Burkina Faso	90	40	30	40	20	30	80	30	40	50	30	30
Côte d'Ivoire	180	70	50	210	80	50	90	40	30	80	40	30
Guinea-Bissau	10	10	40	10	10	40	10	10	50	10	10	50
Mali	60	60	40	30	30	40	20	20	40	30	30	40
Niger	0	0	20	0	0	20	0	0	30	0	0	30
Senegal	20	20	150	10	10	100	10	10	230	10	10	310
Togo	120	120	110	140	140	100	90	90	110	80	80	100
UEMOA	60	40	40	40	30	40	40	30	60	40	20	70

Notes: CS = Cottonseed; CC = Cottonseed cake; GC = Groundnut cake.

closer to consumption zones, in intensive rearing of the most profitable species and breeds.

Note that apart from the inter-annual variability, there is a great variability in quantities available, due in part to each country's raw material production capacity, but also to the size of the cattle herd. Thus, even though Togo is not a groundnut producer, groundnut cake supplies in the country are greater than those in Niger or Burkina Faso. In fact, the number of cattle in Togo is among the lowest of the countries considered.

Cottonseed producing countries, such as Burkina Faso, are also involved in livestock production. This is not the case for Benin, where the cattle herd is smaller and therefore enjoys proportioanally greater supplies.

Prices also constitute constraints to the use of feed. The average producer cannot afford agro-industrial by-products. This explains why in most Sahelian countries, the State is involved through external assistance and provides livestock producers with largely subsidized products, especially during the dry season and low rainfall years.

The price study also showed high variations depending on country and year. The only explanation is the effect of supply and demand in the case of cotton (Baffes, 2010; WACIP, 2010). Besides, until the early 1980s, before establishing cottonseed crushing factories, the seed was burnt or abandoned around the factory. It is only since then that factories realized the potential of exploiting the by-products obtained from ginning and crushing.

Even though there exist in the various countries more or less efficient or practicable pricing mechanisms for cottonseed and seeds intended for crushing, these mechanisms do not exist for the seed intended for livestock or cake production. Besides, within a country or region, the local selling price of cake varies from one crusher to the other. Thus in Burkina Faso, out of about twenty crushers surveyed by Baffes (2010), the price of a tonne of cottonseed in 2009 varied from CFAF 75 000 to CFAF 92 000 per tonne and cottonseed cake from CFAF 60 000 to CFAF 111 000 per tonne.

According to Baffes (2010), while until 2006–2007 the sales price of cottonseed covered only 4–6 percent of ginning costs, this contribution is now up to 16–20 percent. This probably explains the increase in prices of cotton by-products.

In addition to pricing issues, the problem of transport can be mentioned since it penalizes a non-producing landlocked country such as Niger.

Finally, it is certainly easier for a producing country such as Benin to export its by-products by sea and in bulk, without special packaging and in larger quantities, than to haul them to Niger.

Legal constraints also exist, although legislation on the livestock sector in West Africa are mainly framework laws for the sector. These laws essentially pertain to land tenure, range management (involving indirectly but most certainly crop residues), and the administration as well as marketing of animal products.

There is legislation specific to veterinary medicines, notably regarding their introduction in the UEMOA region and their marketing. At the same time, there is almost no legislation regulating the marketing and use of cattle feed, apart from ministerial decrees that frequently ban the exportation of selected agro-industrial by-products. Niger is an exception, where the modalities for establishing feed manufacturing companies and for manufacturing feed are outlined in an article of the framework law.

Naturally, as in all other sectors, colonial texts that have since not been modified are still enforced, even if cattle feed is barely considered.

PART 6: RESEARCH AND DEVELOPMENT ON THE USE OF AGRICULTURAL RESIDUES AND AGRO-INDUSTRIAL BY-PRODUCTS

6.1 NATIONAL AND SUB-REGIONAL RESEARCH BODIES

All UEMOA member countries have at least one agricultural research body:

- INRAN in Niger,
- INERA in Burkina Faso,
- IER in Mali,
- INRAB in Benin,
- ISRA in Senegal,
- CNRA in Côte d'Ivoire, and
- ITRAG in Togo.

All these bodies have a department or structure responsible for animal production. In addition, all these countries have a higher agricultural education institution, and whether they are research institutions or academic institutes, cattle feed is part of the priority programmes for animal production units.

After a period of great enthusiasm, crop residues and food processing of by-products during the 1980s, activities in this area have been declining over the past decade. This is the case in Senegal, where several studies were conducted in the past, notably regarding groundnut haulms. Similarly in Benin, limited studies have been conducted on the use of roots and tubers peels in feeding pigs, small ruminants or non-conventional livestock.

Mali has also experienced intense activities in the field during the 1980s and 1990s, with high level scientific studies.

In Niger, these by-products have been subject to very few scientific studies. Research activities on these crops were relatively numerous during cooperation with CIRAD, but have largely decreased over the past years.

Generally, all these institutions have conducted operations on urea treatment of straw.

Nigeria seems to be the country where research activities in this area are the most extensive.

It should be noted that online consultation of these institutions' documentation centres (when they appear on Web sites) provided only outdated information.

The Dakar Interstate School of Veterinary Sciences and Medicine (EISMV) and the Centre International de Recherche-Développement sur l'Elevage en zone Subhumide (CIRDES – International Centre for Animal Husbandry Development and Research in Sub-humid Regions) are two West African institutions established with the aim of developing the sector in the sub-region. Even though there exist departments responsible for animal feed issues within these institutions, for the past fifteen years EISMV has no longer been focusing on crop residues and agro-industrial by-products. In that institution, between the 1970s and 1980s, theses by veterinary students were relatively numerous on the subject, with at least a quarter of all theses devoted to it. Now, activities in this area are minimal.

Between 2000 and 2005, CIRDES conducted a small project on treating straw with urea and on the economic aspects of the use of agro-industrial by-products. For the past 4 years, CIRDES has been implementing, with European partners, a project on mixed farming in the cotton zone of Burkina Faso.

However, there is no relevant systematic research activity, whether from the evaluation, development, socio-economic value or processing points of view.

Human resources in the area of livestock production are generally the least important in national research or academic education institutions. Moreover, the laboratories visited had very limited equipment, and that was often very outdated.

6.2 INTERNATIONAL RESEARCH BODIES

Among those operating in Africa, there are CIRAD and the member countries of the Consultative Group for International Agricultural Research (CGIAR).

Even though during the 1970s to 1990s CIRAD was very involved in developing crop residues and agricultural by-products, this subject is no longer a research priority as a specific programme. However, the institution is still interested in mixed farming, a subject that necessarily includes developing use of crop residues, despite the focus being essentially socio-economic issues.

CGIAR centres operating in West Africa include ICRISAT, IITA, AfricaRice and ILRI.

ILCA (former ILRI) has conducted intense activities in the area of cattle feeding and has even initiated a dynamic network on cattle feed in Africa (AFReNet) which worked extensively on crop residues and agro-industrial by-products. Moreover, its other networks on cattle and small ruminants have conducted studies on the development of these by-products in Africa as a whole, and especially in West Africa.

In the mid-1980s, ICRISAT worked extensively on developing crop residue usage in particular, in relation to soil fertility, but also in relation to the varietal improvement of millet, sorghum and cowpea for better integration of farming and livestock. In this area, the Center teamed up with ILRI and IITA. Today there still exists a task force involving 12 CGIAR centres, namely the "System-wide Livestock Program" (SLP), mainly involved with the socio-economic aspects of mixed farming, and therefore in developing crop residue uses.

Thus, the development of crop residues and agro-industrial by-products for animal uses has been little researched for the past ten to fifteen years in national and sub-regional institutions of the UEMOA zone. However, international institutions are interested in specific aspects of crop residues and their role.

It should also be noted that it is not out of lack of interest or ignorance over the relevance of these subjects, but rather due to the weaknesses of agricultural research systems (qualitatively and quantitatively), which lead them to align on the themes proposed within the framework of external financing, Such external funding can constitute, when it exists, between 40 and 75 percent of an institute's budget (ASTI, 2011).

6.3 DEVELOPMENT AT NATIONAL LEVEL

All West African countries have defined a strategic framework for poverty alleviation, in accordance with the Millennium Development Goals aiming at halving poverty in the world by 2015.

Therefore, each country defined sectoral orientations and a programme for priority activities in Poverty Reduction Strategy Papers. The livestock sector in all the countries has been considered as a priority since most of the activities performed by the poorest and disadvantaged, such as women and the youth, and animal product imports, especially dairy products, are important factors in foreign exchange balances. The States have thus committed to improve livestock production systems, and the focus was especially put on short-cycle livestock species production. Moreover, they focused on genetic improvement by using artificial insemination. These various perspectives involve the issue of animal feeding.

Even though several rural development projects exist on livestock issues, the specific subject of animal feeding has not been a specific project.

However, in Mali, there is a national programme titled "Operation fenaison" (Operation Haymaking) which is implemented from September in order to initiate or remind farmers of best practices in chopping and conserving crop residues. Livestock services are involved in this programme through TV programmes, data sheets in local languages and video cassettes. Technical services in Mali claim to be able to collect more information on the quantities and prices in weekly markets. In Senegal, operations to distribute mowers to chop crop residues should be implemented every year. It seems that in these two countries, traders have specialized in groundnut and cowpea haulms, which are highly profitable during the dry season. In Niger, a project titled "Karkara" is conducting training sessions for farmers on chopping and haymaking techniques.

In all the countries visited, projects for the treatment of straw with urea have been conducted, generally in partnership with FAO, early in the 1980s. A project on urea multi-

nutrient blocks recently ended in Niger. In other words, agro-industrial by-products were currently not the focus of specific projects in the countries.

Moreover, in a country such as Burkina Faso, discouraged by the difficulties they encountered in accessing these by-products, the technical services have maintained that they intend re-introducing intensification of fodder crops in their priorities for animal feeding (Ministry of Animal resources of Burkina Faso, 2009).

In fact, the relevance of developing various by-products is well known, as development techniques are well known. The real problem is the dissemination and adoption of these techniques, contrary to what is observed in Asian countries.

6.4 DEVELOPMENT AT REGIONAL LEVEL

UEMOA and ECOWAS have each designed a common agricultural policy, with no specific differences. Issues related to livestock are top priority, and even if the issue of feed is not explicitly described, it is implied. During the implementation, programmes should define the actions to be promoted. The same holds true for agricultural research for which UEMOA has already secured and continues to secure funding through competitive calls for tenders.

In the animal feed sector, especially in the use of agro-industrial by-products, UEMOA has indirectly taken initiatives through a programme to "Restructure and upscale the Member States Industry" (PRMN, 2008). This programme aims at boosting industrial production, investment promotion, employment and improving economies at regional and international levels. UEMOA's programme started off in 2007 with 120 agro-industrial industries. Prior to its launching, a study was conducted to identify priority agro-industrial sectors of economic interest for processing in each country. The objectives of this study were:

- to highlight national priorities in the area of agro-industrial development by identifying sectors that have a potential for post-harvest or post-livestock activities; and
- to develop recommendations to Member states for priority actions to be implemented in order to help develop the agro-industrial sector.

For its part, ECOWAS has initiated the "West African Common Industrial Policy" (WACIP), the aims of which match those of the UEMOA programme, and are to:

- diversify and increase the industrial production base in the region, by progressively increasing local inputs processing rate from 15–20 percent to an average of 30 percent in 2030 through support to new industrial production capacity, and the development and up-scaling of existing capacity;
- progressively increase the contribution of manufacturing output to regional GDP, from the current average of 6–7 percent, to an average of over 20 percent in 2030;
- progressively increase intra-community trade in West Africa, from the current less than 12 percent to 40 percent in 2030, with goods manufactured in the region having a 50 percent share, especially in the energy sector (equipment, electricity, oil products, etc.); and
- progressively increase the export rate in the global market of manufactured products originating from West Africa, from the current 0.1 percent to 1 percent in 2030, by strengthening and developing skills; industrial and infrastructure competitivity; quality (standardization, accreditation and certification); information; communication; and transport.

PART 7: RECOMMENDATIONS

More specific recommendations are presented according to the possible areas of intervention.

At geographic level

- There is a need to extend activities to the entire sub-region of West Africa in the ECOWAS region due to the existing policy of integration in member countries, to their special commercial linkages and agro-ecological complementarity. A study should be completed to include non-UEMOA ECOWAS member states. It is necessary to conduct a more systematic assessment of animal feed potential, using streamlined conversion methods.

At technical and socio-economic level

- There is a need to obtain more information on supplies and trade in each country studied. The study should examine national policies pertaining to cattle and other animal feed, and more specifically analyse the reasons for the loss of interest and let-up regarding this issue after periods of greater interest. It is equally important to specify the underlying reasons for the non-adoption of certain technologies, the positive effects of which are well known.

At scientific level

- There is a need to understand the reasons behind the lack of interest of researchers for this subject, and also the lack of activities on crop residues and agricultural by-products as animal feed.
- Regular frameworks for concerted action should be promoted to restore the crops studied to their rightful place in the development of animal production in West Africa.

At national level there is a need to consider and address the issue of residues and by-products in the following areas:

- supply control;
- price control;
- technology transfer;
- legislation development;
- quality control; and
- agricultural research strengthening.

At regional level there is need to improve the efficiency of the following activities:

- regional trade data collection and follow-up;
- streamlined assessments of production and marketing costs; and
- development and implementation of an appropriate legal framework to promote the use and trade of crop residues and agro-industrial by-products.

The above recommendations should not be considered independently with regard to the relevant institutions or separately by the various types of stakeholders within the livestock sub-sector; partnership offers the best way forward to achieve targets.

It is essential to immediately launch a regional initiative for the improved use of crop residues and agro-industrial by-products, with the effective and sustainable involvement of relevant actors at national and regional levels. This initiative would consolidate approaches and coordinate efforts based on the draft action plan presented below.

PART 8: ACTION PLAN

An action plan is proposed to coordinate the implementation of appropriate measures to improve the use of crop residues (CRs) and agro-industrial by-products (AIBPs) in animal feeding, especially in West Africa. At both national and regional levels, the aim is to facilitate access to the various by-products, improve their availability, and to disseminate adequate techniques for their use in well-regulated conditions and complete safety. The ultimate goal is to contribute to improving animal production by adapting animal feeding to the various situations prevalent in livestock production.

In terms of approach, the proposed preliminary action plan is entirely based on observations made during this study, specifically on the constraints encountered while using CRs and AIBPs to feed cattle. The recommended actions are presented according to the relevant actors, timeframe and timeline.

The action plan is organized based on:

- the constraints identified for each by-product category (CR and AIBP);
- the categories of actors and their possible roles; and
- the time required and level of urgency (short, medium or long term).

The action plan is structured reflecting the major constraints identified and from which expected outcomes and actions have been derived based on the timeframe and main actors. Due to their specificity, CRs are distinguished from AIBPs in the action plan.

The expected outcomes and actions of the action plan are outlined below.

Outcome 1: CR supplies are improved

- Development of a standardized method to assess residues per country and per type of crop (stems/leaves/seeds; peels; harvest ratios; and conversion factors).
- Development of multi-use varieties (human and animal) per type of crop and per country.
- Precise knowledge of the animals to be provided with by-products.
- Determination of the necessary supplies per species and per production type based on the agro-ecological zones.
- Determination of the shares of by-products used for purposes other than animal feeding.
- Development of efficient collection, transport and conservation techniques to reduce losses.

Outcome 2: Quality of CRs is improved

- Development of adapted fertilization techniques.
- Varietal selection to improve nitrogen content.
- Development of conservation methods to maintain nutrient levels per type of crop.
- Identification of optimal use patterns.
- Identification of best food associations per animal species according to the type of residue.
- New technology testing (ruminal flora manipulation to improve straw digestibility, etc.).

Outcome 3: Access to CRs is facilitated

- Socio-economic studies on technology and best practices (urea treatment of straw, multinutrient blocks, straw chopping, etc.).
- Training of producers.
- Identification of production and marketing costs and their variation factors according to country and by-product.
- Price regulation.
- Identification of marketing channels.
- Formulation and implementation of adapted legislation.

Outcome 4: Reliability of AIBP supplies-related data is improved

- Adoption of a regional regulation on reporting of original production and by-product supplies.
- Sensitization and capacity strengthening of national and regional statistical services regarding AIBP coverage.

- Determination of the exact quantities used for purposes other than animal feeding.

Outcome 5: Access to AIBPs is facilitated

- Identification of the number of users of market-oriented livestock production.
- Study of production and marketing costs to promote transparency in pricing.
- Improvement of the efficiency of marketing channels per country and for regional trade.
- Formulation and implementation of adapted legislation promoting intra-community trade.
- Establishment of an information mechanism on supplies and points of sale.
- Support to livestock keepers' organizations as users of AIBPs.

Outcome 6: AIBP quality and safety are improved

- Creation or strengthening of AIBP quality control laboratories.
- Development of regional legislation on nutrient content and objectionable content, as well as feed production for cattle and poultry.
- Rehabilitation or promotion of small- and medium-scale units and feed processors for cattle and poultry.
- Formulation of feed rations according to by-products and production types.

Outcome 7: Use of AIBPs in livestock production is increased

- Capacity strengthening in the area of technical and economic information on AIBP use.
- Promotion of sub-regional trade in AIBPs.

Outcome 8: Research capacity in CRs and AIBPs is strengthened

- Strengthening of animal feed research laboratories.
- Launching of a West African research network on animal feed, with special emphasis on CRs and AIBPs.
- Launching of a regional network of animal feed control laboratories.
- Introduction of modules on CRs and AIBPs in curricula.

The States will have a key role in areas under the control of the national public sector and Regional Communities for the sub-regional public sector. The expected outcomes according to the type of actor are presented in the following Outcomes.

Outcome 9: National and regional regulation on CRs and AIBPs prepared and adopted

- Annual diffusion of by-product prices, taking into account production and marketing costs, origin and quality.
- Regulation of packaging, transport and characteristics of points of storage and sale.
- Regulation of the composition of feed and limits for maximum content of harmful substances.
- Requirements for industries to declare their production of by-products, their use and their share in animal feed.
- Adoption of quotas for intra-community imports and exports.

Outcome 10: Control of CRs and AIBPs at national and regional levels implemented

- Strict control of inputs and outputs of AIBPs at borders by customs services.
- Creation and/or strengthening of feed analysis laboratories.
- Systematic control of the safety of AIBPs by national laboratories.

Outcome 11: National and regional statistics on CRs and AIBPs improved

- Inclusion of CRs and AIBPs in agricultural statistics collection and analysis systems at national and regional levels, in collaboration with industries generating CRs and AIBPs.
- Regular dissemination of information to experts and to the general public.
- Strengthening of national statistics services to monitor animal feed trade.

Outcome 12: CR and AIBP users' national committees and West African federation operational

- Support the creation, organization and operation of national CR and AIBP user committees.
- Support the creation of a West African federation of CR and AIBP users.
- Training of users.

Outcome 13: Research and training on CRs and AIBPs strengthened

- Inventory of by-products used in animal feed by type and by species.
- Collection of samples to be used as teaching aids in bromatology.
- Analysis of by-products and by-product-based rations.
- Education in agricultural by-products use in animal feeding.
- Coordination by EISMV of a West African research network on agricultural by-products usable in animal feeding.
- Coordination of teaching in animal production, including the use of CRs and AIBPs.
- Coordination by CIRDES of a regional network of cattle feed analysis laboratories for the sub-region.

Outcome 14: International technical research and support strengthened

- Involvement of national and regional institutions in System-wide Livestock Program (SLP) and other CGIAR programmes (ILRI, IITA, ICRISAT and AfricaRice).
- Development of a special programme for rice by-products in partnership with other African institutions (AfricaRice).
- Execution of socio-economic studies on CRs and AIBPs (IFPRI, CIRAD).

The calendar of proposed actions is presented in Tables 31A–C.

Table 31A. Chronology of the action plan – Crop residues

Activities	Result	Period	Partners
Expected outcome 1: CR supplies improved			
1. Development of a method to assess residues per country, per plant species, and per variety.	Assessment streamlined	2 years	Higher agricultural educational institutions per country; ICRISAT; IITA.
2. Development of multi-use varieties (for humans and animals) per crop type and per country	Multi-use varieties available	3–5 years	Higher agricultural educational institutions per country; ICRISAT; IITA.
3. Specific knowledge of exact number of animals to be supplied with by-products	Target cattle herd size known	2 years	National research institution per country.
4. Determination of the necessary supplies per species and per production type based on the agro-ecological zones	Annual needs per country specified	2–5 years	Higher agricultural educational institutions per country; EISMV.
5. Specific determination of the shares of by-products used for purposes other than animal feeding	Competing uses known	2 years	Higher agricultural educational institutions per country; agricultural services.
6. Development of efficient collection, transport and conservation techniques to reduce losses	CR losses reduced	2–5 years	Civil engineering services; higher agricultural educational institutions per country.
Expected outcome 2: Quality of CRs improved			
1. Development of adapted fertilization techniques	Fertilization techniques available	2–5 years	Research and training; ICRISAT; IITA.
2. Varietal selection to improve nitrogen content	Varieties available	2–5 years	Research and training; ICRISAT; IITA.
3. Development of conservation methods to maintain nutrients rates adapted per type of crop	Conservation methods available	2–5 years	Research and training; ICRISAT; IITA.
4. Identification of favourable periods for use	Periods favourable for use known	2 years	Research and training; EISMV.
5. Identification of best food associations per animal species according to the types of residues	Associations known	2–5 years	Research and training; EISMV.
6. Tests of new technology such as ruminal flora manipulation to improve straw digestibility, etc.	Technologies available	2–5 years	Research and training; EISMV.

Activities	Result	Period	Partners
Expected outcome 3: Access to CRs facilitated			
1. Socio-economic studies to determine the causes of the non-adoption on a large scale of existing technology (urea treatment of straw, multinutrient blocks, straw chopping, etc.) according to country	Solutions to eliminate the constraints are proposed		
2. Training of producers	Techniques to improve CRs are mastered	1 year	Extension services in each country.
3. Identification of exact costs and their variation factors by country and by product;	Prices and price trends are well known	1 year	FAO.
5. Price regulation	Price fluctuations are well known	1 year	Ministry of Trade.
6. Identification of points of sale and regulation	Points of sale known, market knowledge is improved	1 year	Ministry of Trade.

Table 31B. Chronology of the action plan – Agro-industrial by-products

Activities	Expected results	Period	Responsible	Partners
Expected outcome 4: Reliability of AIBP supply-related data improved				
1. Establish regional legislation on declaring original products and by-products supplies	AIBPs supplies controlled	1 year	ECOWAS	UEMOA, States, Industries
2. Sensitize and strengthen national and regional statistical services on the subject	The trend in supplies controlled, variation factors known	1 year	ECOWAS	UEMOA, States
3. Determine the exact quantities used for purposes other than animal feeding	Supplies intended for animals determined	1 year	Ministries of Industry	CEDEAO, UEMOA, Industries
Expected outcome 5: Access to AIBP facilitated				
1. Improvement of supplies for the animals in need by determining the exact dimensions of market-oriented livestock production	National and regional quantitative needs known	1 year	Ministries of Livestock	Research and training, UEMOA, ECOWAS
2. Study to determine a pricing mechanism	Prices are objective, price increases avoided	1 year	UEMOA	ECOWAS, States
3. Formalize the marketing channels through legislation in each country and regulation for regional trade	Trade in AIBPs more transparent. Pricing mechanism controlled, trades certified and known	2 years	ECOWAS	UEMOA, States
4. Formulation and implementation of regional legislation promoting intra-community trade	Intra-community supplies improved	1 year	ECOWAS	UEMOA. Requires a consultation.
5. Establishment of an information mechanism on supplies and points of sale	Points of sale, sales companies, selling prices regularly known	1 year	Ministry of Trade	Producer Organizations, Chambers of Agriculture
6. Launch/support national associations and a regional federation of AIBP users to contribute to informational intelligence on selling prices	Prices controlled, access facilitated, information sharing improved	1 year	States	UEMOA, ECOWAS, ROPPA, CTA, FAO
Expected outcome 6: AIBP quality and safety improved				
1. Creation or strengthening of quality control laboratories	Producers have access to risk-free products	3–5 years	States	UEMOA, ECOWAS
2. Development of legislation on contents (nutrients and objectionable elements)	Producers have access to risk-free products	1 year	States	UEMOA, ECOWAS, FAO

Activities	Expected results	Period	Responsible	Partners
3. Rehabilitation or advocacy for the creation of feed factories by means of sound legislation on feed production	Ready-to-use feed available, marketing channels simplified, traceability ensured	5 years	States	UEMOA, ECOWAS
4. Formulation of feed rations according to by-products and production types in some countries	Animal performance controlled and improved	2 years	Research institutes per country. Agri-education institutions	EISMV, CIRDES, ILRI, CIRAD
Expected outcome 7: Use of AIBPs in livestock production increased				
Strengthen extension, training and information capacity of technical servicesfor use of AIBPs.	Producers familiar with utilization techniques	1 year	Extension Services	National research

Table 31C. Chronology of the action plan – Crop residues and agro-industrial by-products

Activities	Expected results	Period	Responsible	Partners
Expected outcome 8: Research capacity in CRs and AIBPs is strengthened				
1. Strengthening of higher animal feed education and research laboratories	Technologies generated	>5 years	States	UEMOA, ECOWAS, FAO
2. Launching of a West African research network on animal feed with special emphasis on CRs and AIBPs	Knowledge shared	1 year	Research institute per country, agricultural education institution	ILRI, CIRDES, CIRAD
3. Launching of a regional network of animal feed control laboratories	Control methods standardized, products traceable	2–3 years	States	FAO
4. Introduction of modules on CRs and AIBPs in the curricula	Knowledge disseminated, research improved	2 years	Research institute per country, agricultural education institution	CAMES
Expected outcome 9: A national and regional regulation on CRs and AIBPs is prepared and adopted				
1. Annual diffusion of by-products prices taking into account production and marketing costs, origin and quality	Improved knowledge of prices	1 year	States	UEMOA, ECOWAS, CILSS, FAO
2. Adoption of a regulation on packaging, transport and characteristics of points of storage and sale	Improved storage and sale	>5 years	States	UEMOA, ECOWAS, FAO
3. Adoption of a regulation on the composition of feed and their maximum content in harmful substances	Improved quality	1 year	National research	ILRI, CIRDES, CIRAD
4. Adoption of a regulation on the declaration of industries regarding their production of by-products, the use and share of animal feed	Improved information	2–3 years	States	UEMOA, ECOWAS, CILSS, FAO
5. Adoption of quotas for intra-community imports and exports	Improved intra-community trade	2 years	States	UEMOA, ECOWAS, CILSS, FAO
Expected outcome 10: Control of CRs and AIBPs at national and regional levels is implemented				
1. Strict control of inputs and outputs of agro-industrial by-products at borders by customs services	Follow up of supplies improved	1 year	States	UEMOA, ECOWAS, CILSS, FAO
2. Creation and/or strengthening of cattle feed analysis laboratories	Improved information	>5 years	States	UEMOA, ECOWAS, FAO
3. Systematic control of the safety of AIBPs by national laboratories	Improved quality	1 year	National research	ILRI, CIRDES, CIRAD

Activities	Expected results	Period	Responsible	Partners
Expected outcome 11: National and regional statistics on CRs and AIBPs are improved				
1. Inclusion of CRs and AIBPs in agricultural statistics collection and analysis systems at national and regional levels in collaboration with industries producing CRs and AIBPs	Information improved	1 year	States	UEMOA, ECOWAS, CILSS, FAO
3. Regular dissemination of information to experts and to the general public	Information improved	1 year	States	UEMOA, ECOWAS, FAO
4. Strengthening of national statistics services capacity for cattle feed trade	Information improved	>5 years	National research	ILRI, CIRDES, CIRAD
Expected outcome 12: CRs and AIBPs users national committees and West African federation are operational				
1. Support to the creation, organization and operation of national CRs and AIBPs users committees	Capacity strengthened	1 year	States	UEMOA, ECOWAS, CILSS, FAO
2. Support to the creation of a West African federation of CRs and AIBPs users	Capacity strengthened	1 year	States	UEMOA, ECOWAS, FAO
3. Training of users	Capacity strengthened	>2 years	States	All
Expected outcome 13: Research and training on CRs and AIBPs are strengthened				
1. Inventory of by-products used in animal feed by type and by species	Increased use	1 year	States	International technical partners
2. Collection of samples to be used as bromatology teaching aids	Research facilitated	>2 years	States	International technical partners
3. Analysis of by-products and by-products-based rations	Research facilitated	1 year	States	International technical partners
4. Education on agricultural by-products used in animal feeding	Training facilitated	>2 years	States	International technical partners
5. Coordination of a West African research network on agricultural by-products usable in animal feeding	Research facilitated	>2 years	States	International technical partners
6. Coordination of education in animal production including the use of CRs and AIBPs	Training facilitated	>2 years	States, EISMV	International technical partners
7. Coordination of a regional network of cattle feed analysis laboratories for the sub-region	Research facilitated	>2 years	States, CIRDES	International technical partners
Expected outcome 14: International technical research and support strengthened				
1. Involvement of national and regional institutions in 'SLP' programmes and other CGIAR programs (ILRI, IITA, ICRISAT and AfricaRice)	Capacity strengthened	1 year	ILRI, IITA, ICRISAT AfricaRice	National technical partners
2. Development of a special programme for rice by-products in partnership with the other African institutions (AfricaRice)	Capacity strengthened	1 year	Africa Rice, FAO	International technical partners
3. Execution of socio-economic studies on CRs and AIBPs (IFPRI, CIRAD)	Capacity strengthened	1 year	IFPRI, CIRAD; FAO	International technical partners

CONCLUSIONS

The following conclusions can be drawn from the study.

The livestock sector is undergoing a transformation in West Africa with:

- an increasingly high quantitative demand for animal products related to a particularly important demographic increase in urban centres;
- increasing numbers of animals due, among other reasons, to the efficiency of major epizootics control;
- a qualitative demand increase related to the improvement of living standards in urban centres;
- the emergence of new actors in the sector, with market-oriented production, namely in peri-urban areas; and
- the emergence of new livestock systems with an increasingly strong association between farming and livestock, and reflecting the agro-ecological backgrounds.

Growing agricultural production is poorly diversified because:

- countries are practically specialized for particular production in view of their agroclimatic context;
- there has been a significant increase in crop production over the past 25 years; and
- [a] there is interdependence among the various countries in the area of agricultural products.

The agro-industrial system has good potential but is poorly exploited, due to:

- diversity of raw materials;
- prevalence of oilseeds industries;
- high dependence on external exports of producing countries and poor sub-regional trade;
- weak policy on by-product prices;
- prices overly reliant on demand and supply for these by-products; and
- process infrastructure overcapacity.

Agricultural by-products supplies are distributed according to agro-ecological zones:

- the drier zones, the major livestock production areas, have larger supplies of cereals and legumes than more humid zones, while more humid zones have more roots and tubers; and
- agro-industrial by-product supplies are naturally dependent on the nature of production according to country, but also according to the level of industrial development of each country.

Development services are unable to control food resource systems:

- while there is an awareness of the relevance of these crops, there is no political will for their use;
- legislation on the subject is lacking or obsolete;
- regional policy for the use of these resources is lacking;
- it is difficult for producers to adopt technologies in spite of their proven relevance;
- national programmes in support of producers are lacking; and
- research in the subject area is lacking.

Favourable trends include:

- possible improvement in agricultural resources and consequently in feed supply for livestock;
- formulation of a rationalization policy for the industrial system;
- awareness of the need for a policy on agro-industrial by-product prices;
- priority livestock production in national and regional development policies; and
- countries sensitized on the need for research for development.

Ultimately, the relevance of the use of crop residues and agro-industrial by-products is well known by all livestock stakeholders. Livestock producers currently use crop residues. However,

social, economic and technical constraints exist regarding their accessibility and their development. Regarding agro-industrial by-products, the constraints related to their accessibility are even stronger, but are more of an economic than technical nature.

Trade in crop residues between UEMOA member countries is practically non-existent. Agro-industrial by-products are traded, albeit in small quantities, but could be considered if economic solutions are discussed at regional level.

In the meantime, more detailed studies per country and in the whole ECOWAS region are necessary on both supplies and trade issues, and agricultural research should be more present and constant in this area, together with sustained efforts to adopt relevant technologies.

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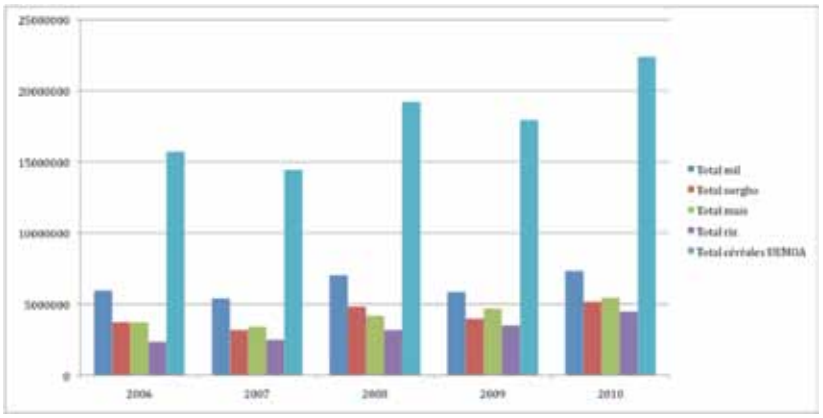
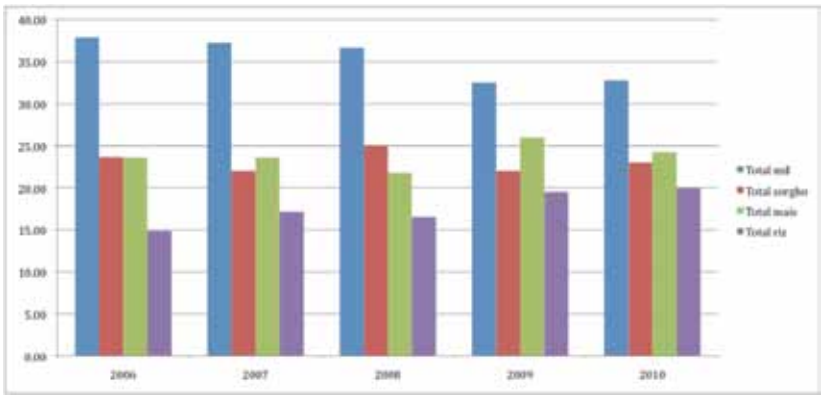
ANNEXES

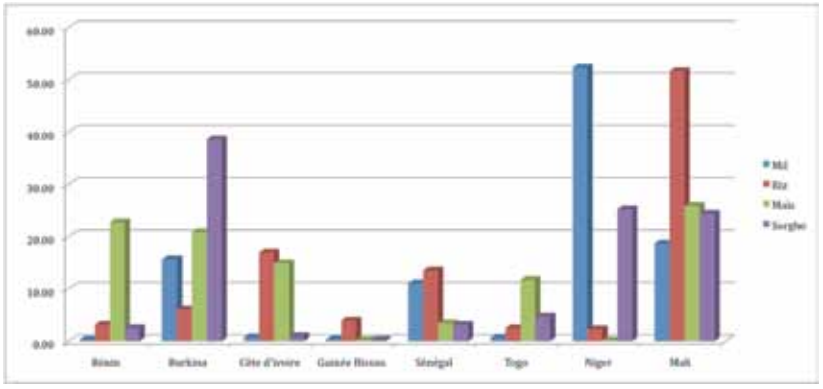
ANNEX 1
Trend in crop production (tonne) in the UEMOA region
(Agrhymet. 2011)



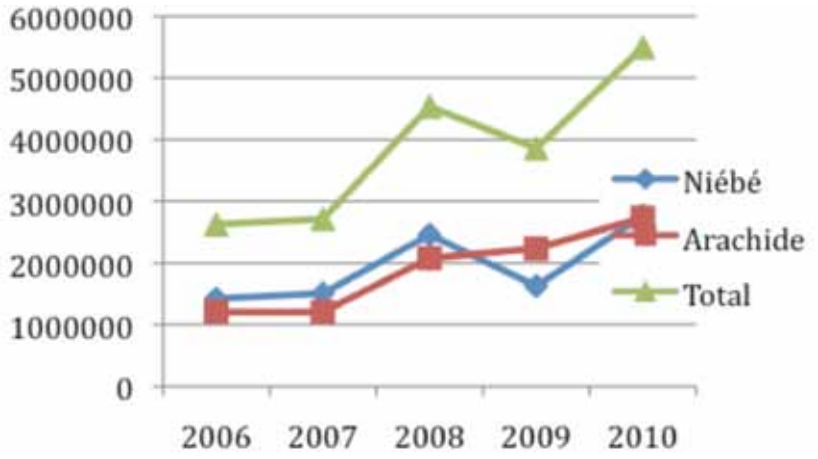
ANNEX 2
Trend in the contribution of different crops to the total grain production in the UEMOA region
(Agrhymet. 2011)



ANNEX 3
Crop distribution (percent) in the UEMOA region by country
(Agrhymet. 2011)



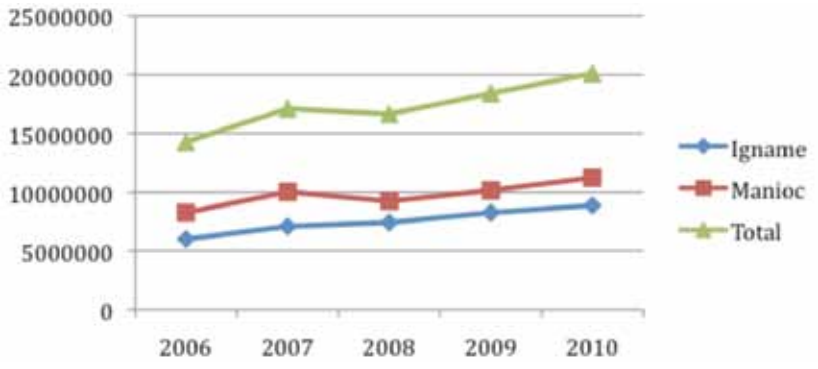
ANNEX 4
Trend in legumes production (tonne) in the UEMOA region
(Agrhymet. 2011)



ANNEX 5
Trend (percentage change) in countries' contribution to the production of groundnut and cowpea in the UEMOA region
(Agrhymet. 2011)

Country	2006		2007		2008		2009		2010	
	Groundnut	Cowpea	Groundnut	Cowpea	Groundnut	Cowpea	Groundnut	Cowpea	Groundnut	Cowpea
Benin	0.92	6.78	10.6	6.04	6.58	4.01	5.81	5.43	6.09	3.94
Burkina Faso	17.85	30.69	20.33	16.80	16.67	21.87	14.80	27.92	12.44	22.64
Côte d'Ivoire	5.74	0	0	0	3.90	0	3.80	0	3.81	0
Guinea-Bissau	0	0	0	0	2.24	0.11	2.60	0.18	2.55	0.12
Mali	22	5	26.91	3.87	18.69	3.17	13.45	8.21	11.50	4.66
Niger	12.64	50.10	12.26	66.43	14.68	62.96	11.34	48.47	14.86	64.12
Senegal	38.16	3.72	27.44	2.68	35.19	5.14	36.21	5.33	47.06	1.77
Togo	2.69	3.72	2.99	4.18	2.05	2.74	1.99	4.45	1.70	2.75

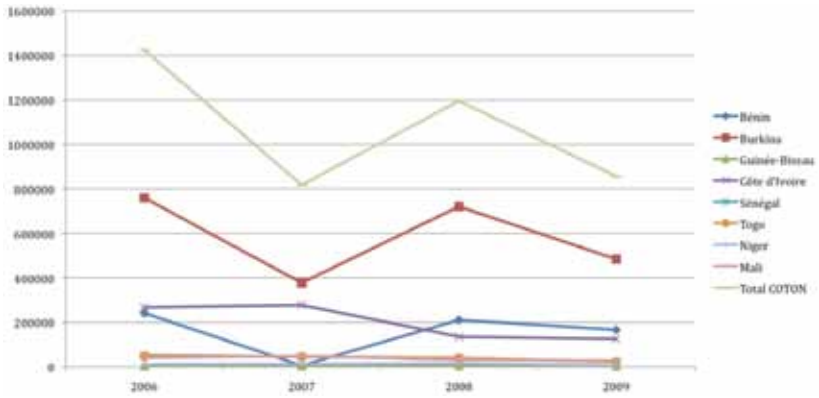
ANNEX 6
Trend in yam and cassava production (tonne) in UEMOA countries
(Agrhymet, 2011)



ANNEX 7
Trend in UEMOA countries contribution (percent) to the production of yam and cassava (Agrhymet, 2011)

Country	2006		2007		2008		2009		2010	
	Yam	Cassava	Yam	Cassava	Yam	Cassava	Yam	Cassava	Yam	Cassava
Benin	25.54	47.5	23.68	42.45	27.39	49.21	23.36	48.89	24	49.81
Burkina Faso	0.27	0	0.20	0	0.47	0	0.80	0	0.87	0
Côte d'Ivoire	66.6	39.64	69.11	42.20	64.37	34.49	68.26	36.120	68.01	36.84
Guinea-Bissau	0	0	0	0	0	1.09	0	0.78	0	1.01
Mali	0.94	0	0.85	0	0.75	0	0.64	0	0.80	0
Niger	0	0.22	0	0	0	0	0	0	0	0
Senegal	0	1.92	0	4.29	0	12.55	0	3.25	0	2.05
Togo	6.65	10.71	6.16	11.06	7.02	2.66	6.93	10.90	6.32	10.29

ANNEX 8
Trend in cotton production (tonne) in UEMOA member countries (Agrhymet. 2011)



ANNEX 9
Trend in livestock numbers ('000) in the UEMOA region (FAO, 2009)

Animal species	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Camel	1 882	1 948	2 023	2 107	2 206	2 314	2 442	2 587	2 748	2 825
Goat	33 503	34 591	35 457	36 630	37 882	39 252	40 767	41 879	43 628	45 190
Sheep	28 363	29 268	30 006	31 033	32 113	33 216	34 485	35 385	37 506	38 937
Cattle	26 710	27 111	27 385	27 862	28 834	29 476	30 108	30 626	31 165	31 794
Total ruminants	**90 458**	**92 918**	**94871**	**97 632**	**101 035**	**104 257**	**107 801**	**110 477**	**115 046**	**118 746**
Poultry	136 441	137 460	144 093	146 786	153 026	157 031	165 725	175 658	186 702	196 050
Pig	3 071	3 271	3 489	3 716	3 955	4 225	4 531	4 390	4 167	4 159
Total monogastrics	**139 512**	**140 731**	**147 582**	**150 502**	**156 981**	**161 256**	**170 256**	**180 048**	**190 869**	**200 209**

ANNEX 10
Annual livestock growth rate (percent) per country and per species for 2000 to 2009 (FAO, 2009)

Country	Camel	Cattle	Sheep	Goat	Pig	Poultry
Benin	0	4.21	3.74	4.12	3.6	2.53
Burkina Faso	2.34	5.27	4.90	5.22	4.37	2.90
Côte d'Ivoire	0	3.89	3.90	3.8	3.22	2.35
Guinea-Bissau	0	3.62	3.73	3.56	3.43	1.99
Mali	4.5	5.20	5.46	5.35	3.02	2.78
Niger	3.85	5.38	5.21	5.39	2.15	-1.96
Senegal	2.06	4.08	4. 56	4.47	3.42	3
Togo	0	3.55	4.28	3.56	3.92	2.75
UEMOA		5.56	6.08	6.10	4.63	3.39

ANNEX 11
Factors for conversion of cereal production into residues (Kossila, 1988)

By-product or residue	Africa	Asia	North Africa/ West Asia	Mali	Niger	Senegal	Mali
Maize	3	3	2	1.5			
Sorghum	5	4	6	3	3.8		
Millet	5	4	6	4	3.8		
Rice straw		1.3	2.1		0.86	1.66	2.8
Groundnut haulm				3			
Cowpea haulm					0.22		
Wheat bran				0.35			
Rice bran					0.075		
Millet bran							
Sorghum bran					0.35		
Root and tuber peel	0.30						
Cotton stem				2			

Notes: The review by Kossila had two reports for Mali.

ANNEX 12
Extra- and intra-community exports (tonne and as percentage of national production) of cottonseed cake per country in the UEMOA region

Country	2005				2006				2007				2008				2009			
	ExtraC		IntraC		ExtraC		IntraC		ExtraC		IntraC		ExtraC		IntraC		ExtraC		IntraC	
	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%
Benin	49 024	25.28	0	0.03	56 350	45.44	40.30	0.03	43 621	29.47	0	0	28 621	21.20	0	0	17 488	13.88	0	0
Burkina Faso	1 200	0.32	0	0	0	0	13 712	3.68	0	0	14 774	5.78	325	0.10	0	0	11 861	4.39	0	0
Côte d'Ivoire	2 488	1.72	7 031	0.37	238	0.24	55	0..06	0	0	2 197	2.93	0	0	9 129	14.04	0	0	5774	9.16
Guinea-Bissau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mali	4 370	0.82	733	0.45	560	0.13	260	0.06	675	0.27	0	0	0	0	4 334	2.14	0	0	2 089	0.89
Niger	0	0	110	2.49	0	0	0	0	0	0	30	0.25	0	0	249	1.7	0	0	0	0
Senegal	0	0	5 054	16.86	0	0	5 217	10.03	0	0	3 637	8.06	0	0	7 324	18.87	0	0	2 683	12.14
Togo	19 540	19.89	0	0	13 507	33.78	509	1.27	10 957	22.45	1 078	2.21	4 526	15.92	8 489	26.12	120	0.41	11 192	38.56
Total	76 622	5.61	12 928	0.80	70 655	6.21	19 794	1.74	55 252	7.16	21 716	2.8	33 472	14.13	29 525	3.65	24 470	3.90	21 737	2.88

Notes: ExtraC = extra-community; IntraC = intra-community; T = tonne; % = per cent share in national production.

ANNEX 13
Extra- and intra-community exports of groundnut cake in the UEMOA region

Countries	2005				2006				2007				2008				2009			
	ExtraC		IntraC		ExtraC		IntraC		ExtraC		IntraC		ExtraC		IntraC		ExtraC		IntraC	
	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%
Benin											60	0.05								
Mali																				
Niger	1 198	0.86																		
Senegal	7 154	1.02			4 881	10.60	70	0.02	29 756	8.98	120	0.04	7 487	1.02			14 952	1.45		
Togo													1 206	2.91			2 250	6.08		

Notes: ExtraC = extra-community; IntraC = intra-community; T = tonne; % = percent share in national production.

ANNEX 14
Trend in average prices (CFAF/tonne) for various cake exported within UEMOA

Zone	2005			2006			2007			2008			2009		
	CC	SC	GC	CC	SC	GC	CC	SC	GC	CC	SC	GC	CC	SC	GC
Outside UEMOA	35 475	133 956	72 626	37 417	158 436	25 392	46 602	180 239	95 161	83 778	215 233	138 103	80 782	219 354	148 410
Within UEMOA	53 052	—	50 956	47 229	68 000		50 956	—		109 806	—		120 967	955 548	

Notes: CC = cotton cake; SC = soybean cake; GC = groundnut cake.

ANNEX 15
Trend in bran exports (tonne) of UEMOA origin

Zone	2005			2006			2007			2008			2009			Total 2005–2009		
	WB	RB	MB	WB	RB	MB	WB	RB	MB	WB	RB	MB	WB	RB	MB	WB	RB	MB
Outside UEMOA	20 835	0	0	38 225	0	0	38 270	0	0	15 824	0	0	56 961	0	0	170 115	0	0
Within UEMOA	16,517	994.3	0	6 961	0	0	8 965	12.0	0	10 708	0	14	4 147	155	26.3	47 297	1 161	41
Total exports	37 352	994.3	0	45 185	0	0	47 234	12	0	26 532	0	14	61 108	155	26.3	217 412	1 161	41
Overall exports outside UEMOA	55.8%			84.7%			81%			59.6%			93.2%			78.4%		

Notes: WB = wheat bran; RB = rice bran; MB = maize bran.

ANNEX 16
Trend in average prices for bran exports within UEMOA (CFAF)

Zone	2005			2006			2007			2008			2009		
	WB	RB	MB	WB	RB	MB	WB	RB	MB	WB	RB	MB	WB	RB	MB
Outside UEMOA	10 028			25 393			33 203			37 911			38 753		
Within UEMOA	29 530	58 051		32 741	-		28 907	9 221			18 462	76 351	76 050	16 964	

Notes: WB = wheat bran; RB = rice bran; MB = maize bran.

ANNEX 17
Share of extra- and intra-community imports of agro-industrial by-products between 2005 and 2009 (percent)

Product	2005	2006	2007	2008	2009	Average 2005–2009
			Intra-community imports			
Maize Bran	1.20	13.90	1.94	0.00	13.66	6.14
Wheat Bran	2.40	45.03	1.99	7.58	58.29	23.06
Rice Bran	15.80	4.32	2.11	16.25	7.74	9.24
Soybean Cake	51.91	16.14	24.02	5.32	20.32	23.54
Groundnut Cake	0.31	2.38	4.41	13.12	0.00	4.05
Cotton Cake	28.37	18.23	65.53	57.72	0.00	33.97
	100.00	100.00	100.00	100.00	100.00	100.00
			Extra-community imports			
Maize Bran	0.09	0.00	0.33	0.12	1.35	0.38
Wheat Bran	90.09	81.26	58.26	43.70	47.81	64.22
Rice Bran	0.01	1.21	2.38	3.73	4.62	2.39
Soybean Cake	7.41	13.41	36.32	51.64	44.94	30.74
Groundnut Cake	2.19	4.12	2.62	0.33	0.18	1.89
Cotton Cake	0.21	0.00	0.09	0.48	1.11	0.38
	100.00	100.00	100.00	100.00	100.00	100.00

ANNEX 18
Percentage of intra-community imports compared with total imports per by-product

	2002	2003	2004	2005	2006	2007	2008	2009
Maize bran	0.00	84.38	99.01	82.91	100.00	74.50	0.00	48.73
Wheat bran	0.85	0.16	0.97	0.98	22.27	1.66	6.13	10.27
Rice bran	98.14	91.66	0.00	99.83	64.93	30.52	62.11	13.59
Cotton cake	100.00	99.45	100.00	98.05	100.00	99.71	97.85	95.55
Groundnut cake	48.40	20.32	4.35	5.03	22.98	45.43	93.82	0.00
Soybean cake	72.07	88.20	59.13	72.15	38.37	24.67	3.74	4.07

ANNEX 19
Importance of intra-community imports by country from 2005 to 2009

Country	Quantity traded (tonne)						As percentage of intra-community imports					
	MB	WB	RB	CC	SC	GC	MB	WB	RB	CC	SC	GC
Benin	1 329	>1	90	25 753	0	15.5	57.85	0.00	0.14	83.28	0.00	0.49
Burkina Faso	0	0	359	1 435	2 657	0	0.00	0.00	0.54	4.64	13.14	0.00
Côte d'Ivoire	13	20	35	1 203	13	709.6	0.55	0.33	0.05	3.89	0.06	22.36
Guinea-Bissau	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0.00
Mali	100	169	0	2 517	0	0	4.35	2.82	0.00	8.14	0.00	0.00
Niger	735	285	0	0	0	0	32.01	4.76	0.00	0.00	0.00	0.00
Senegal	0	0	0	0	0	133.2	0.00	0.00	0.00	0.00	0.00	0.00
Togo	120	5 516	65 510	15	17 546	2 315	5.23	92.09	99.27	0.05	86.79	72.95

Notes: WB = wheat bran; RB = rice bran; MB = maize bran; CC = cotton cake; SC = soybean cake; GC = groundnut cake.

ANNEX 20
Importance of extra-community imports by country from 2005 to 2009

	Quantity traded (tonne)						As percentage of extra-community imports					
	MB	WB	RB	CC	SC	GC	MB	WB	RB	CC	SC	GC
Benin	0	72	2 193	0	1 216	0	0.00	0.04	27.44	0.00	2.42	0.00
Burkina Faso	6	0	7	329	32.1	0	0.76	0.00	0.00	54.15	0.06	0.00
Côte d'Ivoire	0	0	2	0.3	26 010	>1	0.00	0.00	0.00	0.05	51.81	0.01
Guinea-Bissau	0	5 971	1 600	0	0	0	0.00	3.20	20.02	0.00	0.00	0.00
Mali	2	1.1	0	0	291	0	0.22	0.00	0.00	0.00	0.58	0.00
Niger	730	40 272	1 664	232	5	2 143	95.17	21.56	20.82	38.24	0.01	73.60
Senegal	0	140 060	1 606	0	22 373	534	0.00	74.99	20.10	0.00	44.56	18.33
Togo	30	390	920	46	278	235	3.85	0.21	11.52	7.56	0.55	8.06

Notes: WB = wheat bran; RB = rice bran; MB = maize bran; CC = cotton cake; SC = soybean cake; GC = groundnut cake.

This publication presents the availability, access and utilization of crop residues and agro-industrial by-products in West Africa. It contributes to the efforts to strengthen mechanisms to establish and maintain feed assessments in West Africa. National feed assessments in a country build and improve resilience in its livestock production, support the formulation and implementation of livestock policies and programmes for sustainable livestock production, contribute to the use of appropriate feeding strategies, and respond to the impact of floods and drought.

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